Advanced Enterprise Solutions Overview

HUAWEI TECHNOLOGIES CO., LTD.

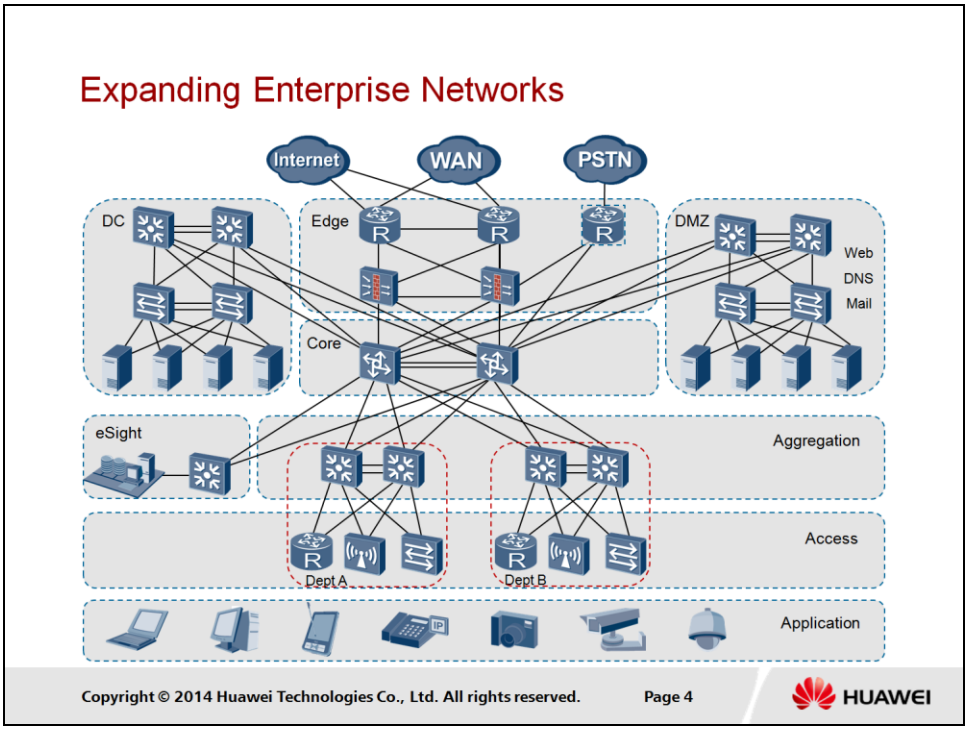
Foreword

An expanding enterprise business requires much more than just a fundamental network through which the transmission of data is supported. Enterprise networks are expected to support a growing number of services which involves the integration of technologies that are not native to packet switched networks. The enterprise network should provide high resiliency from network failure and threats, both internal and external, along with performance growth through the implementation of solutions that optimize data flow. It is therefore necessary that skills be attained for the implementation of technologies that enable an established enterprise network to apply services and solutions, that compliment ever growing enterprise networks for true industry application .

Objectives

Upon completion of this section, trainees will be able to:

- Describe the architecture of an established enterprise network.
- Describe the business considerations for enterprise networks.



The establishment of local and internetwork connectivity through TCP/IP protocols represents the foundation of the enterprise network, however does not represent a complete solution to enabling an enterprise network to be business ready. As an enterprise grows, so do the requirements for the network on which it is supported. This includes the implementation of effective network designs capable of supporting an expanding business where user density may grow in a short period of time, where operations as a mobile office may constantly be required, where growing technological requirements need to be smoothly facilitated, and the traffic generated is managed efficiently without disruption to base network operations.

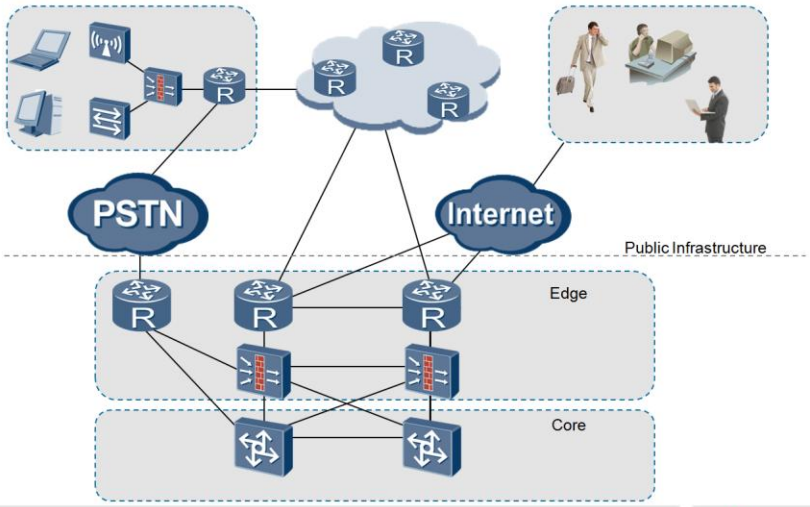
It is therefore imperative that a clear understanding be built of how solutions can be applied to establish an enterprise network capable of supporting ever changing industry needs. An enterprise network can be logically divided into five areas, including a core network, data center, DMZ, enterprise edge, and operations and maintenance (O&M). Huawei's campus network solution focuses on the core network zone. The core network implements a three-layer architecture consisting of a core, aggregation, and access layer.

This three-layer architecture has advantages in providing a multi-layer design for which each layer performs specific functions, and establishes a stable topology, to simplify network expansion and maintenance, with a modular design facilitating fault allocation. Network topology changes in one department can be isolated to avoid affecting other departments.

Huawei enterprise networks must be capable of providing solutions for a variety of scenarios, such as dense user access, mobile office, VoIP, videoconference and video surveillance, access from outside the campus network, and all-round network security.

Huawei enterprise solutions therefore must meet customer requirements on network performance, scalability, reliability, security, and manageability, whilst also simplifying network construction.

Telecoms Solutions For Enterprise Networks



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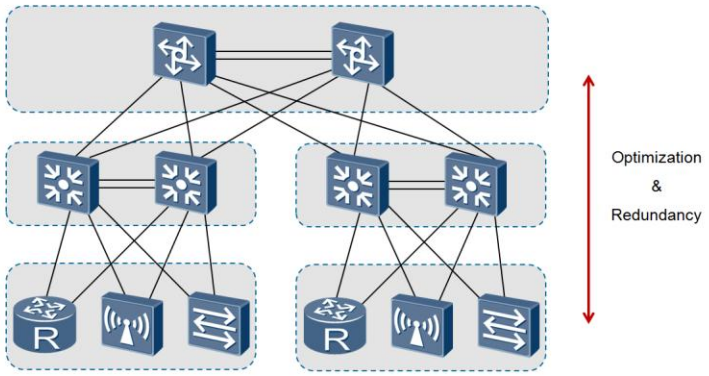
The enterprise network is required to be capable of establishing connectivity via a multitude of telecom service provider networks, building on an ever growing requirement for support of integrated and converged networks. In taking advantage of the ubiquitous nature of IP, it is important that the enterprise network be capable of supporting all services necessary in enterprise based industries to provide access to internal resources through any type of device, at any time and in any location.

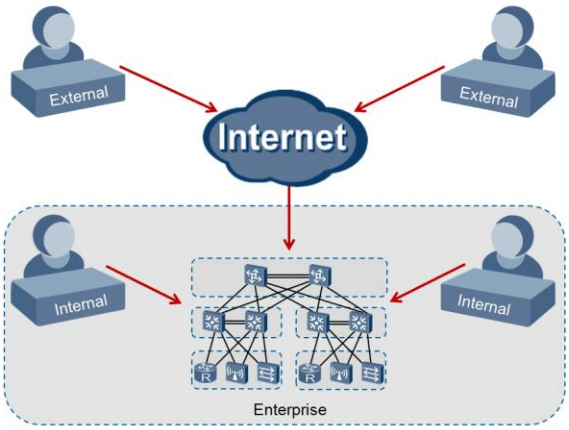
Enterprise Network Efficiency



- Optimization and redundancy solutions enhance performance.

Maintaining efficiency of operation in an enterprise network requires that traffic flow is greatly optimized and redundancy is implemented to ensure that in the case of any device or link failure, isolation of users and resources will not occur. A two-node redundant design is implemented as part of enterprise network design to enhance network reliability, however a balance is required to be maintained, since too many redundant nodes are difficult to maintain and increase overall organizational expenditure.

Enterprise Network Security



- Threats may originate in many forms and from any location.

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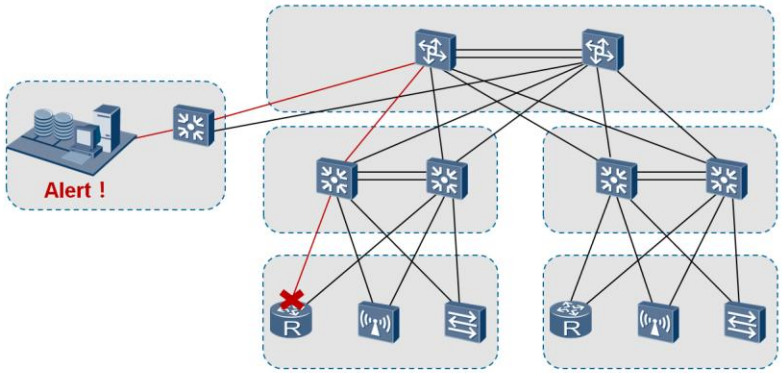
Network security plays an ever increasing role in the enterprise network. The initial development of TCP/IP was never done so with the issue of security in mind, and therefore security implementations have gradually been introduced to combat ever growing threats to IP networks. Security threats are capable of originating both from inside and outside of the enterprise network and therefore solutions to tackle both types of security threats have become prominent. Huawei network security solutions have grown to cover terminal security management, service security control, and network attack defense.

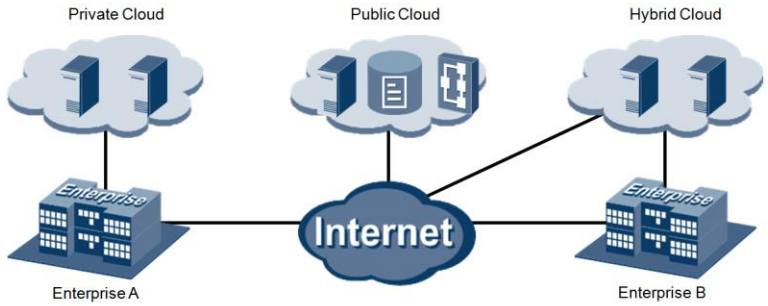
Enterprise Network Management



- Real time discovery of network failures improves resiliency.

The growth of intelligent network designs help to facilitate operations and maintenance (O&M) for which Huawei network solutions provide means for intelligent power consumption management, intelligent fast network deployment, and intelligent network maintenance.

Next Generation Enterprise Networks



- Dynamically scalable solutions for ever changing industry requirements has led to a growth in cloud services for enterprise.

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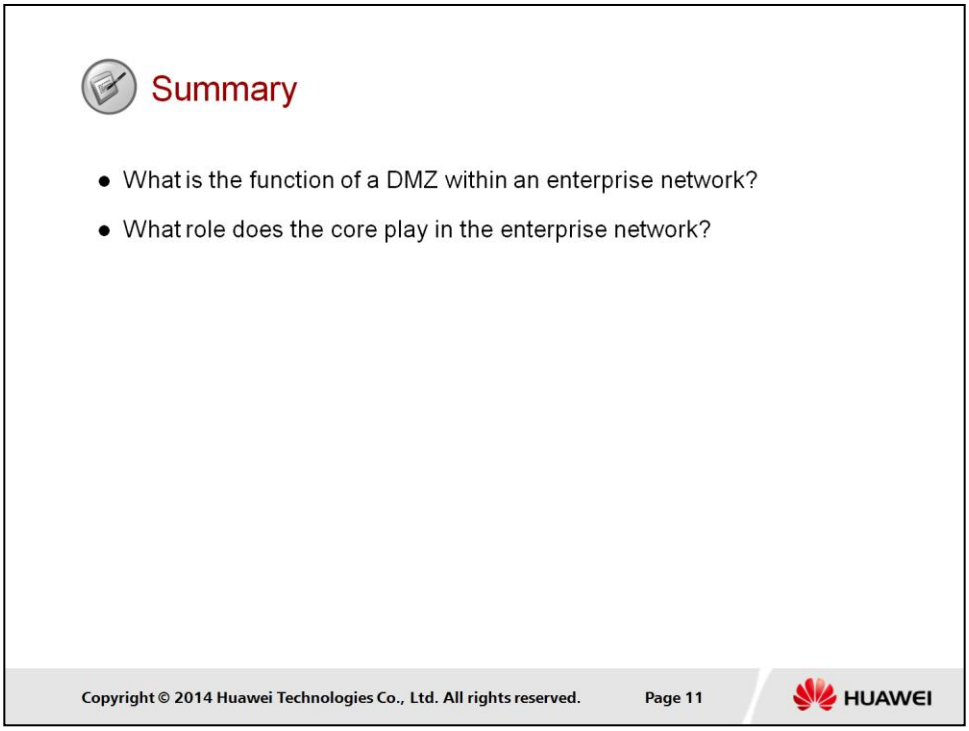
As the industry continues to evolve, new next generation enterprise solutions are introduced including the prominence of cloud technology providing cloud service solutions to infrastructure, platforms, software etc, to meet the needs of each customer. Along with this is the need for support of enterprise built data centers and infrastructure designs allowing for constant expansion in order to keep up with the growing number of services required by customers. This involves the realization of technologies such as virtualization and storage solutions that continue to play an aggressive role in ensuring that the enterprise industry's expansion into the cloud is facilitated on all service levels.



1. The DMZ represents a location that is part of the enterprise network, however the DMZ exists within a location that allows the services to be accessed from both an external location and internally, without allowing external users permission to access locations associated with internal users. This provides a level of security that ensures data never flows between internal and external user locations.

2. The core provides a means for high speed forwarding of traffic between different locations in the enterprise network and to external locations beyond the enterprise network. As such the devices used in the core must be capable of supporting higher performance in terms of processing and forwarding capacity.

Thank you

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Link Aggregation

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Foreword

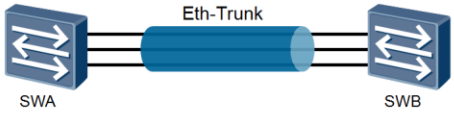
As a means of optimizing the throughput of data, link aggregation enables the binding of multiple physical interfaces into a single logical pipe. This effectively introduces solutions for providing higher utilization of available links, as well as extended resilience in the event that failure of individual links were to occur. Engineers are required to have a clear understanding of the conditions that define the behavior of link aggregation and the skills and knowledge for it's application, to ensure effective link aggregation solutions can be applied to enterprise networks.

Objectives

Upon completion of this section, trainees will be able to:

- Explain the use of link aggregation in the enterprise network.
- Describe the various forms of link aggregation supported.
- Configure link aggregation solutions.

Link Aggregation



- Link Aggregation provides for increased bandwidth, enhanced reliability and support of load balancing.

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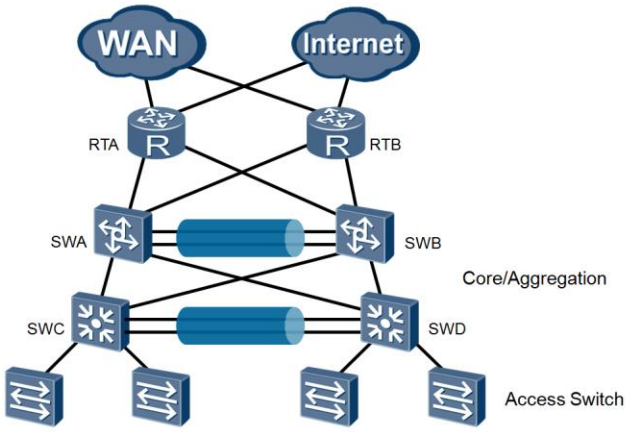
Link aggregation refers to the implementation of a trunk link that acts as a direct point-to-point link, between two devices such as peering routers, switches, or a router and switch combination at each end of the link. The link aggregation comprises of links that are considered members of an Ethernet trunk, and build an association which allows the physical links to operate as a single logical link. The link aggregation feature supports high availability by allowing the physical link of a member interface to switch traffic to another member link in the event that a particular interface fails. In aggregating the links, the bandwidth of a trunk interface is combined, equaling the sum of the bandwidth of all member interfaces, to enable an effective bandwidth increase for traffic over the logical link. Link aggregation can also implement load balancing on a trunk interface. This enables the trunk interface to disperse traffic among its member interfaces, and then transmit the traffic over the member links to the same destination, thus minimizing the likelihood of network congestion.

Application in the Enterprise Network



- Application is made at critical points to enhance throughput.

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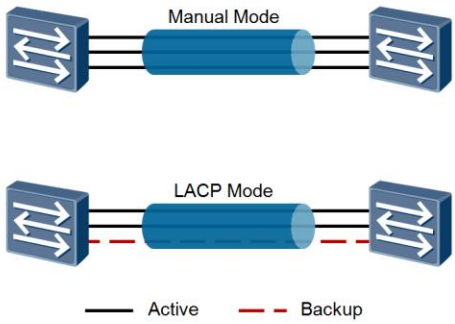
Link aggregation is often applied in areas of the enterprise network where high speed connectivity and the potential for congestion is likely to occur. This generally equates to the core network where responsibility for high speed switching resides, and where traffic from all parts of the enterprise network generally congregates before being forwarded to destinations either in other parts of the network, or remote destinations beyond the boundaries of the enterprise network. The example demonstrates how core switches (SWA & SWB) support link aggregation over member links that interconnect the two core switch devices, as a means of ensuring that congestion does not build at a critical point in the network.

Link Aggregation Modes



- In manual mode all links load balance and are forwarding.
- LACP mode supports backup links for redundancy.

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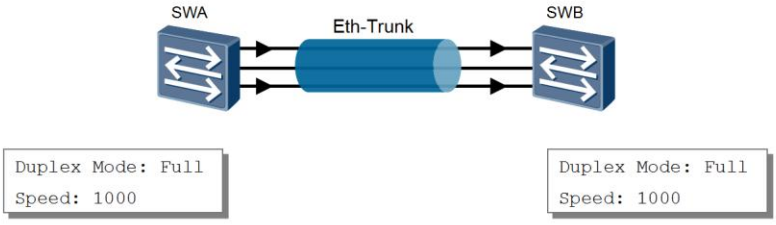
Link aggregation supports two modes of implementation, a manual load balancing mode and static LACP mode. In load balancing mode, member interfaces are manually added to a link aggregation group (LAG). All of the interfaces configured with load balancing are set in a forwarding state. The AR2200 can perform load balancing based on destination MAC addresses, source MAC addresses, exclusive-OR of the source and destination MAC addresses, source IP addresses, destination IP addresses, or Exclusive-OR of source and destination IP addresses. The manual load balancing mode does not use the Link Aggregation Control Protocol (LACP), therefore the AR2200 can use this mode if the peer device does not support LACP.

In static LACP mode, devices at two ends of a link negotiate aggregation parameters by exchanging LACP packets. After the negotiation is complete, the two devices determine the active interface and the inactive interface. In this mode, it is necessary to manually create an Eth-Trunk and add members to it. LACP negotiation determines which interfaces are active and which ones are inactive. The static LACP mode is also referred to as M:N mode, where M signifies the active member links which forward data in a load balancing mode, and N represents those links inactive but providing redundancy. If an active link fails, data forwarding is switched to the backup link with the highest priority, and the status of the backup link changes to active. In static LACP mode, some links may function as backup links, whereas all member interfaces work in a forwarding state in manual load balancing mode, and represents the main difference between the two modes.

Data Flow Control



- Data flow sequence must be maintained over member links.
- Consistency of physical member interfaces must be maintained.

As a logical interface for binding multiple physical interfaces and relaying upper-layer data, a trunk interface must ensure that all parameters of the physical interfaces (member interfaces) on both ends of the trunk link be consistent. This includes the number of physical interfaces, the transmission rates and duplex modes of the physical interfaces, and the traffic-control modes of the physical interfaces, for which it should be noted that member interfaces can be layer 2 or layer 3 interfaces. Where the interface speed is not consistent, it is still possible for the trunk link to operate, however the interfaces operating at a lower rate are likely to experience loss of frames.

In addition, the sequence of the data flow must be unchanged. A data flow can be considered as a group of frames with the same MAC address and IP address. For example, the telnet or FTP connection between two devices can be considered as a data flow. If the trunk interface is not configured, frames that belong to a data flow can still reach their destination in the correct order because data flows are transmitted over a single physical link. When the trunk technology is used, multiple physical links are bound to the same trunk link, and frames are transmitted along these physical links. If the first frame is transmitted over one physical link, and the second frame is transmitted over another physical link, it is possible that the second frame may reach the destination earlier than the first frame.

To prevent the disorder of frames, a frame forwarding mechanism is used to ensure that frames in the same data flow reach the destination in the correct sequence. This mechanism differentiates data flows based on their MAC addresses or IP addresses. In this manner, frames belonging to the same data flow are transmitted over the same physical link. After the frame forwarding mechanism is used, frames are transmitted based on the following rules:

Frames with the same source MAC addresses are transmitted over the same physical link.

Frames with the same destination MAC addresses are transmitted over the same physical link.

Frames with the same source IP addresses are transmitted over the same physical link.

Frames with the same destination IP addresses are transmitted over the same physical link.

Frames with the same source and destination MAC addresses are transmitted over the same physical link.

Frames with the same source and destination IP addresses are transmitted over the same physical link.

L2 Link Aggregation Configuration


```
[SWA]interface Eth-Trunk 1
[SWA-Eth-Trunk1]interface GigabitEthernet0/0/1
[SWA-GigabitEthernet0/0/1]eth-trunk 1
[SWA-GigabitEthernet0/0/1]interface GigabitEthernet0/0/2
[SWA-GigabitEthernet0/0/2]eth-trunk 1
```

- Link Aggregation requires the binding of the physical member interfaces to the Eth-trunk.

Establishment of Link Aggregation is achieved using the interface Eth-trunk <trunk-id> command. This command creates an Eth-Trunk interface and allows for the Eth-Trunk interface view to be accessed. The trunk-id is a value used to uniquely identify the Eth-trunk, and can be any integer value from 0 through to 63. If the specified Eth-Trunk already exists, it is possible to directly enter the Eth-Trunk interface view by using the interface Eth-trunk command. An Eth-Trunk can only be deleted if the Eth-Trunk does not contain any member interfaces. When adding an interface to an Eth-Trunk, member interfaces of a layer 2 Eth-Trunk must be layer 2 interfaces, and member interfaces of a layer 3 Eth-Trunk must be layer 3 interfaces. An Eth-Trunk can support a maximum of eight member interfaces. A member interface cannot have any service or static MAC address configured. Interfaces added to an Eth-Trunk should be hybrid interfaces (the default interface type). An Eth-Trunk interface cannot have other Eth-Trunk interfaces as member interfaces. An Ethernet interface can be added to only one Eth-trunk interface.

To add the Ethernet interface to another Eth-trunk, the Ethernet interface must be deleted from the current Eth-Trunk first. Member interfaces of an Eth-trunk must be the same type, for example, a Fast Ethernet interface and a Gigabit Ethernet interface cannot be added to the same Eth-trunk interface. The peer interface directly connected to a member interface of the local Eth-Trunk must also be added to an Eth-Trunk, otherwise the two ends cannot communicate. When member interfaces have different rates, the interfaces with lower rates may become congested and packet loss may occur. After an interface is added to an Eth-Trunk, MAC address learning is performed by the Eth-Trunk rather than the member interfaces.

L3 Link Aggregation Configuration


```
[RTA]interface eth-trunk 1
[RTA-Eth-Trunk1]undo portswitch
[RTA-Eth-Trunk1]ip address 100.1.1.1 24
[RTA-Eth-Trunk1]quit
[RTA]interface GigabitEthernet 0/0/1
[RTA-GigabitEthernet0/0/1]eth-trunk 1
[RTA-GigabitEthernet0/0/1] quit
[RTA]interface GigabitEthernet0/0/2
[RTA-GigabitEthernet0/0/2]eth-trunk 1
[RTA-GigabitEthernet0/0/2] quit
```


In order to configure layer 3 Link Aggregation on an Ethernet trunk link, it is necessary to transition the trunk from layer 2 to layer 3 using the *undo portswitch* command under the Eth-trunk logical interface. Once the undo portswitch command has been performed, an IP address can be assigned to the logical interface and the physical member interfaces that are to be associated with the Ethernet trunk link can be added.

Displaying Aggregation

```
[RTA]display interface eth-trunk 1
Eth-Trunk1 current state : UP
Line protocol current state : UP
……
--------------------------------------------------
PortName                  Status             Weight
--------------------------------------------------
GigabitEthernet0/0/1        UP                   1
GigabitEthernet0/0/2        UP                   1
--------------------------------------------------
The Number of Ports in Trunk : 2
The Number of UP Ports in Trunk : 2
```

- Two member link ports have been assigned to Eth-trunk 1

Using the *display interface eth-trunk <trunk-id>* command it is possible to confirm the successful implementation of Link Aggregation between the two peering devices. The command can also be used to collect traffic statistics and locate faults on the interface.

The current state of the Eth-trunk is set to UP, signaling that the interface is operating normally. Where the interface shows as down, this signals that an error has occurred at the physical layer, whereas an administratively down error reflects that the *shutdown* command has be used on the interface. The specific error in the event of a failure can be discovered by verifying the status of the ports, for which all ports are expected to show an UP status. Load balancing is supported when the weight of all links is considered equal.

Summary

- If an administrator attempts to add a Gigabit Ethernet and Fast Ethernet interface to the same Eth-trunk interface, what will occur?
- In order to establish backup member links, which mode of link aggregation should be used?

1. A Fast Ethernet interface and a Gigabit Ethernet interface cannot be added to the same Eth-trunk interface, any attempt to establish member links of different types will result in an error specifying that the trunk has added a member of another port-type. It should be noted that the S5700 series switch supports Gigabit Ethernet interfaces only, however this behavior can be applied to other models including the S3700 switch.

2. Only the LACP mode is capable of supporting backup member links and therefore should be used if backup links are required.

Thank you

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VLAN Principles

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Foreword

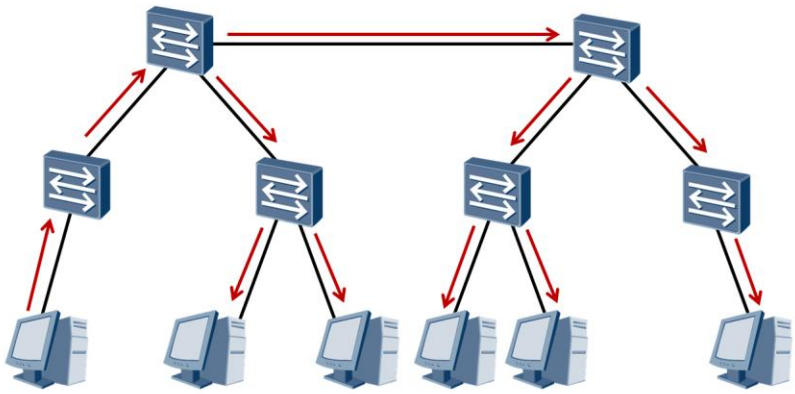
A Virtual Local Area Network (VLAN) represents a form of administrative network that defines a logical grouping of hosts or end system devices that are not limited to a physical location, and may be defined based on a wide range of parameters that allow for a greater flexibility in the way that logical groups are defined. The application of VLAN technology has expanded to support many aspects of enterprise networking as a means of logical data flow management and isolation.

Objectives

Upon completion of this section, trainees will be able to:

- Explain the application of VLAN tagging.
- Describe the different port link types and characteristics.
- Successfully establish port based VLANs.

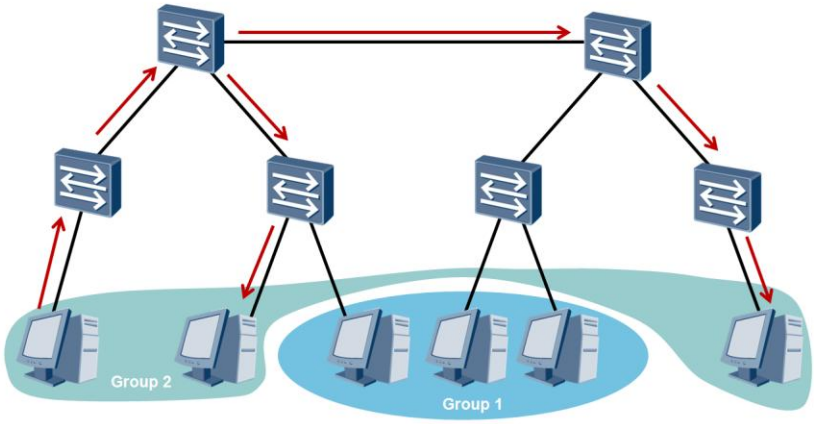
LAN Limitations



- No broadcast domain to manage expanding local networks.

As local networks expand, traffic increases and broadcasts become more common. There are no real boundaries within such an expanding network, causing interrupts and growing traffic utilization to occur. Traditionally, the alternative option was to implement a layer three device within the local network to generate broadcast domains, however in doing so additional expense was incurred and the forwarding behavior of such devices did not provide as efficient throughput as found with switches, leading to bottlenecks at transit points between broadcast domains.

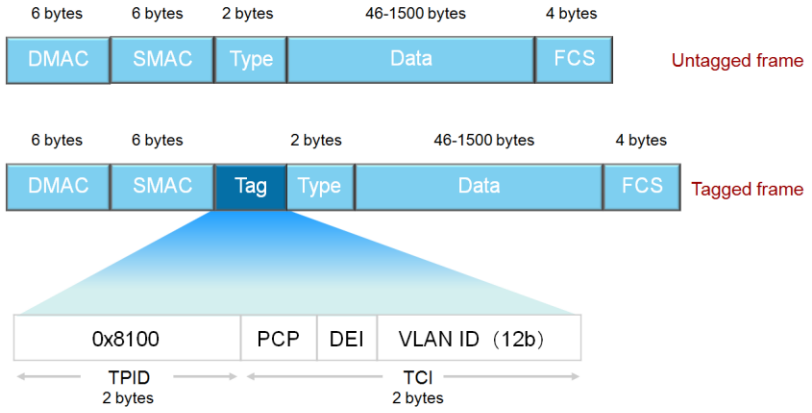
VLAN Technology



- A VLAN enables logical isolation of traffic at the data link layer.

The principle of VLAN technology was introduced that enabled traffic isolation at the data link layer. VLAN technology has the added advantage of traffic isolation without the limitation of physical boundaries. Users can be physically dispersed but still be associated as part of a single broadcast domain, logically isolating users from other user groups at the data link layer. Today VLAN technology is applied as a solution to a variety of challenges.

VLAN Frame Format



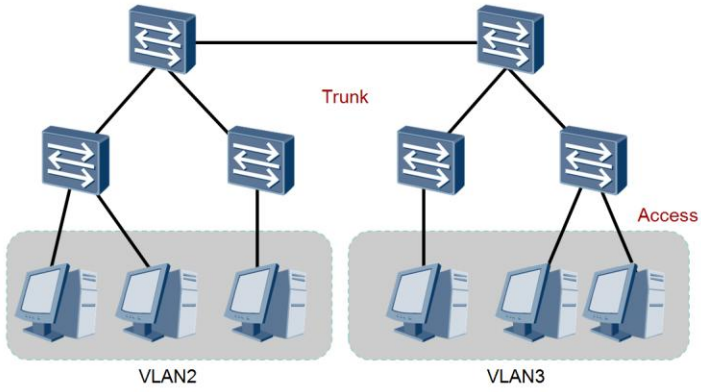
- A VLAN tag is inserted to distinguish frames for each VLAN.

VLAN frames are identified using a tag header which is inserted into the Ethernet frame as a means of distinguishing a frame associated with one VLAN from frames of another. The VLAN tag format contains a Tag Protocol Identifier (TPID) and associated Tag Control Information (TCI). The TPID is used to identify the frame as a tagged frame, which currently only refers to the IEEE 802.1Q tag format, for which a value of 0x8100 is used to identify this format. The TCI contains fields that are associated with the tag format type.

The Priority Code Point (PCP) is a form of traffic classification field that is used to differentiate one form of traffic from another so as to prioritize traffic generally based on a classification such as voice, video, data etc. This is represented by a three bit value allowing a range from 0-7, and can be understood based on general 802.1p class of service (CoS) principles. The Drop Eligibility Indicator (DEI) represents a single bit value that exists in either a True of False state to determine the eligibility of a frame for discarding in the event of congestion.

The VLAN ID indicates the VLAN with which the frame is associated, represented as a 12 bit value. VLAN ID values range from 0x000 through to 0xFFF and for which the two upper and lower values are reserved, allowing 4094 possible VLAN Combinations. Huawei VRP implementation of VLANs uses VLAN 1 as the default VLAN (PVID) as based on IEEE802.1Q standards.

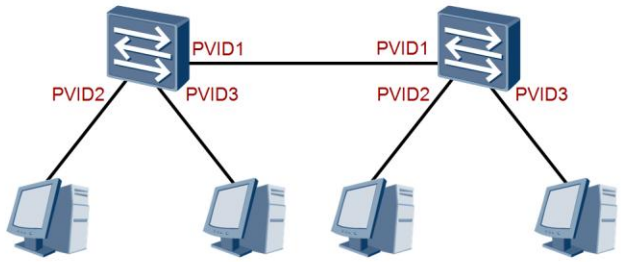
Link Types



- A trunk represents a backbone for the transmission of VLAN traffic between switches.

VLAN links can be classified into two types, an access link type and a trunk link type. The access link refers to the link between an end system and a switch device participating in VLAN tagging, the link between host terminals and switches are all access links. A trunk link refers to the link over which VLAN tagged frames are likely to be carried. The links between switches are generally understood to be trunk links.

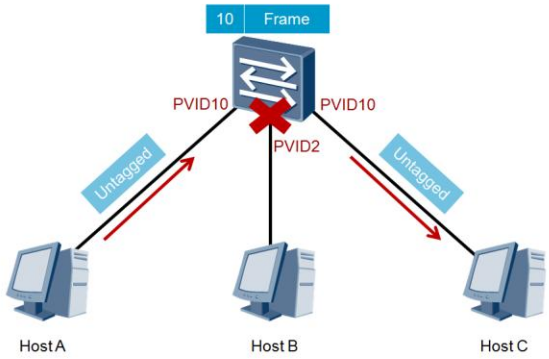
Port VLAN ID



- PVID represents the default VLAN for each interface.
- The PVID is set to VLAN 1 for all ports by default.

Each interface of a device participating in VLAN tagging will be associated with a VLAN. The default VLAN for the interface is recognized as the Port VLAN ID (PVID). This value determines the behavior that is applied to any frames being received or transmitted over the interface.

Port Types – Access

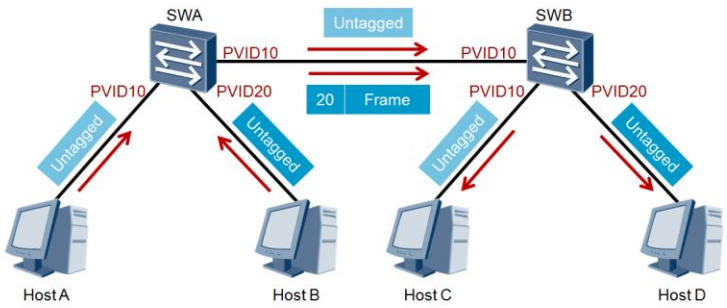


- Access ports remove VLAN tags before forwarding frames.

Access ports associate with access links, and frames that are received will be assigned a VLAN tag that is equal to the Port VLAN ID (PVID) of the interface. Frames being transmitted from an interface will typically remove the VLAN tag before forwarding to an end system that is not VLAN aware. If the tag and the PVID vary however, the frame will not be forwarded and therefore discarded. In the example a frame (untagged) is forwarded to the interface of the switch, which can be understood to forward to all other destinations.

Upon receiving the frame, the switch will associate the frame with VLAN 10 based on the PVID of the interface. The switch is able to identify at the port interface the PVID and make a decision as to whether the frame can be forwarded. In the case of Host C the PVID matches the VLAN ID in the VLAN tag, for which the tag is removed and the frame forwarded. For Host B however the frame and the PVID differ, and therefore the frame is restricted from being forwarded to this destination.

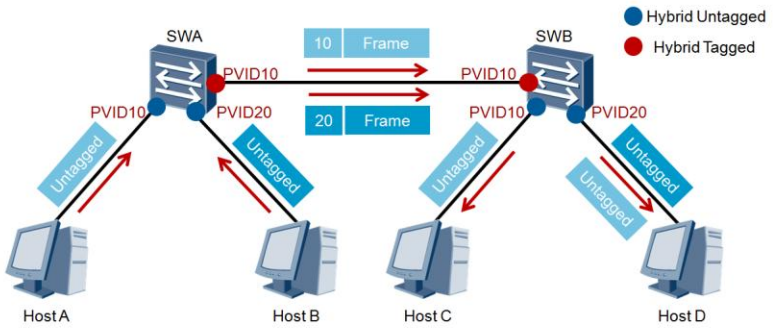
Port Types – Trunk



- Frames carried over a trunk link may be tagged or untagged.
- All VLANs must be permitted before being carried over a trunk.

For trunk ports that are associated with trunk links, the Port VLAN ID (PVID) will identify which VLAN frames are required to carry a VLAN tag before forwarding, and which are not. The example demonstrates a trunk interface assigned with a PVID of 10, for which it should be assumed that all VLANs are permitted to traverse the trunk link. Only frames associated with VLAN 10 will be forwarded without the VLAN tag, based on the PVID. For all other VLAN frames, a VLAN tag must be included with the frame and be permitted by the port before the frame can be transmitted over the trunk link. Frames associated with VLAN 20 are carried as tagged frames over the trunk link.

Port Types-Hybrid



- Hybrid ports are defined as either tagged or untagged.
- VLAN communication can be managed on a port by port basis.

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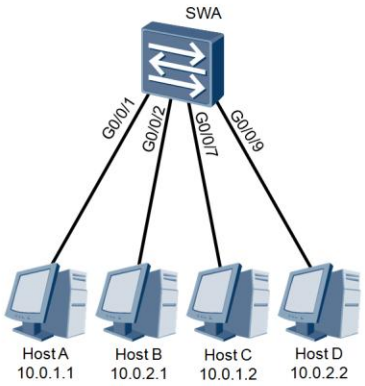
Hybrid represents the default port type for Huawei devices supporting VLAN operation and provides a means of managing the tag switching process associated for all interfaces. Each port can be considered as either a tagged port or an untagged port. Ports which operate as access ports (untagged) and ports which operate as trunk ports (tagged).

Ports which are considered untagged will generally receive untagged frames from end systems, and be responsible for adding a tag to the frame based on the Port VLAN ID (PVID) of the port. One of the key differences is in the hybrid port's ability to selectively perform the removal of VLAN tags from frames that differ from the PVID of the port interface. In the example, Host D is connected to a port which specifies a Port VLAN ID of 20, whilst at the same time is configured to allow for the removal of the tag from frames received from VLAN 10, thereby allowing Host D to receive traffic from both VLANs 10 & 20.

Hybrid Ports that are tagged will operate in a similar manner as a regular trunk interface, however one major difference exists. VLAN frames that both match the PVID and are permitted by the port will continue be tagged when forwarded.

VLAN Assignment Methods



Assignment Method	VLAN 5	VLAN 10
Port based	G0/0/1, G0/0/7	G0/0/2 G0/0/9
MAC based	00-01-02-03-04-AA 00-01-02-03-04-CC	00-01-02-03-04-BB 00-01-02-03-04-DD
IP Subnet based	10.0.1.*	10.0.2.*
Protocol based	IP	IPX
Policy based	10.0.1.* + G0/0/1+ 00-01-02-03-04-AA	10.0.2.* + G0/0/2 + 00-01-02-03-04-BB

- Five methods of VLAN assignment are possible.
- Port based VLAN assignment is the default assignment method.

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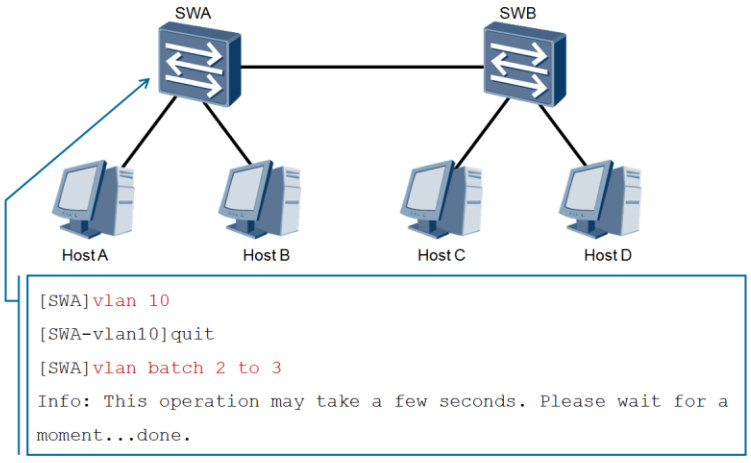
VLAN assignment can be implemented based on one of five different methods, including Port based, MAC based, IP Subnet based, Protocol based and Policy based implementations. The port based method represents the default and most common method for VLAN assignment. Using this method, VLANs are classified based on the port numbers on a switching device. The network administrator configures a Port VLAN ID (PVID), representing the default VLAN ID for each port on the switching device. When a data frame reaches a port, it is marked with the PVID if the data frame carries no VLAN tag and the port is configured with a PVID. If the data frame carries a VLAN tag, the switching device will not add a VLAN tag to the data frame even if the port is configured with a PVID.

Using the MAC address assignment method, VLANs are classified based on the MAC addresses of network interface cards (NICs). The network administrator configures the mappings between MAC addresses and VLAN IDs. In this case, when a switching device receives an untagged frame, it searches the MAC-VLAN table for a VLAN tag to be added to the frame according to the MAC address of the frame. For IP subnet based assignment, upon receiving an untagged frame, the switching Device adds a VLAN tag to the frame based on the IP address of the packet header.

Where VLAN classification is based on protocol, VLAN IDs are allocated to packets received on an interface according to the protocol (suite) type and encapsulation format of the packets. The network administrator configures the mappings between types of protocols and VLAN IDs. The Policy based assignment implements a combination of criteria for assignment of the VLAN tag, including the IP subnet, port and MAC address, in which all criteria must match before the VLAN is assigned.

Creating VLANs



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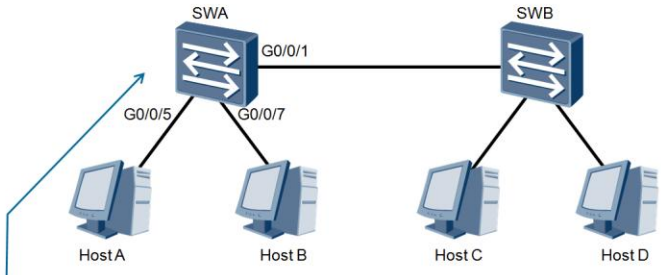
The implementation of VLANs begins with the creation of the VLAN on the switch. The vlan<*vlan-id*> command is used to initially create the the VLAN on the switch which can be understood to exist once the user enters the VLAN view for the given vlan as demonstrated in the configuration example. The VLAN ID ranges from 1 to 4094 and where it is necessary to create multiple VLANs for a switch, the *vlan batch* <*vlan-id1 to vlan-id2*> command can be used where contiguous VLAN ranges need to be created and *vlan batch &<1-4094>* command used where "*&*" represents a space between non-contiguous VLAN ranges. All ports are associated with VLAN 1 as the default VLAN by default, and therefore forwarding is unrestricted.

Creating VLANs

```
[SWA]display vlan
The total number of vlans is : 4
--------------------------------------------------------------
U:Up; D:Down; TG:Tagged; UT:Untagged; MP:Vlan-mapping;
ST:Vlan-stacking; #: ProtocolTransparent-vlan; *:Management-
vlan;
--------------------------------------------------------------
VID  Type    Ports
--------------------------------------------------------------
1    common  UT:GE0/0/1(U) ……
2    common
3    common
10   common
……
```


Once the VLANs have been created, the creation can be verified using the display vlan command. The command allows information about all VLANs to be specified, and if no parameter is specified, brief information about all VLANs is displayed. Additional parameters include display vlan <vlan-id> verbose command, used to display detailed information about a specified VLAN, including the ID, type, description, and status of the VLAN, status of the traffic statistics function, interfaces in the VLAN, and mode in which the interfaces are added to the VLAN. The display vlan <vlan-id> statistics command, allows for the view of traffic statistics on interfaces for a specified VLAN. The display vlan summary command, provides a summary of all VLANs in the system.

Setting the Port Link Type




```
[SWA]interface GigabitEthernet 0/0/1
[SWA-GigabitEthernet0/0/1]port link-type trunk
[SWA-GigabitEthernet0/0/1]interface GigabitEthernet 0/0/5
[SWA-GigabitEthernet0/0/5]port link-type access
```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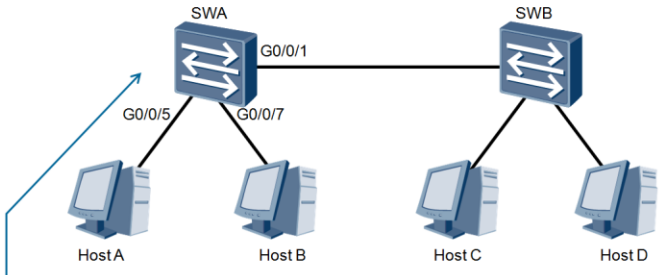
The configuration of the port link type is performed in the interface view for each interface on a VLAN active switch. The default port link type on Huawei switch devices is hybrid. The *port link-type <type>* command is used to configure the port link type of the interface where the type can be set as access, trunk or hybrid. A fourth QinQ option exists but is considered outside of the scope of this course. It should also be noted that in the displayed configuration if no port type is displayed, the default hybrid port link type is configured. Prior to changing the interface type, it is also necessary to restore the default VLAN configuration of the interface so that the interface belongs to only the default VLAN 1.

Assigning Ports to VLANs




```
[SWA]vlan 2
[SWA-vlan2]port GigabitEthernet 0/0/7
[SWA-vlan2]quit
[SWA-GigabitEthernet0/0/5]port link-type access
[SWA-GigabitEthernet0/0/5]port default vlan 3
```

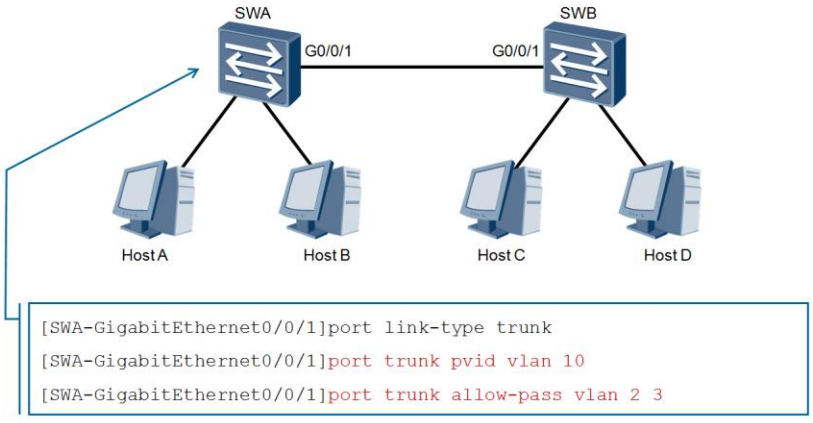

The association of a port with a created VLAN can be achieved using two configuration methods, the first of those is to enter the VLAN view and configure the interface to be associated with the VLAN using the *port <interface>* command. The second means of assigning ports to VLANs involves accessing the interface view for the interface to be added to a VLAN and implement the command *port default <vlan-id>* where the *vlan-id* refers to the VLAN to which the port is to be added.

Verifying VLAN Assignment

```
[SWA]display vlan
The total number of vlans is : 4
--------------------------------------------------------------
U:Up; D:Down; TG:Tagged; UT:Untagged; MP:Vlan-mapping;
ST:Vlan-stacking; #: ProtocolTransparent-vlan; *:Management-
vlan;
--------------------------------------------------------------
VID  Type    Ports
--------------------------------------------------------------
1    common  UT:GE0/0/1(U) ……
2    common  UT:GE0/0/7(D)
3    common  UT:GE0/0/5(U)
10   common
……
```


The *display vlan* command can be used to verify the changes made to the configuration and confirm the association of port interfaces with the VLANs to which the ports have been assigned. In the display example port interfaces Gigabit Ethernet 0/0/5 and Gigabit Ethernet 0/0/7 can be identified as being associated with VLANs 2 and 3 respectively. The UT value identifies that the port is considered untagged either through assigning of the port link type as an access port or as an untagged hybrid port. The current state of the link can also be determined as either up (U) or down (D).

Forwarding Over the Trunk



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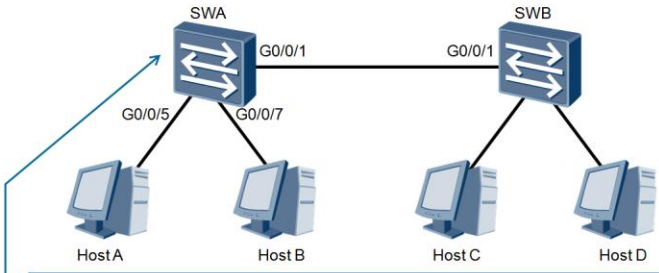
The assigning of the port link type of trunk interfaces enables the trunk to support the forwarding of VLAN frames for multiple VLANs between switches, however in order for frames to be carried over the trunk interface, permissions must be applied. The port trunk *allow-pass vlan* <*vlan-id*> command is used to set the permission for each VLAN, where vlan-id refers to the VLANs to be permitted. It is also necessary that the PVID for the trunk interface be included in the command to enable untagged traffic to be carried over the trunk link. The example demonstrates the changing of the default Port VLAN ID (PVID) for the interface to 10 and the applying of permission for VLANs 2 and 3 over the trunk link. In this case, any frames associated with VLAN 10 will not be carried over the trunk even though VLAN 10 is now the default VLAN for the trunk port. The command *port trunk allow-pass vlan all* can be used to allow all VLANs to traverse the trunk link.

Forwarding Over the Trunk

```
[SWA]display vlan
The total number of vlans is : 4
--------------------------------------------------------------
U:Up; D:Down; TG:Tagged; UT:Untagged; MP:Vlan-mapping;
ST:Vlan-stacking; #: ProtocolTransparent-vlan; *:Management-
vlan;
--------------------------------------------------------------
VID  Type    Ports
--------------------------------------------------------------
1    common  UT:GE0/0/1(U) ……
2    common  UT:GE0/0/7(D) TG:GE0/0/1(U)
3    common  UT:GE0/0/5(U) TG:GE0/0/1(U)
10   common
……
```


The changes to the VLAN permissions can again be monitored through the *display vlan* command, for which the application of VLANs over the trunk link are reflected. The TG value identifies that VLANs have been associated with a tagged interface either over a trunk or tagged hybrid port interface. In the display example, VLANs 2 and 3 have been given permission to traverse the tagged interface GigabitEthernet0/0/1, an interface that is currently active.

Configuring Hybrid Ports




```
[SWA-GigabitEthernet0/0/5]port link-type hybrid
[SWA-GigabitEthernet0/0/5]port hybrid pvid vlan 3
[SWA-GigabitEthernet0/0/5]port hybrid untagged vlan 3
[SWA-GigabitEthernet0/0/7]port link-type hybrid
[SWA-GigabitEthernet0/0/7]port hybrid pvid vlan 2
[SWA-GigabitEthernet0/0/7]port hybrid untagged vlan 2
```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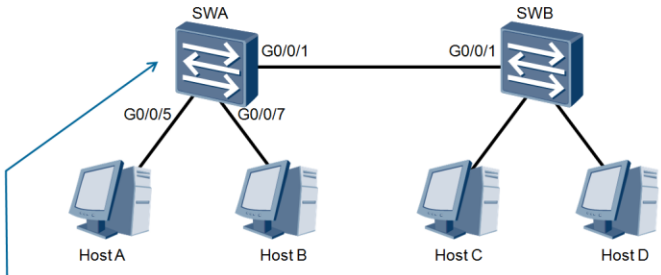
Hybrid port configuration represents the default port type on switch port interfaces and therefore the command *port link-type hybrid* is generally only necessary when converting the port link type from an access or a trunk port link type. Each port however may require to be associated with a default Port VLAN ID (PVID) over which frames are required to be either tagged or untagged. The *port hybrid pvid vlan* <*vlan-id*> command enables the default PVID to be assigned on a port by port basis following which it is also necessary to associate the forwarding behavior for a given port.

For ports that are to operate as access ports, this is achieved using the *port hybrid untagged vlan*<*vlan-id*> command. It should be clearly noted that the use of this command multiple times under the same interface view shall result in the interface being associated with all VLANs specified, with the associated VLAN frames being untagged before forwarding. The *undo port hybrid vlan* command can be used restore the default VLAN setting of VLAN1 and return to the default untagged mode.

Configuring Hybrid Ports




```
[SWA-GigabitEthernet0/0/1]port link-type hybrid
[SWA-GigabitEthernet0/0/1]port hybrid tagged vlan 2 to 3
```

- Trunk links using the hybrid port link-type must enable tagging of VLAN frames before forwarding.

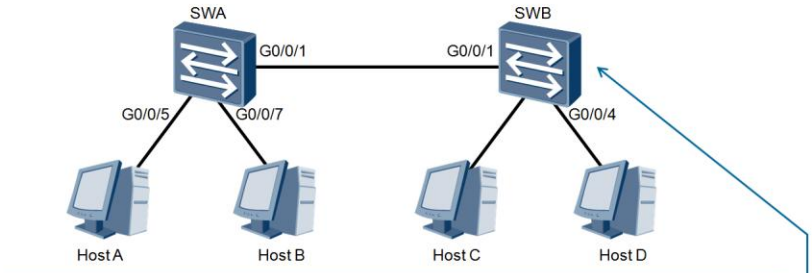
For ports that are to operate as trunk ports, the *port hybrid tagged vlan <vlan-id>* command is used. It should be clearly noted that the use of this command multiple times under the same interface view shall result in the interface being associated with all VLANs specified, with the associated VLAN frames being tagged before forwarding. In the example the hybrid port interface Gigabit Ethernet 0/0/1 is expected to tag all frames that are associated with VLANs 2 and 3 before such frames are forwarded over the interface.

Configuration Validation

```
[SWA]display vlan
The total number of vlans is : 4
--------------------------------------------------------------
U:Up; D:Down; TG:Tagged; UT:Untagged; MP:Vlan-mapping; ST:Vlan-
stacking; #: ProtocolTransparent-vlan; *:Management-vlan;
--------------------------------------------------------------
VID  Type    Ports
--------------------------------------------------------------
1    common  UT:GE0/0/1(U) ……
2    common  UT:GE0/0/7(D)
             TG:GE0/0/1(U)
3    common  UT:GE0/0/5(U)
             TG:GE0/0/1(U)
10   common
……
```


Through the *display vlan* command, the results of the tagged and untagged hybrid port configuration can be verified. Interface Gigabit Ethernet 0/0/7 has been established as a VLAN 2 untagged interface, while interface Gigabit Ethernet 0/0/5 has been established as an untagged interface associated with VLAN 3. In terms of both VLAN 2 and VLAN 3, frames associated with either VLAN will be carried as a tagged frame over interface Gigabit Ethernet 0/0/1.

Configuring Hybrid Ports




```
[SWB-GigabitEthernet0/0/4]port link-type hybrid
[SWB-GigabitEthernet0/0/4]port hybrid pvid vlan 3
[SWB-GigabitEthernet0/0/4]port hybrid untagged vlan 2 to 3
```

- Hybrid ports can be configured to receive VLAN traffic from multiple VLANs by simply removing the tag at the port interface.

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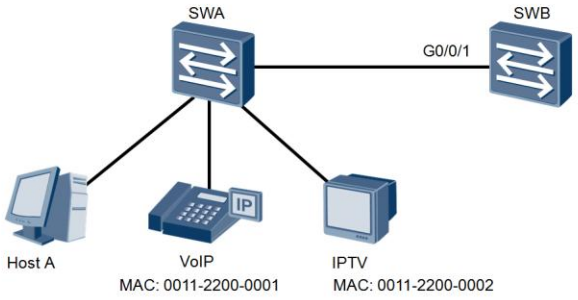
Switch port interfaces can use the *port hybrid untagged vlan* <*vlan-id*> [*to* <*vlan-id*>] command to apply the untagged behavior on a port interface for multiple VLANs in a single batch command. This behavior enables hybrid interfaces to permit the untagged forwarding of traffic from multiple VLANs to a given end system. All traffic forwarded from the end system is associated with the PVID assigned to the port and tagged respectively.

Configuration Validation

```
[SWB]display vlan
The total number of vlans is : 3
--------------------------------------------------------------
U:Up; D:Down; TG:Tagged; UT:Untagged; MP:Vlan-mapping; ST:Vlan-
stacking; #: ProtocolTransparent-vlan; *:Management-vlan;
--------------------------------------------------------------
VID  Type    Ports
--------------------------------------------------------------
1    common  UT:GE0/0/1(U) ......
2    common  UT:GE0/0/4(U)
3    common  UT:GE0/0/4(U)
4    ......
```


The command *port hybrid untagged vlan 2 to 3* on interface Gigabit Ethernet 0/0/4 results in the interface applying untagged behavior to both VLAN 2 and VLAN 3. This means that any traffic forwarded from a host associated with either VLAN, to an end system associated with Gigabit Ethernet interface 0/0/4, can be successfully received.

Voice VLAN Application

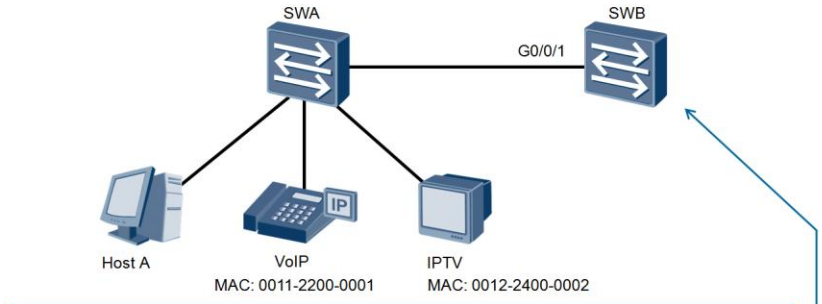


- Voice VLANs are used to distinguish, isolate and prioritize voice traffic over service traffic as a means of quality assurance.

The growth of IP convergence has seen the integration of multiple technologies that allows High Speed Internet (HSI) services, Voice over IP (VoIP) services, and Internet Protocol Television (IPTV) services to be transmitted over a common Ethernet & TCP/IP network. These technologies originate from networks consisting of different forms of behavior. VoIP originates from circuit switched network technologies that involve the establishment of a fixed circuit between the source and destination, over which a dedicated path is created, ensuring that voice signals arrive with little delay and in a first-in-first-out signal order.

High Speed Internet operates in a packet switched network involving contention, and packet forwarding with no guarantee of orderly delivery for which packet re-sequencing is often necessary. Guaranteeing that technologies originating from a circuit switched network concept are capable of functioning over packet switched networks has brought about new challenges. This challenge focuses on ensuring that the services are capable of differentiating voice data from other data. The solution involves VoIP traffic being isolated through different VLANs and being assigned a higher priority to ensure voice quality throughput. Special voice VLANs can be configured on the switch, which allows the switch to assign a pre-configured VLAN ID and a higher priority to VoIP traffic.

Voice VLAN Configuration




```
[SWB]vlan 2
[SWB-GigabitEthernet0/0/1]voice-vlan 2 enable
[SWB-GigabitEthernet0/0/1]voice-vlan mode auto
[SWB-GigabitEthernet0/0/1]quit
[SWB]voice-vlan mac-address 0011-2200-0000 mask ffff-ff00-0000
```


Configuration of the voice VLAN involves the configuring of a specified VLAN using the *voice-vlan <vlan-id> enable* command. The voice VLAN can be associated with any VLAN between 2 and 4094. The *voice-vlan mode <mode>* command specifies the working mode, by which a port interface is added to a voice VLAN. This is set by default to occur automatically however can be also achieved manually. The *voice-vlan mac-address <mac-address> mask <mask>* command allows voice packets originating from an IP phone to be identified and associated with the voice VLAN, based on the Organizationally Unique Identifier (OUI), to ultimately allow a higher priority to be given to voice traffic.

Configuration Validation

```
[SWB]display voice-vlan status
Voice VLAN Configurations:
------------------------------------------------------------
Voice VLAN ID            : 2
Voice VLAN status        : Enable
Voice VLAN aging time    : 1440(minutes)
Voice VLAN 8021p remark  : 6
Voice VLAN dscp remark   : 46
------------------------------------------------------------
Port Information:
------------------------------------------------------------
Port                     Add-Mode  Security-Mode  Legacy
------------------------------------------------------------
GigabitEthernet0/0/1     Auto      Security       Disable
```


The *display voice-vlan status* command allows voice VLAN information to be viewed, including the status, security mode, aging time, and the interface on which the voice VLAN function is enabled. The status determines whether the voice VLAN is currently enabled or disabled. The security-mode can exist in one of two modes, either normal or security. The normal mode allows the interface enabled with voice VLAN to transmit both voice data and service data, but remains vulnerable to attacks by invalid packets. It is generally used when multiple services (HSI, VoIP, and IPTV) are transmitted to a Layer 2 network through one interface, and the interface transmits both voice data and service data. The security mode applied on an interface enabled with voice VLAN checks whether the source MAC address of each packet that enters the voice VLAN matches the OUI. It is applied where the voice VLAN interface transmits ONLY voice data. The security mode can protect the voice VLAN against the attacks by invalid packets, however checking packets occupies certain system resources.

The Legacy option determines whether the interface can communicate with voice devices of other vendors, where an enabled interface permits this communication. The Add-Mode determines the working mode of the voice VLAN. In auto voice VLAN mode, an interface can be automatically added to the voice VLAN after the voice VLAN function is enabled on the interface, and adds the interface connected to a voice device to the voice VLAN if the source MAC address of packets sent from the voice device matches the OUI. The interface is automatically deleted if the interface does not receive any voice data packets from the voice device within the aging time. In manual voice VLAN mode, an interface must be added to the voice VLAN manually after the voice VLAN function is enabled on the interface.

Summary

- If a trunk link has a PVID of 5 and the command port trunk allow-pass vlan 2 3 is used, which VLAN traffic will be carried over the trunk?
- What action will be taken by an access port with a PVID of 2 when receiving an untagged frame?

1. The PVID on a trunk link defines only the tagging behavior that will be applied at the trunk interface. If the *port trunk allow-pass vlan 2 3* command is used, only frames associated with VLAN 2 and VLAN 3 will be forwarded over the trunk link.

2. An access port configured with a PVID of 2 will tag all received untagged frames with a VLAN 2 tag. This will be used by the switch to determine whether a frame can be forwarded via other access interfaces or carried over a trunk link.

Thank you

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GARP and GVRP

HUAWEI TECHNOLOGIES CO., LTD.

Foreword

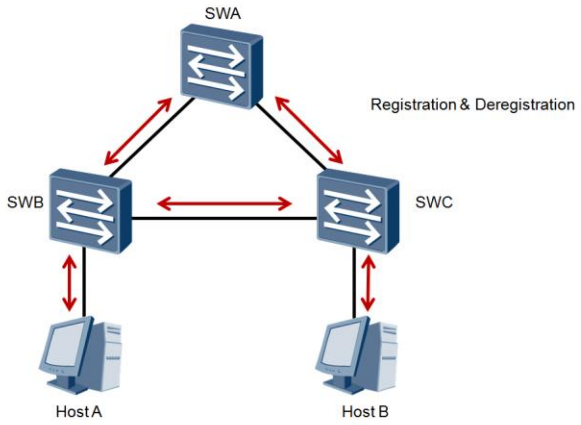
In networks with extensive numbers of devices, changes are at times required for certain attributes such as the implementation or removal of a VLAN. The manual configuration of each switch to recognize and support the new attribute may lead to extensive administration and the potential for human error. The Generic Attribute Registration Protocol (GARP) is used to define the architecture on which attributes can be propagated. The application of GARP, along with GVRP in support of VLAN technology, is introduced as a solution for optimized administration.

Objectives

Upon completion of this section, trainees will be able to:

- Describe the construct and messaging characteristics of GARP.
- Configure GVRP.

Generic Attribute Registration Protocol

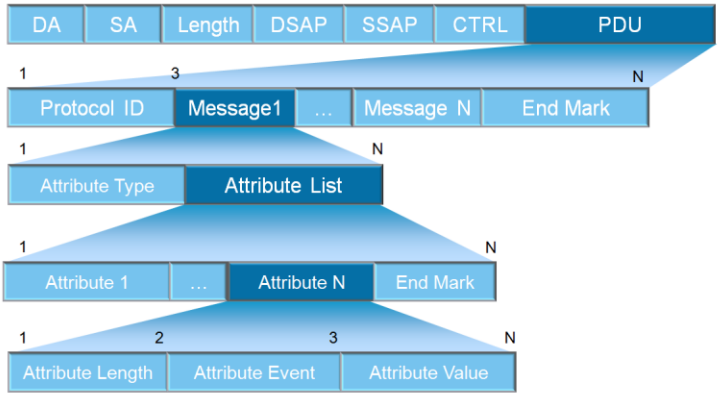


- A mechanism for the registration and deregistration of attributes.

The Generic Attribute Registration Protocol (GARP) is the architecture on which the registration, deregistration and propagation of attributes between switches is enabled. GARP is not an entity in itself but instead is employed by GARP applications such as GVRP to provide a shell on which the rules for operation are supported. Interfaces that are associated with GARP applications are considered to be GARP participants.

The primary application for GARP exists in allowing greater efficiency in the management of multiple switches in medium to large networks. In general the maintenance of multiple switches can become a huge burden on administrators when system configuration details for example need to be manually applied to each active switch. GARP helps to automate this process for any applications that are able to employ this capability. GARP generally relies on the spanning tree protocol to define an active topology for propagation, however the GVRP protocol can run only in the realm of the Common and Internal Spanning Tree (CIST).

GARP PDU Format

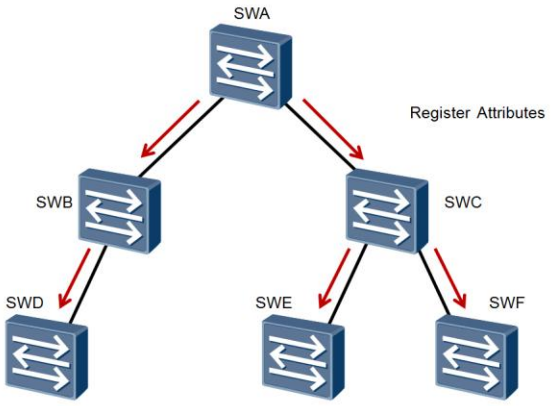


- Attributes are carried as lists within GARP PDU messages.

PDUs are sent from a GARP participant and use multicast MAC address 01-80-C2-00-00-21 as the destination MAC address. When a device receives a packet from a GARP participant, the device identifies the packet according to the destination MAC address of the packet and sends the packet to the corresponding GARP participant (such as GVRP). GARP uses messages within the PDU to define attributes that are identified based on an attribute type field and an attribute list.

The list contains multiple attributes for the specific attribute type and each attribute is described through attribute length, event and value fields. The length of the attribute can be anywhere from 2 to 255 bytes, the value specifies a particular value for the attribute and the event may be one of a number of specific events that the GARP supports represented by a value. These events include, 0: LeaveAll event, 1: JoinEmpty event, 2: JoinIn event, 3: LeaveEmpty event, 4: LeaveIn event, and 5: Empty event.

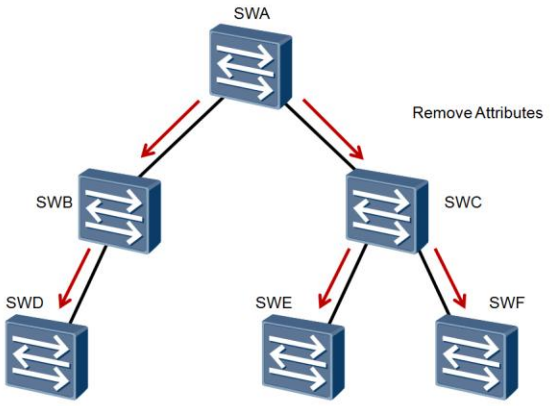
Attribute Events - Join Messages



- Registration of attributes is achieved using Join messages.

When a GARP participant expects other devices to register its attributes, it sends Join messages to other devices. When a GARP participant receives a Join message from another participant, or is statically configured with attributes, it sends Join messages to other devices to allow the devices to register the new attributes. Join messages are classified into JoinEmpty messages and JoinIn messages. JoinEmpty are used to declare an unregistered attribute, whereas JoinIn messages are used to declare a registered attribute.

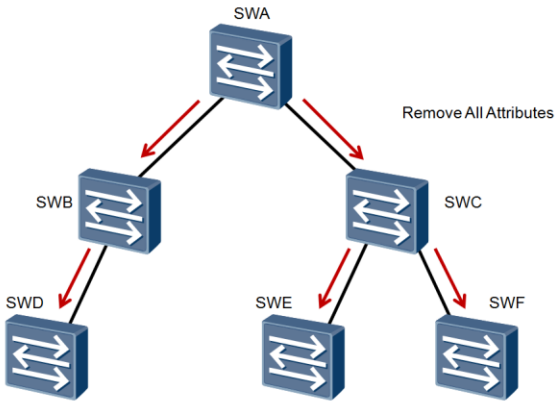
Attribute Events - Leave Messages



- Deregistration of select attributes relies on Leave messages.

Leave messages are used when a GARP participant expects other devices to deregister its attributes, it sends Leave messages to other devices. When the GARP participant receives a Leave message from another participant or some of its attributes are statically deregistered, it also sends Leave messages to other devices. Leave messages are classified into LeaveEmpty messages and LeaveIn messages. LeaveEmpty messages are used to deregister an unregistered attribute, whereas LeaveIn messages will deregister a registered attribute.

Attribute Events - Leave All Messages

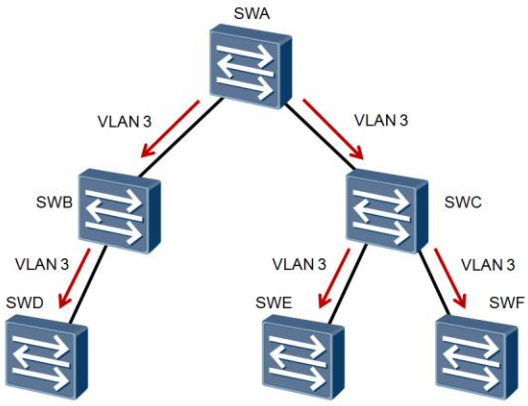


- Leave All messages remove all attributes of a sender.

Leave All messages are applied when a GARP participant when the participant wishes to request other GARP participants deregister all the attributes of the sender.

The Join, Leave, and Leave All messages are used to control registration and deregistration of attributes. Through GARP messages, all attributes that need to be registered are sent to all GARP-enabled devices on the same LAN.

GVRP

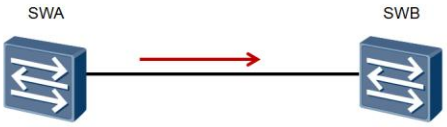


- Application for the propagation of VLAN registration information

GVRP is an application of GARP, and based on the working mechanism of GARP, GVRP maintains dynamic VLAN registration information in a device and propagates the registration information to other devices.

After GVRP is enabled on the switch, it can receive VLAN registration information from other devices, and dynamically update local VLAN registration information. VLAN registration information includes which VLAN members are on the VLAN and through which interfaces their packets can be sent to the switch. The switch can also send the local VLAN registration information to other devices. Through exchanging VLAN registration information, all devices on the same LAN maintain the same VLAN information. The VLAN registration information transmitted through GVRP contains both static local registration information that is manually configured and dynamic registration information from other devices.

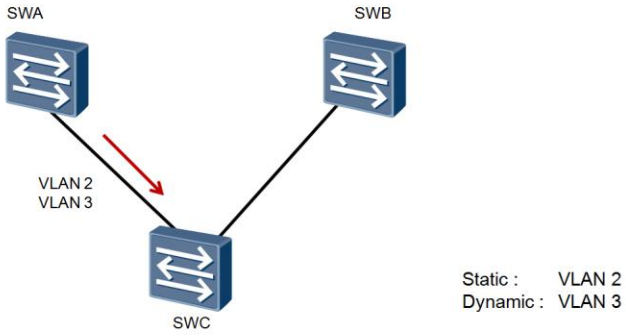
Registration Modes



- VLAN Types
  - Static
  - Dynamic
- Registration Modes
  - Normal
  - Fixed
  - Forbidden

Registration can be achieved either statically or dynamically for a VLAN within the device. A manually configured VLAN is a static VLAN, and a VLAN created through GVRP is a dynamic VLAN. They way in which registration is performed is dependant on the registration mode that has been configured. There are three registration modes that can be set, which includes normal, fixed and forbidden registration modes.

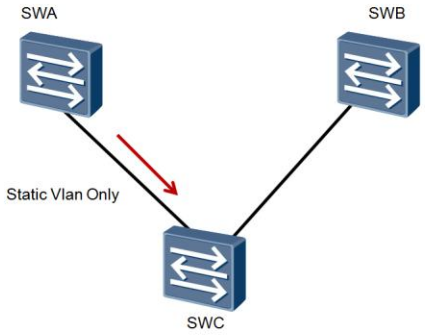
Registration Modes - Normal



- Permits the registration of both static and dynamic VLANs on a port interface.

In the normal registration mode, the GVRP interface can dynamically register and deregister VLANs, and transmit both dynamic VLAN registration information and static VLAN registration information.

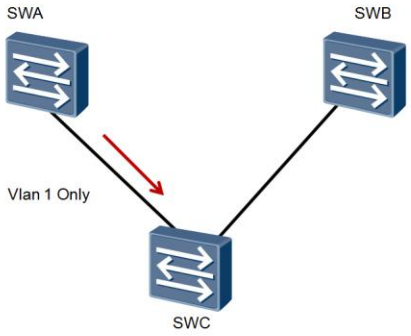
Registration Modes - Fixed



- Registration or deregistration of dynamic VLANs is restricted
- Port interface only sends declaration of static VLANs.

In the fixed mode, the GVRP interface is restricted from dynamically registering and deregistering VLANs and can transmit only the static registration information. If the registration mode of a trunk interface is set to fixed, the interface allows only the manually configured VLANs to pass, even if it is configured to allow all VLANs to pass.

Registration Modes - Forbidden



- All VLANs with the exception of VLAN 1 are deleted from the port, and all ports can only send declarations of VLAN 1.

In the forbidden mode, the GVRP interface is disabled from dynamically registering and deregistering VLANs and can transmit only information about VLAN 1. If the registration mode of a trunk interface is set to forbidden, the interface allows only VLAN 1 to pass even if it is configured to allow all VLANs to pass.

Enabling GVRP


```
[SWA]gvrp
[SWA]interface Gigabitethernet 0/0/1
[SWA-GigabitEthernet0/0/1]port link-type trunk
[SWA-GigabitEthernet0/0/1]port trunk allow-pass vlan all
[SWA-GigabitEthernet0/0/1]gvrp
[SWA-GigabitEthernet0/0/1]gvrp registration fixed
```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The configuration of GVRP relies on the protocol attribute being firstly enabled in the system-view before it can be applied at an interface-view. The command *gvrp* is used to enable GVRP on the device. Once an interface has been configured to operate as part of the VLAN, GVRP can be applied to the interface using the *gvrp* command at the interface-view. The registration mode can also be applied using the *gvrp registration* <*mode*> command where the mode may be either normal, fixed, or forbidden. The registration mode is set as normal by default.

GVRP Status

```
[SWA]display gvrp status
 GVRP is enabled
[SWA]display gvrp statistics
  GVRP statistics on port GigabitEthernet0/0/1
    GVRP status                          : Enabled
    GVRP registrations failed            : 0
    GVRP last PDU origin                 : 0000-0000-0000
    GVRP registration type               : Fixed
```


Verifying the configuration for GVRP involves entering the *display gvrp status* command. This will simply identify whether GVRP has been enabled on the device. The *display gvrp statistics* command can provide a little more information regarding the configuration for each interface (participant) that is currently active in GVRP. From the example, it is possible to identify the current status of GVRP on the interface and also the registration type that has been defined in relation to the interface.

Summary

- What is the default registration mode used by GVRP?
- What is necessary in order to allow the VLAN information to be propagated over the links between each of the GVRP capable devices?

1. The normal registration mode is used by default.

2. The ports for the links between each of the devices supporting GVRP must be established as VLAN trunk ports in order to allow the VLAN information to be propagated.

Thank you

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VLAN Routing

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Foreword

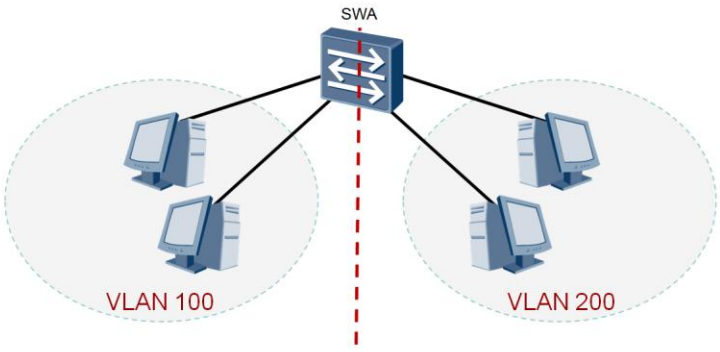
The implementation of VLAN technology within an enterprise network effectively establishes broadcast domains that control the scope of traffic. One of the limitations of broadcast domains is that communication at the link layer is hindered between hosts that are not part of the same VLAN. Traditional link layer switches supporting VLANs are not capable of forwarding traffic between these broadcast domains, and therefore routing must be introduced to facilitate communication. The application of VLAN routing when using link layer switches, together with a device capable of routing VLAN traffic is introduced, along with details of how layer three switches capable of network layer operations can enable communication over VLAN defined broadcast domains.

Objectives

Upon completion of this section, trainees will be able to:

- Explain the purpose of VLAN routing.
- Explain how VLAN routing is achieved for layer 2 & layer 3 switches.
- Configure VLAN routing.

VLAN Disadvantages

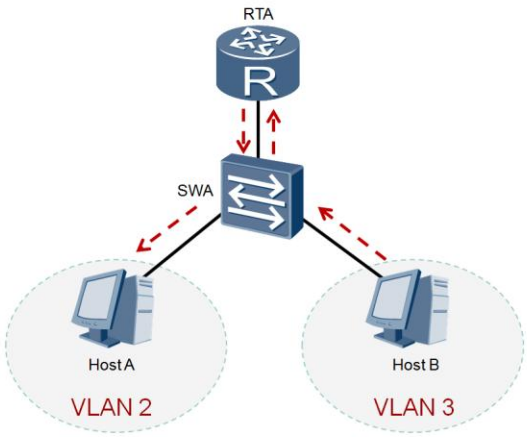


- Attempts to limit broadcast domain size through VLAN implementation isolates users.

The general principle of VLAN implementation is to isolate networks as a means of minimizing the size of the existing broadcast domain, however in doing so, many users are cut off from other users within other VLAN domains and require that layer three (IP) communication be established in order for those broadcast domains to re-establish communication through reachable routes. The implementation of a layer three switch offers an ideal means for supporting VLAN routing whilst reducing operating costs. One of the constraints however of VLAN routing is the need for strict IP address management.

Generally however the VLAN routing principle is applicable to small scale networks on which users belong to different network segments and IP addresses of users are seldom changed.

VLAN Routing

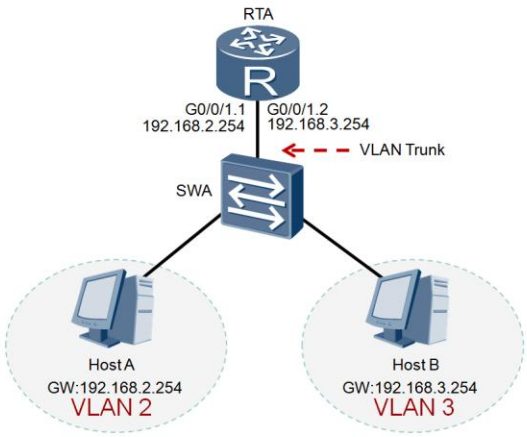


- VLAN frames are routed over a trunk link for port conservation.

After VLANs are configured, the hosts in different VLANs are unable to directly communicate with each other at Layer 2. It is therefore necessary to facilitate the communication through the creation of routes between VLANs. There are generally two main methods via which this is achieved, the first relies on the implementation of a router connected to the layer 2 switch. VLAN communication is then routed through the router before being forwarded to the intended destination. This may be over separate physical links, which leads to port wastage and extra link utilization, or via the same physical interface as shown in the example.

The second method relies on the use of a layer 3 switch that is capable of performing the operation of both the switch and the router in one single device as a more cost effective mechanism.

VLAN Routing Features

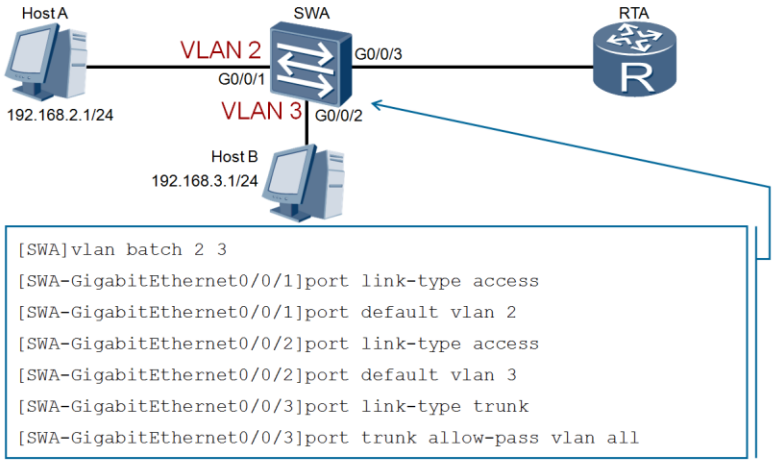


- A single trunk supports VLAN routes by using sub-interfaces.

In order to allow communication over a single trunk interface, it is necessary to logically segment the physical link using sub-interfaces. Each sub-interface represents a logical link for the forwarding of VLAN traffic before being routed by the router via other logical sub-interfaces to other VLAN destinations. Each sub-interface must be assigned an IP address in the same network segment as the VLAN that it is created for as well as 802.1Q encapsulation to allow for VLAN association as traffic is routed between VLANs.

It is also necessary to configure the type of the Ethernet port of the switch that connects to the router as either a Trunk or Hybrid link type, and allow frames of the associated VLANs (VLAN 2 & VLAN 3 in this case) to pass.

VLAN Routing Configuration



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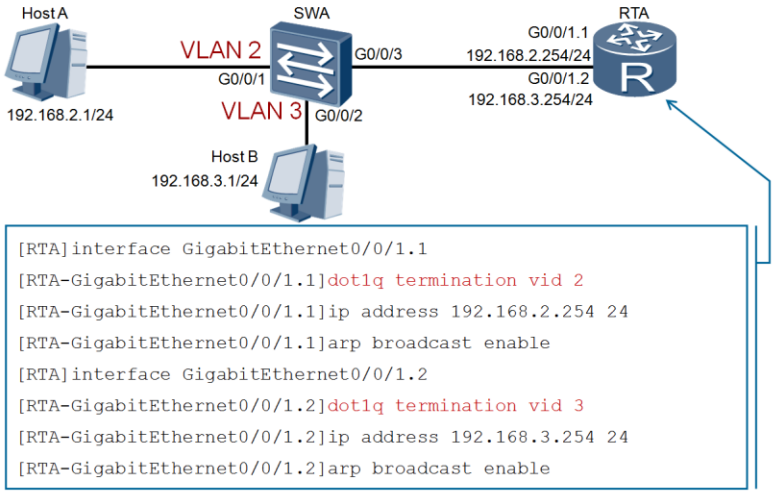
The trunk link between the switch and the router must be established for support of traffic for multiple VLANs, through the port link-type trunk or port link-type hybrid command as well as the port trunk allow-pass vlan 2 3 or port hybrid vlan 2 3 command respectively. Once the trunk is established, the VLAN sub-interfaces must be implemented to allow the logical forwarding of traffic between VLANs over the trunk link.

VLAN Routing Configuration



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The sub-interface on a router is defined in the interface view using the interface <*interface-type interface-number.sub-interface number*> command where the sub-interface number represents the logical interface channel within the physical interface. The command *dot1q termination vid* <*vlan-id*> is used to perform two specific functions. Where a port receives a VLAN packet, it will initially remove the VLAN tag from the frame and forward this packet via layer three routing.

For packets being sent out, the port adds a tag to the frame before sending it out, in accordance with the respective VLAN and IP settings for the router's logical interface. Finally the *arp-broadcast enable* command is applied to each logical interface. This is necessary as the capability for ARP to broadcast on sub-interfaces is not enabled by default. If ARP broadcasts remain disabled on the sub-interface, the router will directly discard packets. The route to the sub-interface generally is considered as a blackhole route in these cases since the packet is effectively lost without a trace. If ARP broadcasts are enabled on the sub-interface, the system is able to construct a tagged ARP broadcast packet and send the packet from the sub-interface.

VLAN Routing Configuration

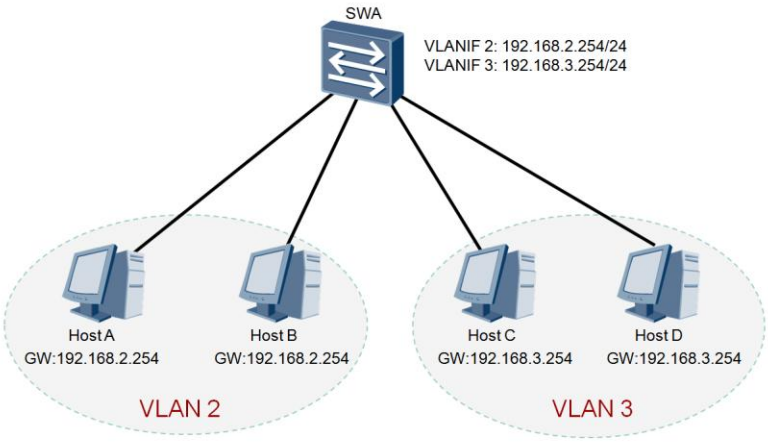
```
HostA>ping 192.168.3.1

Ping 192.168.3.1: 32 data bytes, Press Ctrl_C to break
From 192.168.3.1: bytes=32 seq=1 ttl=127 time=15 ms
From 192.168.3.1: bytes=32 seq=2 ttl=127 time=15 ms
From 192.168.3.1: bytes=32 seq=3 ttl=127 time=32 ms
From 192.168.3.1: bytes=32 seq=4 ttl=127 time=16 ms
From 192.168.3.1: bytes=32 seq=5 ttl=127 time=31 ms

--- 192.168.3.1 ping statistics ---
  5 packet(s) transmitted
  5 packet(s) received
  0.00% packet loss
  round-trip min/avg/max = 15/21/32 ms
```


Following the configuration of VLAN routing between VLAN 2 and VLAN 3, the ping application can be used to verify reachability. The example demonstrates how Host A (192.168.2.2) in VLAN 2 is capable of reaching Host B (192.168.3.2) in VLAN 3. The TTL reflects that the packet has traversed the router to reach the destination in VLAN 2.

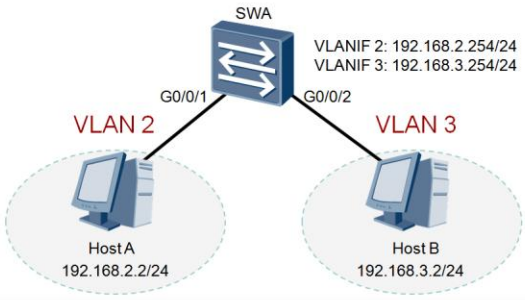
L3 Switch based VLAN Routing



- VLANIF are used by each VLAN as a route gateway.

The implementation of L3 switches brings about benefits to the process of VLAN routing that are not possible through the use of a router. One of those features is the ability to forward VLAN traffic with very little delay due to support of what is known as line speed forwarding as a result of bottom layer ASIC chips that allow traffic to be forwarded based on hardware rather than software. Along with this is the fact that a single device is used with no trunk link that may otherwise face congestion under heavy traffic loads. VLAN routing when using a layer 3 switch relies on the implementation of VLAN interfaces (VLANIF). If multiple users on a network belong to different VLANs, each VLAN requires a VLANIF that acts as the VLAN gateway and so must associate with an IP address relevant to the network of the VLAN. If a large number of VLANs exist however, this can tally up to a large number of IP addresses being required to support each VLANIF, as well as the hosts that are part of the VLAN with which the VLANIF is associated. Through the VLANIF, routing between different VLANs can be supported.

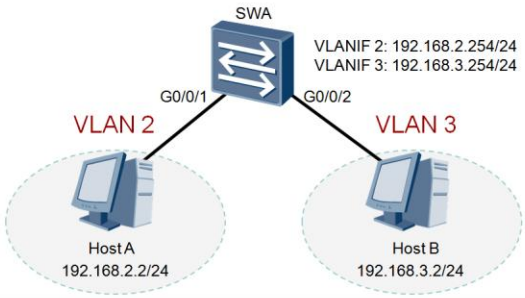
L3 Switch Configuration




```
[SWA]vlan batch 2 3
[SWA-GigabitEthernet0/0/1]port link-type access
[SWA-GigabitEthernet0/0/1]port default vlan 2
[SWA-GigabitEthernet0/0/2]port link-type access
[SWA-GigabitEthernet0/0/2]port default vlan 3
```

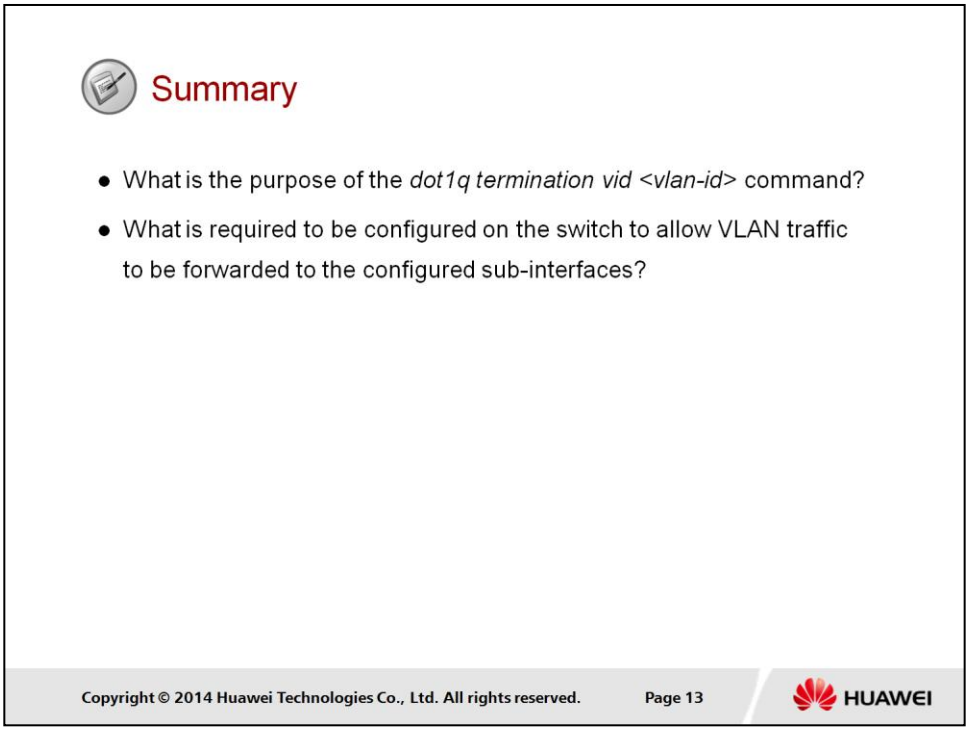

Configuration of VLAN routing on a switch operating at layer 3 requires that the VLANs be initially created and the interfaces be assigned to those respective VLANS. The configuration follows the principles for configuration of VLANs covered as part of the VLAN principles. This involves defining the port link-type for each port and the PVID that is associated with each port interface.

L3 Switch Configuration




```
[SWA]interface vlanif 2
[SWA-Vlanif2]ip address 192.168.2.254 24
[SWA-Vlanif2]quit
[SWA]interface vlanif 3
[SWA-Vlanif3]ip address 192.168.3.254 24
[SWA-Vlanif3]quit
```


Configuration of VLAN routing is implemented by creating VLAN interfaces that are to operate as gateway interfaces for each VLAN within the layer 3 switch. Entering the VLANIF view is achieved via the *interface vlanif <vlan-id>* command, where the *vlan-id* refers to the associated VLAN. The IP address for the interface should be in the same network segment as the hosts. This IP address shall represent the gateway for the hosts and support the inter-VLAN communication.



1. The *dot1q termination vid <vlan-id>* command is used to perform two specific functions. Where a port receives a VLAN packet, it will initially remove the VLAN tag from the frame and forward this packet via layer 3 routing. For packets being sent out, the port adds a tag to the packet before sending it out, in accordance with the respective VLAN and IP settings for the routers logical interface.

2. The switch must be configured to allow frames carried over the switch/router medium to be tagged, either through the use of the trunk command or using tagged hybrid interfaces. Additionally the VLAN traffic must be permitted over this link using the port trunk allow-pass vlan <vlan> or port hybrid tagged vlan <vlan> command.

Thank you

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Wireless LAN Overview

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Foreword

Wireless local area networks (WLAN) represent a natural evolution of the fixed Ethernet network as a solution to demands for flexible and mobile business environments. WLAN applies radio frequency (RF) technology to the enterprise Ethernet network, and governed primarily by standards defined by the IEEE standards organization. A general understanding of WLAN requires a principle knowledge of these standards as well as the benefits that WLAN technology brings to the enterprise network. This section provides a brief overview of WLAN technology and its application in an enterprise, as a considerable solution to providing benefits to an existing enterprise network infrastructure.

Objectives

Upon completion of this section, trainees will be able to:

- Explain the basic application of WLAN in the enterprise network.
- Describe the benefits that WLAN introduces to the enterprise network.

Development of WLAN

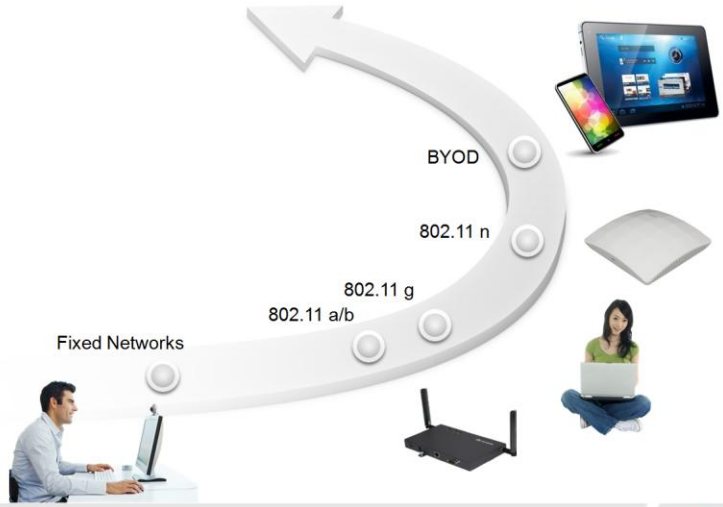
- Wireless networks and mobile equipment have allowed for the evolution of a more efficient work environment.

The Wireless Local Area Network (WLAN) is seen as a rapidly developing future network technology, to which many enterprise networks are gradually transitioning towards, with the expectation that wired Ethernet networks used today as the primary network infrastructure in nearly all enterprise businesses will eventually be superseded by WLAN solutions, and provide reliable ubiquitous access.

Recent evolutions in technology have introduced a need for change in the way in which enterprise industries operate, as a wave of tablet computing and smart mobile device usage paves the way for Bring Your Own Device (BYOD) solutions, in which users enhance their work capability through personal devices, for which in most cases, wired Ethernet connectivity is not supported. Additionally, many new challenges are faced by wireless networks in terms of supporting a greater density of devices in the enterprise network as well as providing media based (voice & video) support without signal loss or periodic connection outages, and providing non intrusive security to users.

Wireless networks continue to play a secondary role to wired networks but with the constant push to change the way enterprise networks support users, it is expected that WLAN will continue to play an increasingly dominant role throughout all enterprise industries.

Wireless Local Area Network Evolution



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The evolution of enterprise networks involving WLAN have undergone three general phases since the 1980's, from fixed office, to supporting early mobile office solutions through the use of standalone access points (AP) that provided only limited coverage and mobility for users, to a more centralized form of WLAN involving management of multiple (thin) AP clients by a central controller.

Standards growth has also enabled the support of different services initially supporting only data throughput, however as the capacity of the Ethernet wired network continues to develop, it is generally expected that the WLAN be capable of supporting the same services. The capacity to support services such as real time traffic for voice and video require increasing amounts of bandwidth to which new 802.11 standards are developed to support, absorbing an increasingly larger amount of the 2.4GHz spectrum in order to do so.

With the introduction of BYOD, new challenges to WLAN are faced to ensure density of devices are supported with suitable bandwidth and connection reliability for supported applications, whilst defending the enterprise network against malicious entities including spyware and malware.

IEEE 802.11 Standards

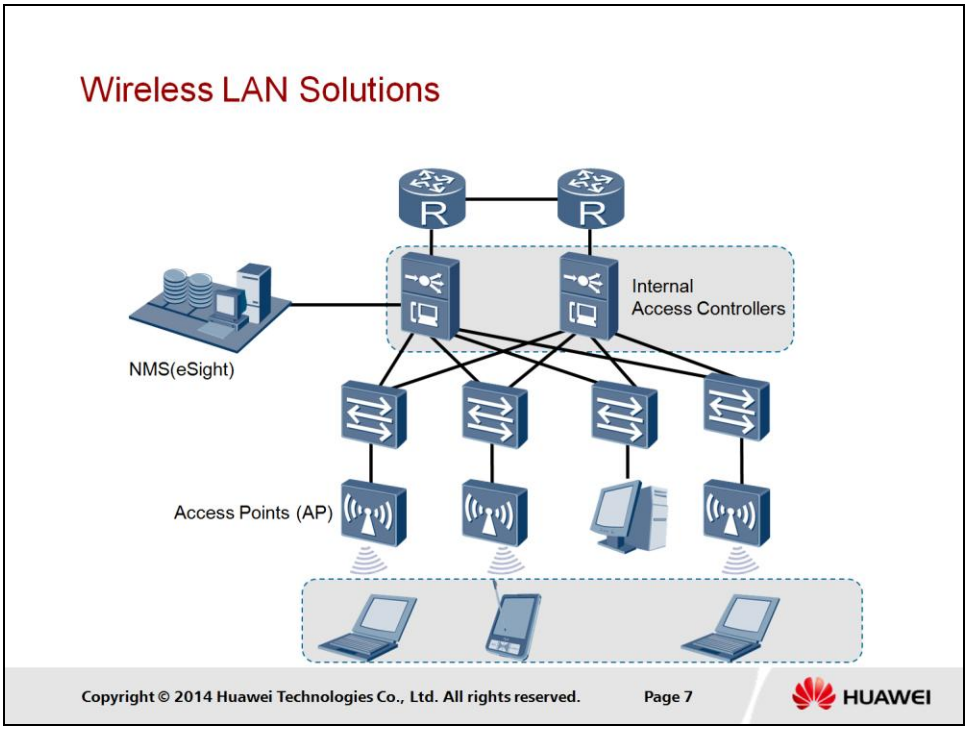
Version	Year	Frequency Band	Rate
802.11	1997	2.4 GHz	2 Mbps
802.11 a	1999	5 GHz	54 Mbps
802.11 b	1999	2.4 GHZ	11 Mbps
802.11 g	2003	2.4 GHz	54 Mbps
802.11 n	2009	2.4 GHz 5 GHz	600 Mbps
802.11 ac	2013	5 GHz	> 1 Gbps

- IEEE 802.11 defines the standards for wireless networks.

IEEE 802.11 represents the working group that supports the development of all Wireless LAN standards, originating in 1997 with initial standards that worked within a 2.4GHz range and relatively low frequency rates of up to 2Mbps. The evolution of standards saw the introduction of the 802.11a and 802.11b standards which operated under the 5GHz and 2.4GHz signal bands respectively.

Each of these standards provides a variation in signal range, and due to increased signal fading in the 5GHz signal band, strong adaptation has been towards 2.4GHz which generally provides a greater range of transmission, as such allowing for the deployment of fewer access points (AP) over a broader range.

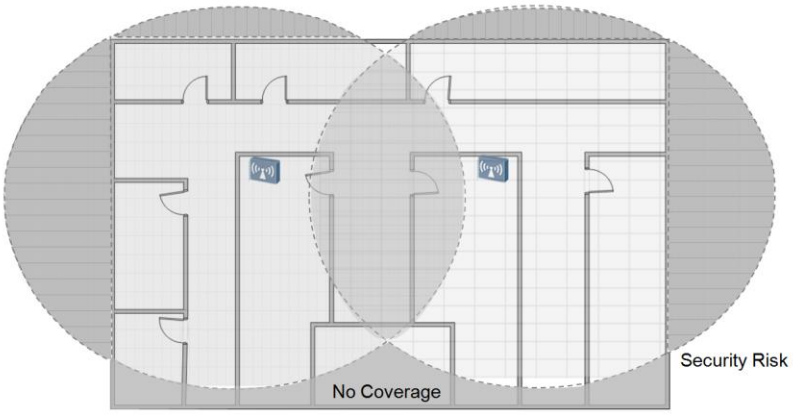
Over time however the 2.4GHz band has become increasingly crowded, making interference ever more likely where transmission is concerned. In addition, an increased rate requires a larger portion of the frequency spectrum for which it has become increasingly difficult to accommodate, for within the 2.4GHz band. This has seen in recent years a transition to a less crowded 5GHz band where frequency ranges for higher rates can be accommodated, at the cost however of the transmission range, resulting from attenuation that naturally affects the 5GHz band.



Wireless network deployment solutions over existing Ethernet networks commonly apply a two-layer architecture that is capable of meeting customer requirements, with minimal impact to the physical structure of the enterprise campus.

Access Controllers (AC) are deployed at the core layer of the network and operate, in what is known as bypass mode, as a general practice. This means that access controllers that manage the access points are not directly connected to each AP that they manage, mainly to allow for a wireless network overlay to be achieved whilst minimizing physical change to the existing enterprise network architecture.

Wireless Coverage



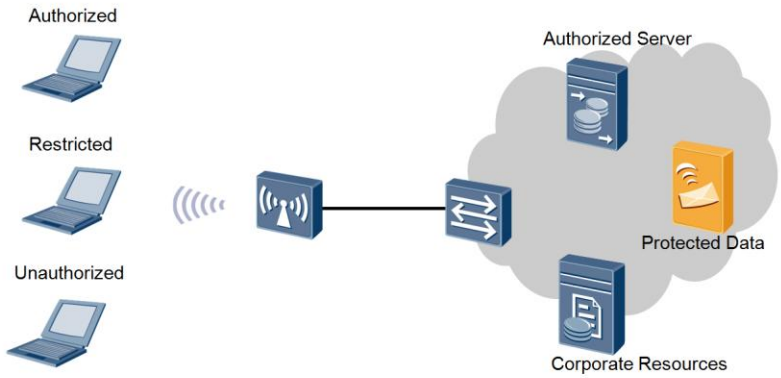
- Overlapping signals provides continuity of coverage.

Each Access Point (AP) within a wireless local area network is designed to provide a level of coverage that encompasses the surrounding area of the established enterprise campus. A single AP is considered to have a finite range that may vary depending on a number of factors and objects that are capable of interfering with the general signal range, through imposing greater attenuation to, or refraction of signals.

Wireless coverage is generally extended therefore by implementing multiple AP that operate as cells, with overlapping cell ranges to allow users to effectively hop between each AP as the user becomes mobile within the area in which coverage is provided. Any good wireless deployment should allow for complete coverage over an entire campus with eradication of any grey areas or black spots where WLAN coverage may suddenly be lost.

Another important factor involving wireless coverage is the issue of security. Unlike wired Ethernet connections, the scope of a wireless networks may extend beyond the physical boundaries of the building or site in which the network is intended, allowing for potential access to resources from unknown external users without authority, therefore imposing a great risk to the integrity of the network.

Wireless LAN Security



- Network Access Control (NAC) is used to manage user access.

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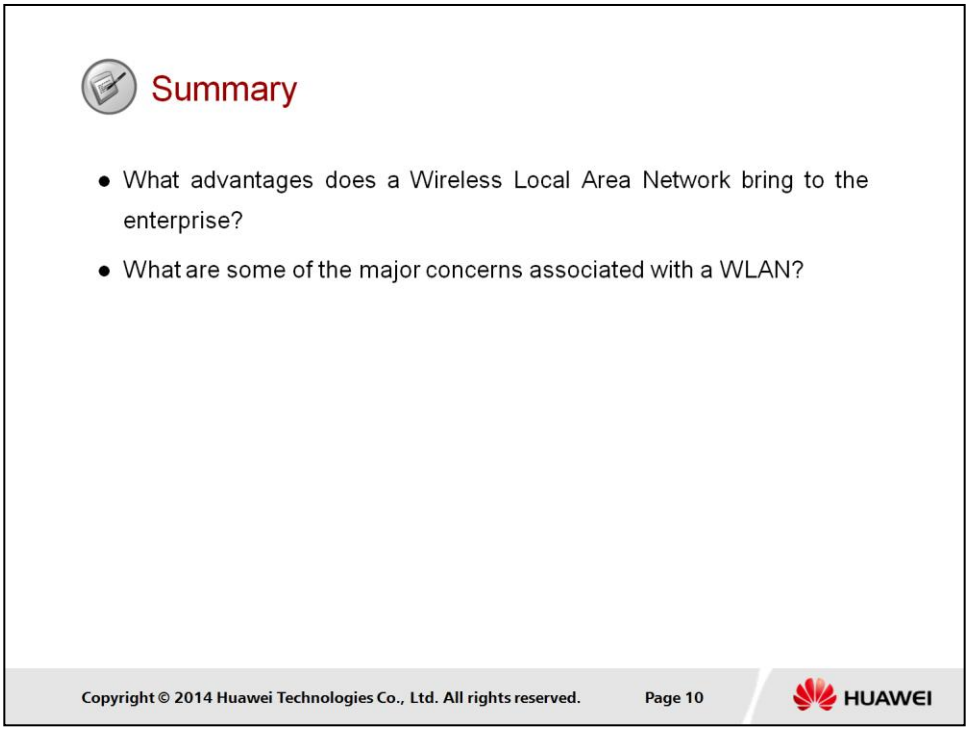
Multiple security mechanisms have been devised for maintaining the overall integrity of the wireless enterprise. The implementation of perimeter security as a means of protecting 802.11 networks from threats such as implementation of unauthorized APs and users, ad-hoc networks, and denial of service (DoS) attacks is an example of a typical wireless solution.

A wireless intrusion detection system (WIDS) can be used to detect unauthorized users and APs. A wireless intrusion prevention system (WIPS) can protect an enterprise network against unauthorized access by wireless network devices such as a rogue AP.

User access security is another common solution where link authentication, access authentication, and data encryption are used as forms of Network Access Control (NAC) to ensure validity and security of user access on wireless networks, essentially managing user access based on defined permissions. Service security is another feature that may also be implemented to protect service data of authorized users from being intercepted by unauthorized users during transmission.



1. A growing majority of employees require mobility within an enterprise network as part of daily work procedures, whether for meetings or collaboration, which fixed line networks generally limit. Adoption of WLAN allows for greater mobility and also flexibility in the number of users connecting to the enterprise network.

2. With flexibility of access comes a greater need for security to monitor user access and prevent sensitive information being accessed from within the network. As a greater number of employees begin to rely on personal devices and connect to the enterprise network over the WLAN, the potential for viruses, malware and spyware amongst others, becomes a greater potential threat to the network as a whole.

   As the need to support a growing number of services and users, greater bandwidth is required which translates to a larger wireless spectrum requiring to be adopted by standards. The 5GHz bandwidth has begun to take a prominent role in newer standards due to spectrum limitations in the 2.4GHz range, which results in a shorter range in AP signal transmissions for future standards.

Thank you

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Bridging Enterprise Networks with Serial WAN Technology

HUAWEI TECHNOLOGIES CO., LTD.

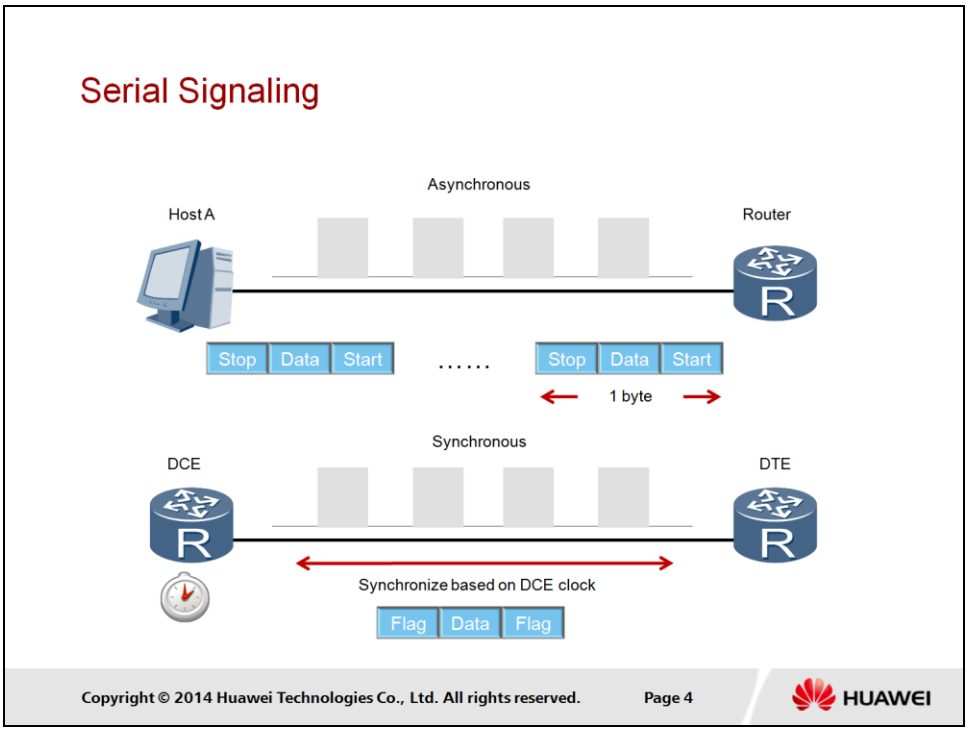
Foreword

Serial has in recent years been slowly phased out in many parts of all networks in favor of Ethernet technology, however still remains active as a legacy technology in a great number of enterprise networks alongside Ethernet. Serial has traditionally provided solutions for communication over long distances and therefore remains a prominent technology for Wide Area Network (WAN) communication, for which many protocols and legacy WAN technologies remain in operation at the enterprise edge. A thorough knowledge of these technologies is required to support many aspects of WAN operation.

Objectives

Upon completion of this section, trainees will be able to:

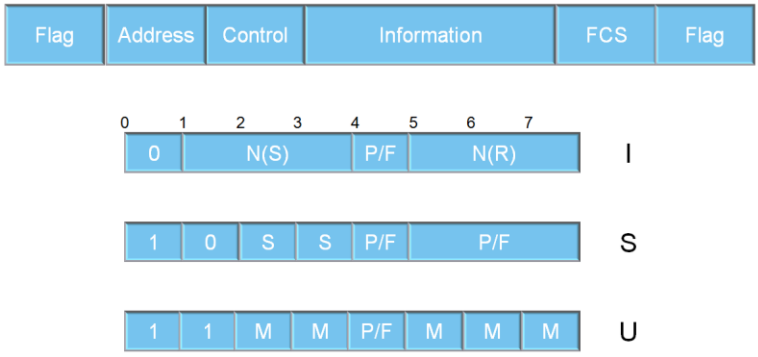
- Explain how data is carried over a serial based medium.
- Configure link layer protocols for serial links.



Serial connections represent a form of legacy technology that has commonly been used for the support of Wide Area Network (WAN) transmissions. The transmission of data as electrical signals over a serial link again requires a form of signaling to control the sending and receiving of frames as found with Ethernet. Serial connections define two forms of signaling that may be used for synchronization of transmissions, known as Asynchronous and Synchronous communication. Asynchronous signaling works on the principle of sending additional bits referred to as start and stop bits with each byte or frame to allow the receiving node to be aware of the incoming frame, and thus periodically reset the timing between frames to ensure that the rates between transmission and reception are maintained. The start bit is always represented as a 0 bit value while the stop bit represents a 1 bit value. One of the main concerns with this signaling method is the additional overhead as a result for each frame delivered, with the start and stop bits representing a large percentage of the frame overall. This method however is commonly associated with technologies such as Asynchronous Transfer Mode (ATM), a form of cell switching technology that generates fixed sized frames (cells) of 53bytes as a means of supporting lower jitter through minimizing queue processing times, making it ideal for real time communication such as voice, but has begun to make way for newer technologies such as MPLS switching and due to the loss of it's advantage over the frame processing speeds that are now possible with routers and switches.

Synchronous serial connections rely on a clocking mechanism between the peering devices in which one side (DCE) provides the clocking to synchronize communication. This clocking is maintained through the carrying of clocking information between the sender and receiver as part of the data signal.

The HDLC Protocol



- Only the information frame (I) format is used on AR2200 series

The High-level Data Link Control (HDLC) is a bit-oriented data link protocol that is capable of supporting both synchronous and asynchronous data transmissions. A complete HDLC frame consists of the Flag fields that are used to mark the start and end of a HDLC frame, often as 01111110, or 01111111 when a frame is to be suddenly aborted and discarded. An address field supports multipoint situations where one or multiple secondary terminals communicate with a primary terminal in a multipoint (multidrop) topology known as unbalanced connections, as opposed to the more commonly applied balanced (point to point) connections. The control field defines the frame type as either information, supervisory or unnumbered, and frame check sequence (FCS) field for ensuring the integrity of the frame.

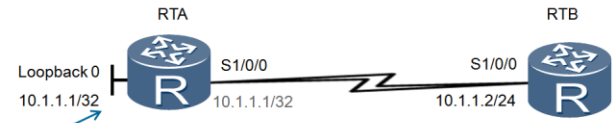
Of the control field frame types, only the information frame type is supported by Huawei ARG3 series routers and is used to carry data. The information frame type carries send N(S) and receive N(R) sequence numbers, as well as Poll and Final bits (P/F) for communicating status between primary and secondary stations. Supervisory frame types in HDLC are used for error and flow control and unnumbered frame types are used to manage link establishment for example between primary and secondary stations.

Basic Configuration of HDLC


```
[RTA]interface Serial 1/0/0
[RTA-Serial1/0/0]link-protocol hdlc
Warning: The encapsulation protocol of the link will be changed.
Continue? [Y/N]:y
[RTA-Serial1/0/0]ip address 10.0.1.1 30
```


Establishment of HDLC as the link layer protocol over serial connections requires simply that the link protocol be assigned using the *link-protocol hdlc* command under the interface view for the serial interface that is set to use the protocol. The configuration of the link protocol must be performed on both peering interfaces that are connected to the point to point network before communication can be achieved.

Assigning Unnumbered Addresses in HDLC




```
[RTA]interface Serial 1/0/0
[RTA-Serial1/0/0]link-protocol hdlc
Warning: The encapsulation protocol of the link will be changed.
Continue? [Y/N]:y
[RTA-Serial1/0/0]ip address unnumbered interface loopBack 0
```

- IP addresses can be borrowed from another interface in order to establish connectivity over the serial link.

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When an interface has no IP address, it cannot generate routes or forward packets. The IP address unnumbered mechanism allows an interface without an IP address to borrow an IP address from another interface. The IP address unnumbered mechanism effectively enables the conservation of IP addresses, and does not require that an interface occupy an exclusive IP address all of the time. It is recommended that the interface that is assigned as the interface from which the unnumbered IP address is borrowed be a loopback interface since this type of interface is more likely to be always active and as such supply an available address.

When using an unnumbered address, a static route or dynamic routing protocol should be configured so that the interface borrowing the IP address can generate a route between the devices. If a dynamic routing protocol is used, the length of the learned route mask must be longer than that of the lender's IP address mask, because ARG3 series routers use the longest match rule when searching for routes. If a static route is used and the IP address of the lender uses a 32-bit mask, the length of the static route mask must be shorter than 32 bits. If a static route is used and the IP address of the lender uses a mask less than 32 bits, the length of the static route mask must be longer than that of the lender's IP address mask.

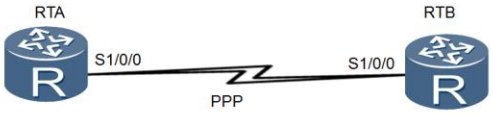
Configuration Validation

```
[RTA]display ip interface brief
*down: administratively down ^down: standby (l): loopback
(s): spoofing
……
Interface                  IP Address/Mask    Physical   Protocol
LoopBack0                  10.1.1.1/32          up         up(s)
Serial1/0/0                10.1.1.1/32          up         up
Serial1/0/1                unassigned           up         down
```

- The IP address is shown to have been borrowed from the loopback interface and assigned to interface serial 1/0/0.

Through the *display ip interface brief* command, a summary of the address assignment is output. In the event of assigning an unnumbered address, the address value will display as being present on multiple interfaces, showing that the IP address has been successfully borrowed from the logical loopback interface for use on the physical serial interface.

PPP Protocol Application



- A multiprotocol standard used as with HDLC to define the link layer operation over a serial medium.

The Point-to-Point Protocol (PPP) is a data link layer protocol that encapsulates and transmits network layer packets over point-to-point (P2P) links. PPP supports point-to-point data transmission over full-duplex synchronous and asynchronous links.

PPP is built upon the Serial Line Internet Protocol (SLIP). PPP supports both synchronous and asynchronous links, whereas other data link layer protocols such as Frame Relay (FR) support only synchronous links. PPP is an extensible protocol, facilitating the extension of not only IP but also other protocols and is capable of supporting the negotiation of link layer attributes. PPP supports multiple Network Control Protocols (NCP) such as the IP Control Protocol (IPCP) and Internetwork Packet Exchange Control Protocol (IPXCP) to negotiate the different network layer attributes. PPP provides the Password Authentication Protocol (PAP) and Challenge Handshake Authentication Protocol (CHAP) for network security authentication. PPP has no retransmission mechanism, reducing the network cost and speeding up packet transmission.

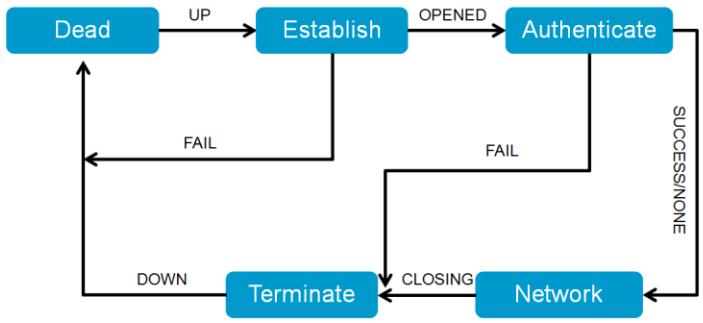
Components of PPP

Name	Function
PPP Encapsulation Method	Defines the format to be used when supporting encapsulation of upper layer protocols such as IP, IPX etc.
Link Control Protocol	Defines the method of establishing, configuring, and testing the data-link connection
Network Control Protocol	Defines a set of protocols for establishing a connection and negotiating parameters for different network-layer protocols

PPP encapsulation provides for multiplexing of different network-layer protocols simultaneously over the same link however in today's networks, the capability of PPP requires generally an IP only solution. The versatility of PPP to accommodate a variety of environments is well supported through Link Control Protocol (LCP). In order to establish communications over a point-to-point link, each end of the PPP link must first send LCP packets to configure and test the data link. More specifically LCP is used to negotiate and establish agreement for encapsulation format options, manage the MRU of packets, detect a looped-back link through magic numbers and determine errors in terms of parameter misconfigurations, as well as terminate an established link. Peer authentication on the link, and determination of when a link is functioning properly and when it is failing represent other optional facilities that are provided by LCP.

After the link has been established and optional facilities have been negotiated as required by the LCP component of PPP, NCP packets must then be sent to choose and configure one or more network-layer protocols. Typical IP based Network Control Protocols enable features such as address configuration (IPCP), and (van Jacobson) compressed TCP/IP.

PPP Link Establishment Process



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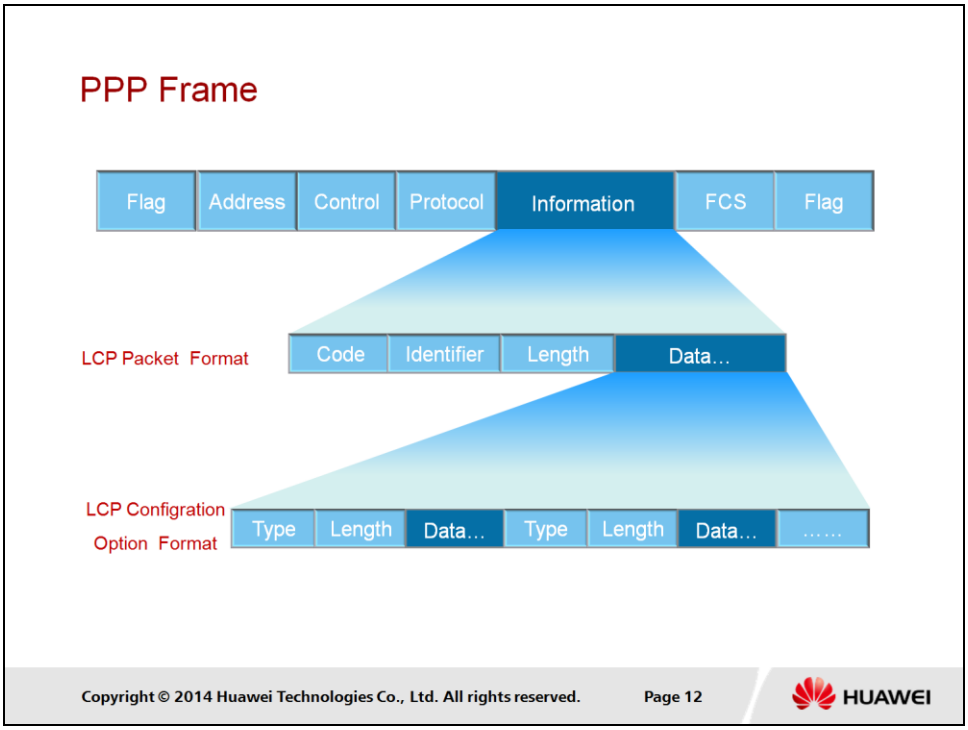
This initiation and termination of a PPP link begins and ends with the dead phase. When two communicating devices detect that the physical link between them is activated (for example, carrier signals are detected on the physical link), PPP will transition from the Dead phase into the Establish phase. In the Establish phase, the two devices perform an LCP negotiation to negotiate the working mode as either single-link (SP) or multi-link (MP), the Maximum Receive Unit (MRU), authentication mode etc.

If the authentication mode is defined, the optional Authenticate phase will be initiated. PPP provides two password authentication modes: PAP authentication and CHAP authentication. Two CHAP authentication modes are available: unidirectional CHAP authentication and bidirectional CHAP authentication. In unidirectional CHAP authentication, the device on one end functions as the authenticating device, and the device on the other end functions as the authenticated device. In bidirectional CHAP authentication, each device functions as both the authenticating device and authenticated device. In practice however, only unidirectional CHAP authentication is used. Following successful authentication, the Network phase initiates, through which NCP negotiation is performed to select and configure a network protocol and to negotiate network-layer.

Parameters. Each NCP may be in an Opened or Closed state at any time. After an NCP enters the Opened state, network-layer data can be transmitted over the PPP link.

PPP can terminate a link at any time. A link can be terminated manually by an administrator, or be terminated due to the loss of carrier, an authentication failure, or other causes.



PPP generally adopts a HDLC like frame architecture for the transmission over serial connections. Flag fields are adopted to denote the start and the end of a PPP frame which is identifiable from the binary sequence 01111110 (0x7E). The address field, although present, is not applied to PPP as is the case with HDLC and therefore must always contain a 11111111 (0xFF) value, which represents an 'All-Stations' address. The control field is also fixed with a value of 00000011 (0x03) representing the unnumbered information command.

The frame check sequence (FCS) is generally a 16 bit value used to maintain the integrity of the PPP frame. PPP additionally defines a 8 or 16 bit protocol field that identifies the datagram encapsulated in the Information field of the packet. Typical examples may include 0xc021 for Link Control Protocol, 0xc023 for Password Authentication Protocol, and 0xc223 for the Challenge Handshake Authentication Protocol. The Information field contains the datagram for the protocol specified in the Protocol field.

The maximum length for the Information field, (not including the Protocol field), is defined by the Maximum Receive Unit (MRU), which defaults to 1500 bytes. Where the value 0xc021 is implemented, communicating devices negotiate by exchanging LCP packets to establish a PPP link.

The LCP packet format carries a code type field that references various packet types during PPP negotiation, for which common examples include Configure-Request (0x01), Configure-Ack (0x02), Terminate-Request (0x05) etc. The Data field carries various supporting type/length/value (TLV) options for negotation, including MRU, authentication protocols etc.

Packet Types Used in LCP Negotiation

Packet Type	Function
Configure-Request	Include the parameters for link establishment and link configuration
Configure-Ack	Confirmation sent once all Configure-Request parameters have been validated
Configure-Nak	The parameters included in Configure-Request are recognized but not all accepted
Configure-Reject	The parameters included in Configure-Request from the peer are not all recognized

As part of the LCP negotiation, a number of packet types are defined that enable parameters to be agreed upon before a PPP data link is established. It is necessary that the two communicating devices negotiate the link layer attributes such as the MRU and authentication mode. In order to achieve this, various packet types are communicated.

The Configure-Request packet type type allows initiation of LCP negotiation between peering devices and must be transmitted at such times. Any Configure-Request packet type sent must be responded to, and may be done so through one of a number of response packet types. Where every configuration option received in a Configure-Request is recognizable and all values are acceptable, a Configure-Ack packet type will be transmitted.

Where all received configuration options in the Configure-Request packet type are recognized, but some values are not accepted, a Configure-Nak packet type will be transmitted, and contain only the unaccepted configuration options originally received in the Configure-Request packet type. A Configure-Reject is used when certain configuration options received in a Configure-Request are not recognizable, and thus are not accepted for negotiation.

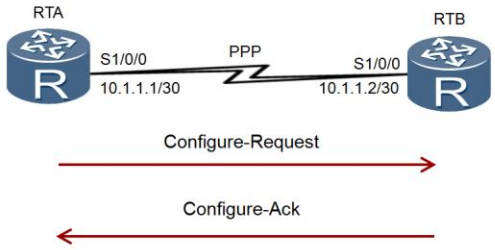
Common Link Parameters of LCP Negotiation

Parameter	Function	Default
Maximum Receive Unit	The total length of the Information and Padding field for the PPP frame.	1500
Authentication protocol	Authentication protocol used by the peer.	No Authentication
Magic-Number	Magic-Number is generated randomly, used for link loop detection.	Enable

Some of the common configuration options that are negotiated and carried as part of the LCP packet include the MRU, Authentication protocol supported by the sending peer as well as the magic number.

The magic number provides a method to detect looped-back links and other anomalies at the data link layer. In the case where a Configure-Request is received containing a Magic-Number as a configuration option, the received Magic-Number is used to compare multiple received Configure-Request messages sent to the peer by comparison of the Magic-Number. If the two Magic-Numbers of the received Configure-Request messages are different, then the link is understood to be a non-looped-back link for which a Request-Ack can be given in response. If the two Magic-Numbers are equal however, then a possibility exists that the link is looped-back and that further checking must be performed for this Configure-Request, and is done so by sending a Configure-Nak to effectively request a different Magic-Number value.

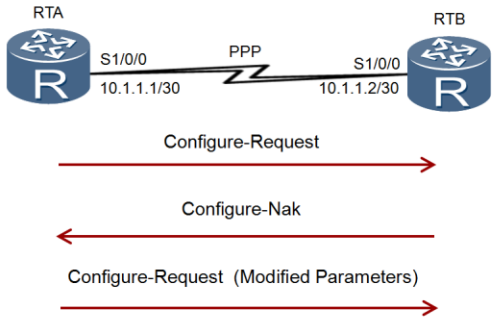
LCP Link Parameters Negotiation



- Successful PPP negotiations result in a Configure-Ack reply to a Configure-Request packet.

The sequence of events leading to the establishment of PPP between two peers is initiated by the sending of a Configure-Request packet to the peering device. Upon receiving this packet, the receiver must assess the configuration options to determine the packet format to respond with. In the event that all configuration options received are acceptable and recognized, the receiver will reply with a Configure-Ack packet.

LCP Link Parameters Negotiation

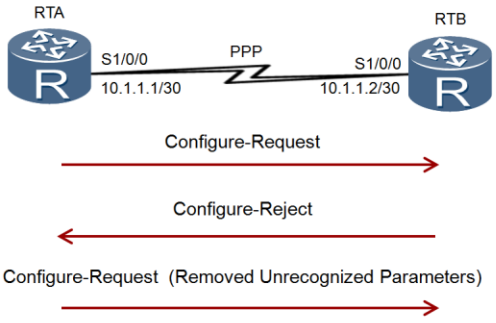


- Configure-Nak packets are generated where parameters are recognized but not all are accepted.

Following the initial transmission of the Configure-Request as part of PPP negotiation, it is also possible that a Configure-Nak be returned, in particular where all configuration options are recognized, but some values are not accepted. On reception of the Configure-Nak packet a new Configure-Request is generated and sent, however the configuration options may generally be modified to the specifications in the received Configure-Nak packet.

Multiple instances of a configuration option may be specified by the Configure-Nak packet for which the peer is expected to select a single value to include in the next Configure-Request packet.

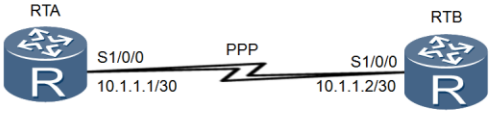
LCP Link Parameters Negotiation



- Configure-Reject packets are generated where not all parameters are recognized by the peer.

For PPP LCP negotiation in which one or multiple configuration options received in a Configure-Request are unrecognized or considered not acceptable for negotiation, a Configure-Reject packet is transmitted. Reception of a valid Configure-Reject indicates that when a new Configure-Request be sent, and any configuration options that are carried together with the Configure-Reject packet must be removed from the configuration options to be sent as part of the following Configure-Request packet.

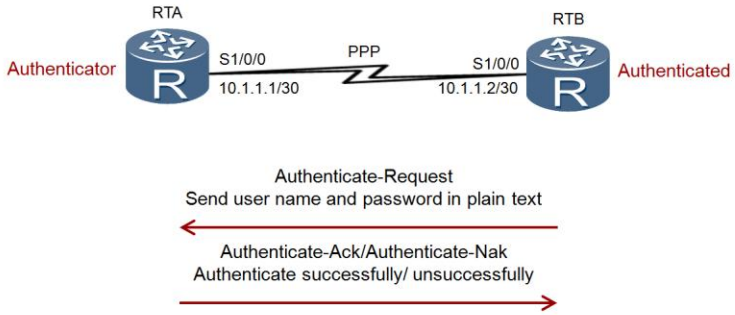
PPP Basic Configuration




```
[RTA]interface Serial 1/0/0
[RTA-Serial1/0/0]link-protocol ppp
Warning: The encapsulation protocol of the link will be changed.
Continue? [Y/N]:y
[RTA-Serial1/0/0]ip address 10.0.1.1 30
```


Establishment of PPP requires that the link layer protocol on the serial interface be specified. For ARG3 series of routers, PPP is enabled by default on the serial interface. In the event where the interface is currently not supporting PPP, the link-protocol ppp command is used to enable PPP at the data link layer. Confirmation of the change of encapsulation protocol will be prompted, for which approval should be given as demonstrated in the configuration example.

PPP Authentication Mode - PAP



- The Password Authentication Protocol relies on the transmission of a password over the link for peer authentication.

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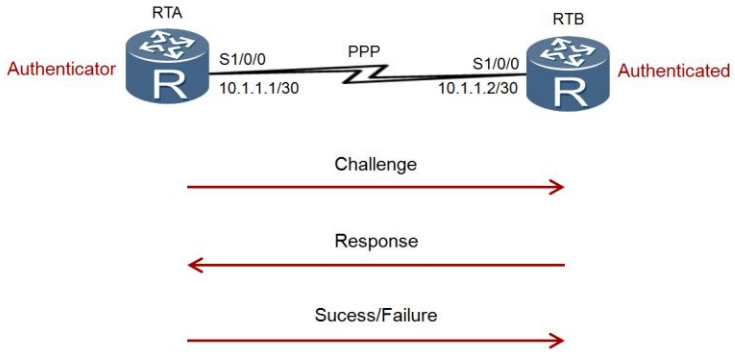
The Password Authentication Protocol (PAP) is a two-way handshake authentication protocol that transmits passwords in plain text. PAP authentication is performed during initial link establishment. After the Link Establishment phase is complete, the user name and password are repeatedly sent by the peer to the authenticator until authentication is acknowledged or the connection is terminated. PAP authentication effectively simulates login operations in which plain text passwords are used to establish access to a remote host. The authenticated device sends the local user name and password to the authenticator. The authenticator checks the user name and password of the authenticated device against a local user table and sends an appropriate response to the authenticated device to confirm or reject authentication.

PPP Authentication Mode - CHAP



- The Challenge Handshake Authentication Protocol relies on a challenge and challenge response for peer authentication.

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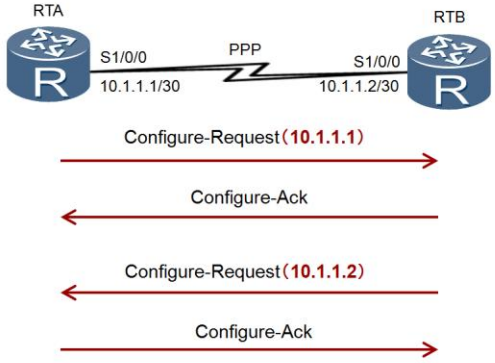
The Challenge Handshake Authentication Protocol (CHAP), is used to periodically verify the identity of the peer using a three-way handshake. This is done upon initial link establishment, and can be repeated periodically. The distinguishing principle of CHAP lies in the protection given through avoiding transmission of any password over the link, instead relying on a challenge and response process that can only be successful if both authenticator and authenticated devices are supporting a value referred to as a secret. An algorithm such as MD5 is commonly used to hash any challenge and response, to ensure the integrity of the value and the resulting hash value, and is compared to a result generated by the authenticator. If both the response and value that is created by the authenticator match, the authenticated peer is approved.

IPCP Static Address Negotiation



- The Internet Protocol Control Protocol (IPCP) is the Network Control Protocol (NCP) used for establishing and configuring IP.

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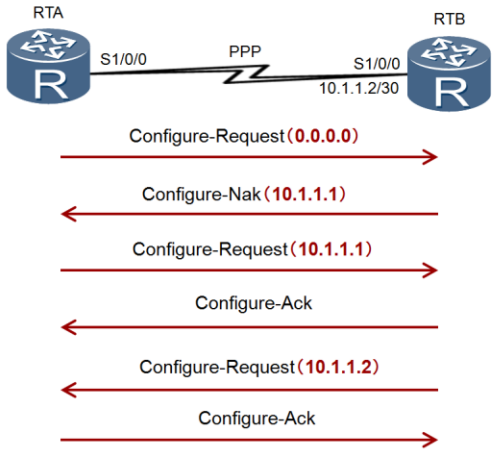
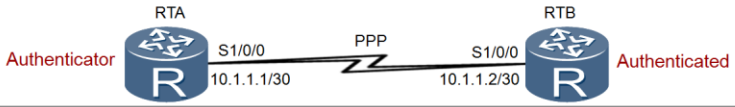
The IP Control Protocol (IPCP) is responsible for configuring, enabling, and disabling the IP protocol modules on both ends of the point-to-point link. IPCP uses the same packet exchange mechanism as the Link Control Protocol (LCP). IPCP packets may not be exchanged until PPP has reached the Network phase. IPCP packets received before this phase is reached are expected to be silently discarded. The address negotiation configuration option provides a way to negotiate the IP address to be used on the local end of the link, for which a statically defined method allows the sender of the Configure-Request to state which IP-address is desired. Upon configuration of the IP address a Configure-Request message is sent containing the IP address requested to be used, followed by a Configure-Ack from the peering device to affirm that the IP address is accepted.

IPCP Dynamic Address Negotiation



A local device operating as a client and needing to be assigned an IP address in the range of the remote device (server) must make a request for a valid address by applying the ip address-ppp negotiate command on the physical interface with which the client peers with the server. Through this method, a client can retrieve a valid address. This is applicable in scenarios such a where a client accesses the Internet through an Internet Server Provider (ISP) network, and through which it can obtain an IP address from the ISP. An address is proposed to the client upon receiving a configure request for which no IP address has been defined. The PPP server (RTB) will respond with a Configure-Nak which contains suggested IP address parameters for RTA. A follow up Configure-Request message with a change to the IP addressing enables the (NCP) IPCP to successfully establish network layer protocols.

Configuring PAP Authentication




```
[RTA]aaa
[RTA-aaa]local-user huawei password cipher huawei123
[RTA-aaa]local-user huawei service-type ppp
[RTA]interface Serial 1/0/0
[RTA-Serial1/0/0]link-protocol ppp
[RTA-Serial1/0/0]ppp authentication-mode pap
[RTA-Serial1/0/0]ip address 10.1.1.1 30
```

```
[RTB]interface Serial 1/0/0
[RTB-Serial1/0/0]link-protocol ppp
[RTB-Serial1/0/0]ppp pap local-user huawei password cipher huawei123
[RTB-Serial1/0/0]ip address 10.1.1.2 30
```


The establishment of PAP authentication requires that one peer operate as the authenticator in order to authenticate an authenticated peer. The PPP PAP authenticator is expected to define the authentication mode, a local user name and password, and the service type. If a domain is defined to which the local user belongs (as defined by AAA), the authentication domain is also expected to be specified under the PAP authentication mode.

An authenticated peer requires that an authentication user name, and authentication password be specified in relation to the username and password set by the authenticator. The *ppp pap local-user <username> password { cipher | simple } <password>* command is configured on the authenticated device to achieve this.

PAP Configuration Validation

```
<RTB>debugging ppp pap all
Aug 20 2013 04:50:24.280.4+00:00 RTB PPP/7/debug2:
  PPP State Change:
      Serial1/0/0 PAP : Initial --> SendRequest
Aug 20 2013 04:50:24.290.3+00:00 RTB PPP/7/debug2:
  PPP State Change:
      Serial1/0/0 PAP : SendRequest --> ClientSuccess
......
```


Through debugging commands which provide a real-time output of events in relation to specific protocols, the authentication request process can be viewed. As displayed in the example, a PAP authentication request is performed to which authentication establishment is deemed successful.

Configuring CHAP Authentication


```
[RTA]aaa
[RTA-aaa]local-user huawei password cipher huawei123
[RTA-aaa]local-user huawei service-type ppp
[RTA]interface Serial 1/0/0
[RTA-Serial1/0/0]link-protocol ppp
[RTA-Serial1/0/0]ppp authentication-mode chap
```

```
[RTB]interface Serial 1/0/0
[RTB-Serial1/0/0]link-protocol ppp
[RTB-Serial1/0/0]ppp chap user huawei
[RTB-Serial1/0/0]ppp chap password cipher huawei123
```


In CHAP authentication, the authenticated device sends only the user name to the authenticating device. CHAP is understood to feature higher security since passwords are not transmitted over the link, instead relying on hashed values to provide challenges to the authenticated device based on the configured password value on both peering devices. In its most simplest form, CHAP may be implemented based on local user assignments as with PAP, or may involve more stringent forms of authentication and accounting achieved through AAA and authentication/accounting servers.

As demonstrated, the configuration of CHAP based on locally defined users requires limited configuration of local user parameters and the enablement of PPP CHAP authentication mode on the authenticator device. Where domains exist, the authenticator may also be required to define the domain being used if different from the default domain.

CHAP Configuration Validation

```
<RTB>debugging ppp chap all
Aug 20 2013 05:15:54.230.1+00:00 RTB PPP/7/debug2:
PPP State Change:
      Serial1/0/0 CHAP : Initial --> ListenChallenge
Aug 20 2013 05:15:54.230.7+00:00 RTB PPP/7/debug2:
  PPP State Change:
      Serial1/0/0 CHAP : ListenChallenge --> SendResponse
Aug 20 2013 05:15:54.250.3+00:00 RTB PPP/7/debug2:
  PPP State Change:
      Serial1/0/0 CHAP : SendResponse --> ClientSuccess
……
```


Debugging of the CHAP authentication processes displays the stages involved with CHAP authentication, originating from listening on the interface for any challenges being received following the LCP negotiation. In the event that a challenge is sent, the authenticated device must provide a response for which a hash value is generated, involving the set authentication parameters on the authenticated peer (password), that the authenticator will promptly validate and provide a success or failure response to.

Summary

- Following a Configure-Request, what packet type is expected to be received before the PPP link layer can be successfully established?
- Which protocol is used to perform the negotiation of IP addresses, and during which phase is this negotiated?

1. A Configure-Ack packet is required in order to allow the link layer to be successfully established when using PPP as the link layer encapsulation mode.

2. The Internet Protocol Control Protocol (IPCP) is used to negotiate the IP protocol modules as part of the NCP negotiation process. This occurs during the Network phase of PPP establishment.

Thank you

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Frame Relay Principles

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Foreword

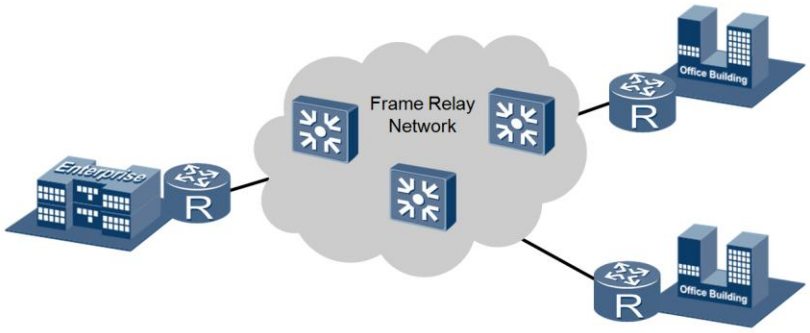
The introduction of Frame Relay during the 1990's saw a rapid growth in it's implementation and adoption by many enterprise businesses. Over time however, newer carrier based solutions such as Multi Protocol Label Switching (MPLS) have been introduced allowing for greater advanced service opportunities to be offered by providers, and so existing Frame Relay networks continue to be maintained for existing customers as the technology is slowly phased out. Frame Relay is primarily a service provider technology however enterprise administration requires that engineers are capable of establishing connectivity over frame relay virtual circuits at the edge of the enterprise network, as well as be familiar with the circuit establishment process to identify and resolve issues that may occur.

Objectives

Upon completion of this section, trainees will be able to:

- Describe the function of the DLCI in a Frame Relay network
- Describe the LMI negotiation process.
- Configure Frame Relay using both static and dynamic mapping.

Frame Relay Application



- Enterprise networks may establish peer relationships over a Frame Relay network.

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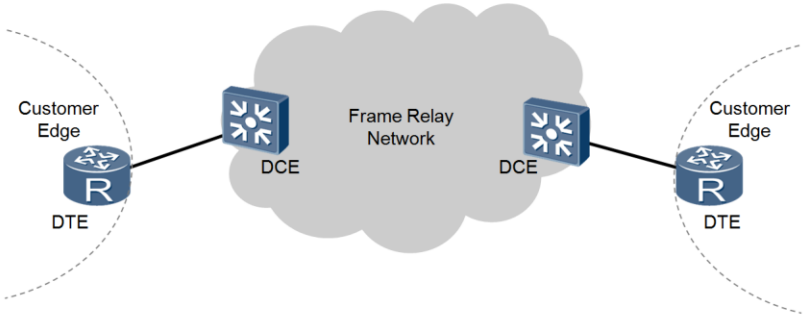
Working at the data link layer of the Open System Interconnection (OSI) model, Frame Relay (FR) is a technique that uses simple methods to transmit and exchange data. A distinct feature of Frame Relay is that it simplifies processes of error control, confirmation and re-transmission, traffic control, and congestion prevention over its predecessor protocol X.25 on packet switch networks, thus reducing processing time. This is important for the effective use of high-speed digital transmission channels. Frame Relay networks are generally in decline with little in the way of the establishment of new Frame Relay networks due to the emergence of technologies such as MPLS that utilize IP networks to provide a vast array of service options for enterprise customers. Where Frame Relay networks are currently maintained however, capability for support and maintenance must be covered at the customer edge.

Frame Relay Network Components



- Frame Relay networks comprise of Data Terminal Equipment (DTE), and Data Circuit-terminating Equipment (DCE)

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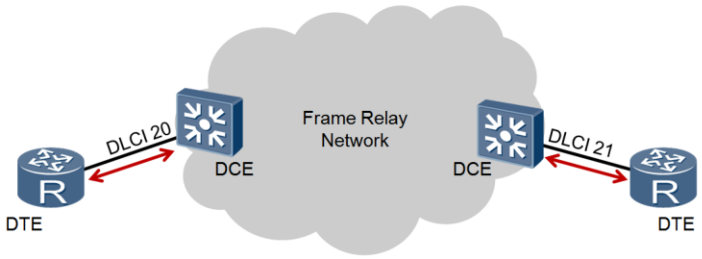
Frame Relay is a packet switched network technology that emulates circuit switched networks through the establishment of virtual circuits (VC) that are used to establish a path between Frame Relay devices at each end of the network. Every VC uses Data Link Connection Identifiers (DLCI) to define a Frame Relay channel that is mapped across the Frame Relay network to an often fixed destination. The user devices are called Data Terminal Equipment (DTE) and represent the point in the Frame Relay network where the circuit is both established and terminated. DTE establish virtual circuits with Data Circuit-terminating Equipment (DCE) that provide the clocking mechanism between the Frame Relay network and the DTE at the edge of the customer network.

Virtual Circuit



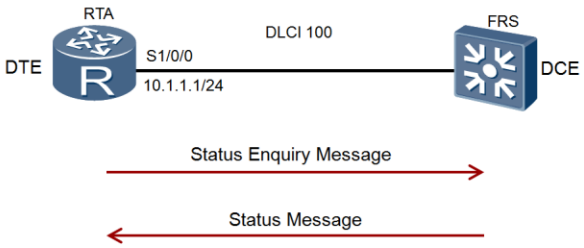
- Data Link Connection Identifiers (DLCI) locally distinguish the virtual circuits to remote destinations.

Frame Relay is a statistical multiplexing protocol. It provides multiple virtual circuits (VCs) on a single physical line. DLCI are applied to differentiate VCs. It is valid only on the local interface and the directly connected peer interface but not valid globally. On a Frame Relay network, the same DLCI on different physical interfaces does not indicate the same VC.

The available DLCI ranges from 16 to 1022, among which DLCIs 1007 to 1022 are reserved. Because the frame relay VC is connection oriented, different local DLCIs are connected to different remote devices. The local DLCI can therefore be considered as the “Frame Relay address" of the remote device. The Frame Relay address mapping associates the peer protocol address with the Frame Relay address (local DLCI), so that the upper-layer protocol can locate the remote device. When transmitting IP packets over Frame Relay links, a router searches for the next-hop address in the routing table first, and then it finds the corresponding DLCI in a Frame Relay address mapping table. This table maintains the mapping information between remote IP address and next hop DLCI. The address mapping table can be configured manually or maintained dynamically using a discovery process known as Inverse ARP. The VC can be understood as a logical circuit built on the shared network between two network devices. VCs can be divided into the permanent VC (PVC) and Switched VC (SVC).

A PVC is a manually created “always up” circuit that defines a fixed path to a given destination, whereas an SVC is a VC that can be created or cleared automatically through negotiation, similar to the way a telephone call is both established and terminated. Generally however, only PVC are implemented for Frame Relay.

LMI Negotiation Process



- The LMI protocol maintains the link and PVC status through status enquiry and status messages.

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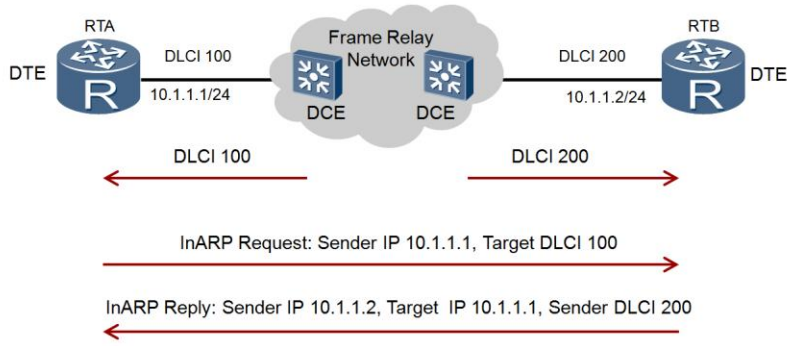
In the PVC, both the network devices and user devices need to maintain an awareness of the current status of each PVC. The protocol that monitors the PVC status is called the Local Management Interface (LMI) protocol. The LMI protocol maintains the link and PVC status of the Frame Relay through status enquiry packets and status packets. The LMI module is used to manage the PVC, including the adding and deleting of the PVC, the detecting of the PVC link integrity, and the PVC status. The system supports three LMI protocols, these include LMI complying with ITU-T Q.933 Appendix A, LMI complying with ANSI T1.617 Appendix D and a Nonstandard compatible protocol. A status request message is used to query the PVC status and link integrity, while a status message is used to reply the status request message, notifying of the PVC status and link integrity.

The interface in DTE mode periodically sends status enquiry messages to the interface in DCE mode. The interface in DCE mode, after receiving a status enquiry message, replies with a status message to the interface in DTE mode. The interface in DTE mode determines the link status and PVC status according to the received status messages. If interfaces in DCE and DTE modes can normally exchange LMI negotiation messages, the link status changes to Up and the PVC status changes to Active resulting in successful LMI negotiation.

Inverse ARP Negotiation Process



- The local hardware address (DLCI) is used to discover and bind the DLCI of a Virtual Circuit to the remote protocol address.

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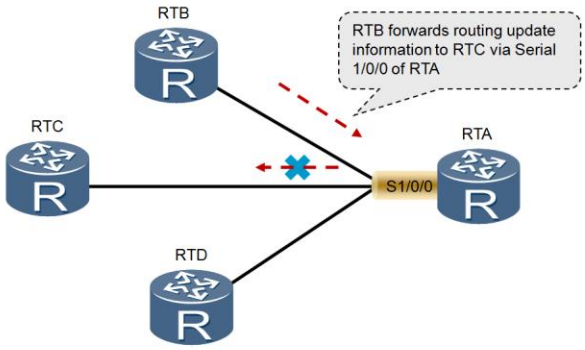
The main function of Inverse ARP is to resolve the IP address of the remote device that is connected to every VC. If the protocol address of the remote device that is connected to a VC is known, the mapping between the remote protocol address and DLCI can be created on the local end, which can avoid configuring the address mapping manually.

When a new VC is found, Inverse ARP sends a request packet to the remote end of this VC if the local interface is configured with the protocol address. This request packet contains the local protocol address. When the remote device receives this request packet, the local protocol address can be obtained to create the address mapping and an Inverse ARP response packet is sent. The address mapping is thus created on the local end. If the static mapping is configured manually or dynamic mapping is created, the Inverse ARP request packet is not sent to the remote end on this VC regardless of whether the remote address in the dynamic mapping is correct. An Inverse ARP request packet is sent to the remote end only when no mapping exists. If the receiver of the Inverse ARP request packet finds the remote protocol address is the same as that in the local configured mapping, it does not create the dynamic mapping.

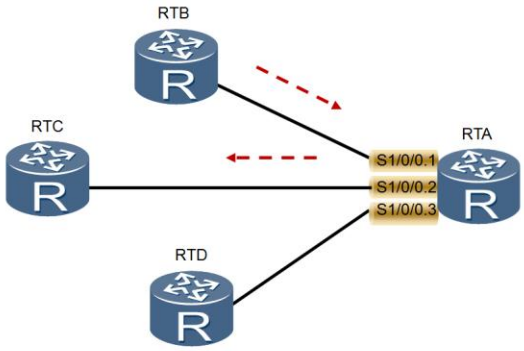
Frame Relay & Split Horizon



- Split-horizon prevents data received on an interface from being forwarded out of the same physical interface.

Routing protocols such as RIP and OSPF are used to provide the means for routing traffic at the network layer between the source and the destination, while frame relay provides the underlying technology to facilitate the data link communication. Frame relay interfaces naturally may involve multiple virtual circuits over a single physical interface. The network layer protocols however generally implement split horizon which does not allow the router to send out the updated information through the interface on which the information is received, as a defense against routing loops. One of the potential solutions to this would be to disable split horizon via the routing protocol however would leave the interface susceptible to the possibility of routing loops. Using multiple physical interfaces to connect multiple adjacent nodes is another alternative, however requires the router to have multiple physical interfaces, and increases the general implementation cost.

Frame Relay Sub-interfaces



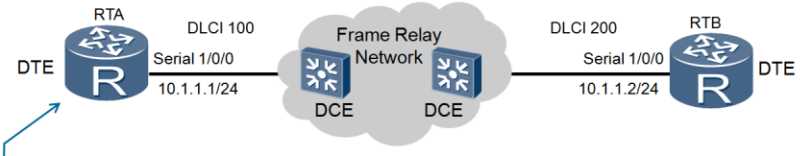
- Sub-interfaces provide a solution to split-horizon by defining logical divisions of a physical interface.

A more effective means to resolve issues arising from the implementation of split horizon over frame relay networks, is to apply logical sub-interfaces to a single physical interface. Frame Relay sub-interfaces can be classified into two types.

Point-to-point sub-interfaces are used to connect a single remote device. Each point-to-point sub-interface can be configured with only one PVC. In this case, the remote device can be determined uniquely without the static address mapping. Thus, when the PVC is configured for the sub-interface, the peer address is identified.

Point-to-multipoint sub-interfaces are used to connect multiple remote devices. Each sub-interface can be configured with multiple PVCs. Each PVC maps the protocol address of its connected remote device. In this way, different PVCs can reach different remote devices. The address mapping must be configured manually, or dynamically set up through the Inverse Address Resolution Protocol (InARP).

Frame Relay Configuration –Dynamic Mapping




```
[RTA]interface Serial 1/0/0
[RTA-Serial1/0/0]link-protocol fr
Warning: The encapsulation protocol of the link will be changed.
Continue? [Y/N]:y
[RTA-Serial1/0/0]fr interface-type dte
[RTA-Serial1/0/0]ip address 10.1.1.1 24
[RTA-Serial1/0/0]fr inarp
```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The configuration of dynamic address mapping for frame relay PVC requires that the Inverse Address Resolution Protocol (InARP) be used. Implementation of dynamic mapping requires that the link layer protocol type be set as frame relay using the *link-protocol fr* command. Once the interface link layer protocol has been changed, the interface on the customer edge device must be set to DTE. This by default on Huawei ARG3 series routers is set to DTE, and therefore this need not be set on any primary configuration. Finally to allow the dynamic mapping to occur, the *fr inarp* command is applied to the interface.

Configuration Validation – Dynamic Mapping

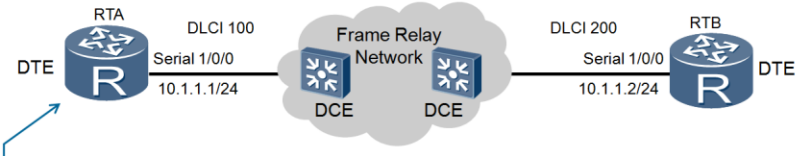
w1

```
[RTA]display fr pvc-info
PVC statistics for interface Serial1/0/0 (DTE, physical UP)
    DLCI = 100, USAGE = UNUSED (00000000), Serial1/0/0
    create time = 2016/03/20 09:02:33, status = ACTIVE
    InARP = Enable, PVC-GROUP = NONE
    in packets = 62, in bytes = 2978
    out packets = 74, out bytes = 3090
```

```
[RTA]display fr map-info
Map Statistics for interface Serial1/0/0 (DTE)
  DLCI = 100, IP INARP 10.1.1.2, Serial1/0/0
    create time = 2016/03/20 09:02:52, status = ACTIVE
    encapsulation = ietf, vlink = 1, broadcast
```


Using the *display fr pvc-info* command, it is possible to discover all permanent virtual circuits (PVC) associated with the local interface. In this instance a single PVC exists and the circuit is established with the support of the inverse ARP protocol. The presence of inbound and outbound packets informs that the frame relay mapping has been successful through Inverse ARP, and that traffic is flowing over the circuit.

Frame Relay Configuration – Static Mapping




```
[RTA]interface Serial 1/0/0
[RTA-Serial1/0/0]link-protocol fr
Warning: The encapsulation protocol of the link will be changed.
Continue? [Y/N]:y
[RTA-Serial1/0/0]fr interface-type dte
[RTA-Serial1/0/0]ip address 10.1.1.1 24
[RTA-Serial1/0/0]undo fr inarp
[RTA-Serial1/0/0]fr map ip 10.1.1.2 100
```


The *fr map ip* [*destination-address* [*mask*] *dlci-number*] command configures a static mapping by associating the protocol address of a peer device with the frame relay address (DLCI value) of the local device. This configuration helps upper-layer protocols locate a peer device based on the protocol address of the peer device. If the DCE is configured with static address mapping and the DTE is enabled with the dynamic address mapping function, the DTE can communicate with the DCE without being configured with static address mapping. If the DTE is configured with a static address mapping and the DCE is enabled with the dynamic address mapping function, the DTE and DCE cannot communicate with each other. Where it is necessary that broadcast packets be carried over the PVC, the *fr inarp* [*destination-address* [*mask*] *dlci-number*] *broadcast* command parameter can be included in the command.

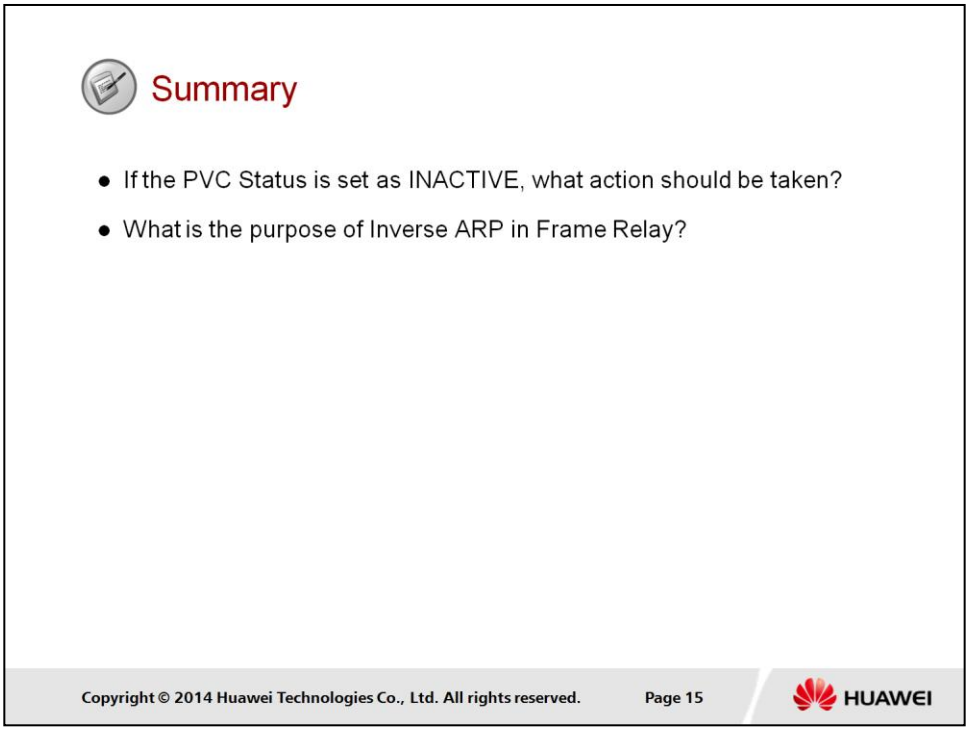
w2

Configuration Validation – Static Mapping

```
[RTA]display fr pvc-info
PVC statistics for interface Serial1/0/0 (DTE, physical UP)
    DLCI = 100, USAGE = LOCAL (00000100), Serial1/0/0
    create time = 2016/03/20 09:10:35, status = ACTIVE
    InARP = Disable, PVC-GROUP = NONE
    in packets = 74, in bytes = 3386
    out packets = 86, out bytes = 3450
```

```
[RTA]display fr map-info
Map Statistics for interface Serial1/0/0 (DTE)
  DLCI = 100, IP 10.1.1.2, Serial1/0/0
    create time = 2016/03/20 09:12:05, status = ACTIVE
    encapsulation = ietf, vlink = 3
```


The state of the PVC can be determined through the display fr pvc-info command. Each PVC that has been created is defined along with the interface for which the PVC is associated, the local DLCI number and also the current status of the DLCI. A fully operational PVC can be determined by an active status, whereas a non operational PVC is given an inactive status. The usage parameter indicates how the PVC is obtained. LOCAL indicates that the PVC is configured locally; UNUSED indicates that the PVC is learned from the DCE side.



1. The frame Relay PVC status will display as INACTIVE in the event that LMI negotiation messages have not been successfully exchanged. This may be caused when the interface with the PVC is inadvertently shut down, or the interface configured with the PVC failed to negotiate with the peer. An administrator would be required to therefore check the LMI negotiation process to discover the point of negotiation failure. The *display fr lmi-info* command can be used to view the related LMI details, for which discarded messages may be seen as the LMI negotiation attempts fail.

2. Inverse ARP is used to resolve the IP address of the peer device connected to the local device through a virtual circuit (VC), allowing the mapping between the peer IP address and the DLCI to be automatically defined on the local device.

Thank you

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Establishing DSL Networks with PPPoE

HUAWEI TECHNOLOGIES CO., LTD.

Foreword

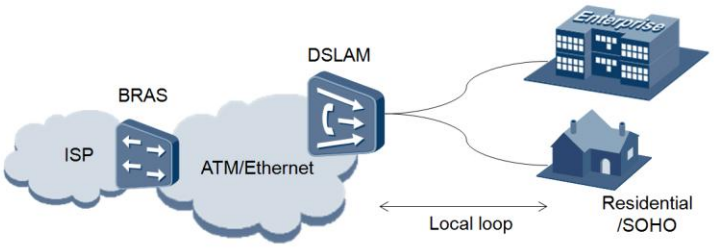
The application of DSL technology relies strongly on the existing telephone infrastructure that is found in almost every household and office globally. With the continued development of newer DSL standards allowing rates of up to 100Mbps, the application of DSL as a WAN technology for home and enterprise remains firmly valid. Traditional DSL connections were established over legacy ATM networks, however Ethernet has continued to emerge as the underlying technology on which many service providers establish their networks, and therefore knowledge of PPPoE technologies remains valued for establishing DSL connectivity at the enterprise edge.

Objectives

Upon completion of this section, trainees will be able to:

- Describe the PPPoE connection establishment process.
- Configure a PPPoE session.

Digital Subscriber Lines



- Successive broadband technology following dial-up.
- Data signals carried over copper telephone lines, or “local loop”.

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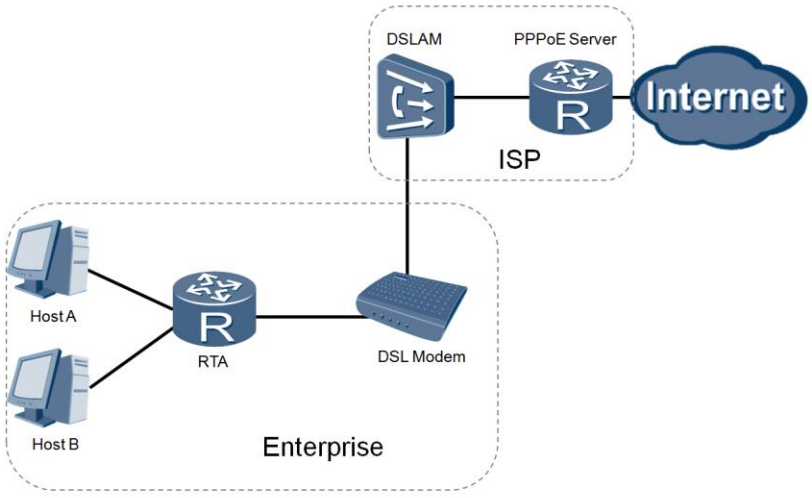
DSL represents a form of broadband technology that utilizes existing telephony networks to allow for data communications. Communication is facilitated through a remote transceiver unit, or modem at the customer premises, which communicates over the existing telephone lines to a central office transceiver unit that takes the form of the Digital Subscriber Line Access Multiplexer (DSLAM) where traffic is multiplexed onto a high speed ATM or Ethernet network before reaching the broadband remote access server (BRAS) or PPPoA/PPPoE server within the service provider network.

The distance between the two transceivers can vary depending on the specific DSL technology applied. In the case of an Asynchronous Digital Subscriber Line (ADSL) the distance expands up to around 18000 feet or 5,460 meters traditionally over an ATM network, whereas with a Very High Speed Digital Subscriber Line (VDSL2), local loop distances of only around 1500 meters are supported with fiber (FTTx) technology applied to provide Ethernet based backend transmission to the BRAS (PPPoE server).

PPPoE Application in DSL



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PPPoE refers to the encapsulation of PPP within Ethernet frames to support a connection over broadband technologies to a PPPoE broadband remote access server (BRAS), located within the service provider network. This is used to support the authentication and accounting process before access to the remote network such as the Internet is provided. The router RTA operates as the client for establishment of the PPPoE session with the PPPoE server via which an authorized connection is established for access to remote networks and resources. The DSL modem provides the modulation and demodulation of signals across the copper telephone wire infrastructure that traditionally exist in homes and offices.

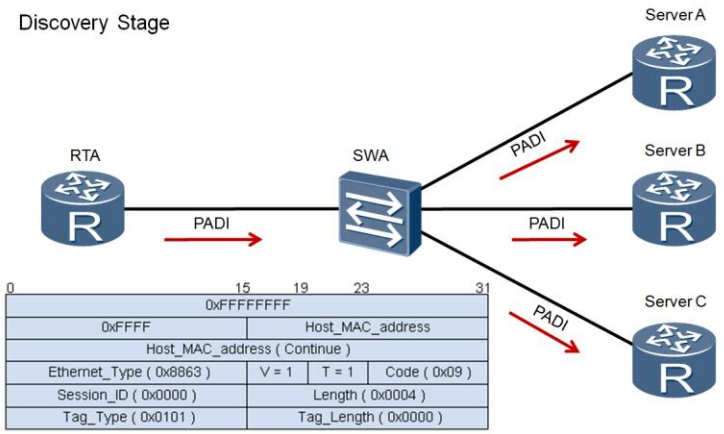
PPPoE Protocol Packets

Type	Description
PADI	PPPoE Active Discovery Initiation (PADI) packet
PADO	PPPoE Active Discovery Offer (PADO) packet
PADR	PPPoE Active Directory Request (PADR) packet
PADS	PPPoE Active Discovery Session-Confirmation (PADS) packet
PADT	PPPoE Active Discovery Terminate (PADT) packet

- Five packet types establish and terminate PPPoE sessions

PPPoE has two distinct stages, initially there is a Discovery stage followed by a PPP Session stage. When a client wishes to initiate a PPPoE session, it must first perform Discovery for which four stages are involved and rely on four individual packet types for the discovery process. These include the PPPoE Active Discovery Initiation (PADI), PPPoE Active Discovery Offer (PADO), PPPoE Active Discovery Request (PADR) and PPPoE Active Discovery Session-confirmation (PADS) protocol packet types. The termination process of the PPPoE session utilizes a PPPoE Active Discovery Terminate (PADT) packet for closure of the PPPoE session.

PPPoE Session Establishment Process



- An initiation packet is broadcast to discover access servers.

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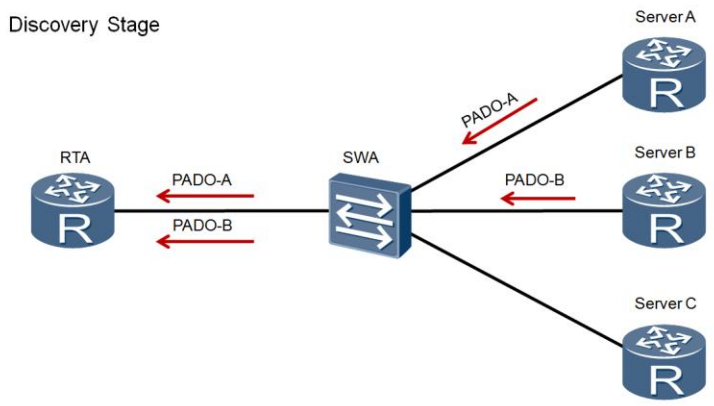
In the Discovery stage, when a client (RTA) accesses a server using PPPoE, the client is required to identify the Ethernet MAC address of the server and establish a PPPoE session ID. When the Discovery stage is complete, both peers know the PPPoE Session_ID and the peer Ethernet address. The PPPoE Session_ID and peer Ethernet address define the unique PPPoE session. The client will broadcast a PPPoE Active Discovery Initiation (PADI) packet. This packet contains the service information required by the client. After receiving this PADI packet, all servers in range compare the requested services to the services that they can provide. In the PADI packet, the Destination_address is a broadcast address, the Code field is set to 0x09, and the Session_ID field is set to 0x0000.

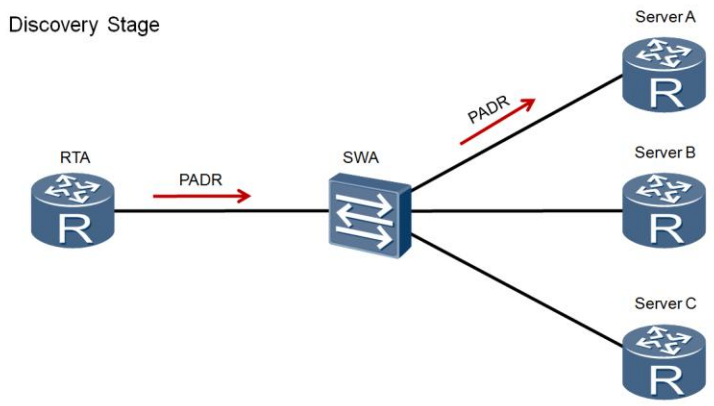
PPPoE Session Establishment Process



- Offers are returned to the sender by all servers that can service the received PADI packet.

The servers that can provide the requested services send back PPPoE Active Discovery Offer (PADO) packets. The client (RTA) can receive more than one PADO packet from servers. The destination address is the unicast address of the client that sent the PADI packet. The Code field is set to 0x07 and the Session_ID field must be set to 0x0000.

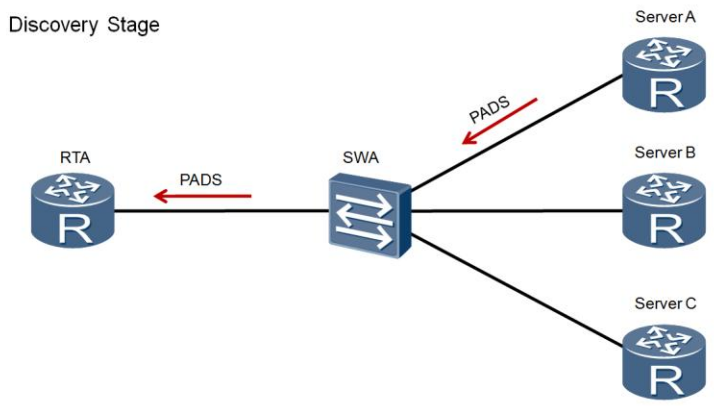
PPPoE Session Establishment Process



- A client responds to a chosen server based on the name or services that are provided by that server.

Since the PADI packet is broadcast, the client can receive more than one PADO packet. It looks through all the received PADO packets and chooses one based on the AC-Name (which stands for the Access Concentrator name, and generally refers to a value the uniquely distinguishes one server from another), or the services offered by the PADO packet. The client looks through the PADO packets to choose a server, and sends a PPPoE Active Discovery Request (PADR) packet to the chosen server. The destination address is set to the unicast address of the access server that sent the selected PADO packet. The code field is set to 0x19 and the session ID field is set to 0x0000.

PPPoE Session Establishment Process



- The chosen server generates a unique PPPoE session ID in preparation for the negotiation of the PPP session.

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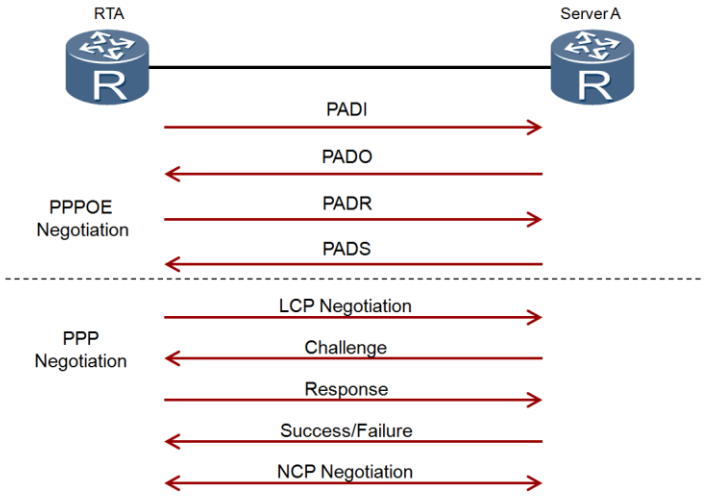
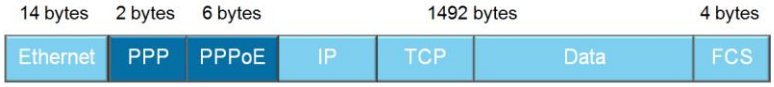
When receiving a PADR packet, the access server prepares to begin a PPPoE session. It generates a unique session ID for the PPPoE session and replies to the client with a PPPoE Active Discovery Session-confirmation (PADS) packet. The destination address field is the unicast Ethernet address of the client that sends the PADR packet. The code field is set to 0x65 and the session ID must be set to the value created for this PPPoE session. The server generates a unique session identifier to identify the PPPoE session with the client and sends this session identifier to the client with the PADS packet. If no errors occur, both the server and client enter the PPPoE Session stage.

PPPoE Session Establishment Process



Once the PPPoE session begins, PPP data is sent as in any other PPP encapsulation. All Ethernet packets are unicast. The ETHER_TYPE field is set to 0x8864. The PPPoE code must be set to 0x00. The SESSION_ID must not change for that PPPoE session and must be the value assigned in the discovery stage. The PPPoE payload contains a PPP frame. The frame begins with the PPP Protocol-ID.

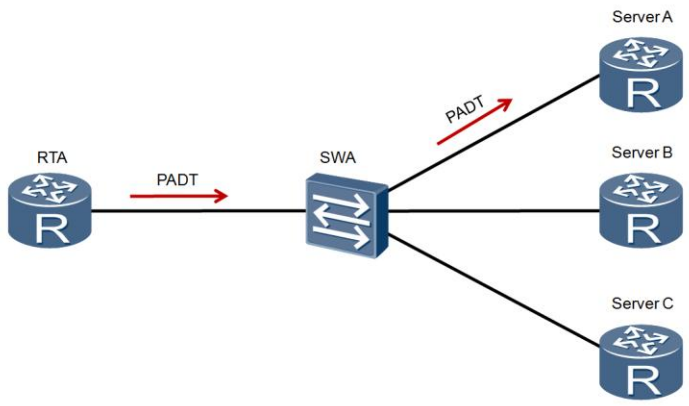
Packet Size Negotiation



- An additional six byte PPPoE header is carried in the frame.
- The MTU/MRU must support a lower value to prevent frame loss.

In the PPPoE session establishment process, PPP LCP negotiation is performed, at which point the maximum receive unit (MRU) is negotiated. Ethernet typically has a maximum payload size of 1500 bytes, where the PPPoE header is 6 bytes, and the PPP Protocol ID is 2 bytes, the PPP maximum receive unit (MRU) cannot be greater than 1492 bytes since this will likely cause packet fragmentation. When LCP terminates, the client and access concentrator (server) stop using that PPPoE session. If the client needs to start another PPP session, it returns to the Discovery stage.

PPPoE Session Termination



- Used to notify of the termination of a PPPoE session.

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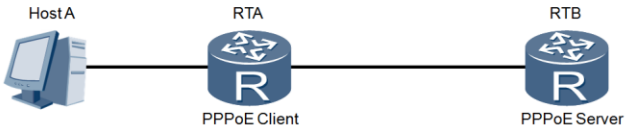
The PPPoE Active Discovery Terminate (PADT) packet can be sent anytime after a session is set up to indicate that a PPPoE session is terminated. It can be sent by the client or access server. The destination address field is a unicast Ethernet address. The Code field is set to 0xA7 and the session ID must be set to indicate the session to be terminated. No tag is required in the PADT packet. When a PADT packet is received, no PPP traffic can be sent over this PPPoE session. After a PADT packet is sent or received, even normal PPP termination packets cannot be sent. A PPP peer should use the PPP protocol to end a PPPoE session, but the PADT packet can be used when PPP cannot be used.

w1

Configuring a PPP Dialer Interface




```
[RTA]dialer-rule
[RTA-dialer-rule]dialer-rule 1 ip permit
[RTA-dialer-rule]quit
[RTA]interface dialer 1
[RTA-Dialer1]dialer user enterprise
[RTA-Dialer1]dialer-group 1
[RTA-Dialer1]dialer bundle 1
[RTA-Dialer1] ppp chap user enterprise@huawei
[RTA-Dialer1] ppp chap password cipher huawei123
[RTA-Dialer1]ip address ppp-negotiate
```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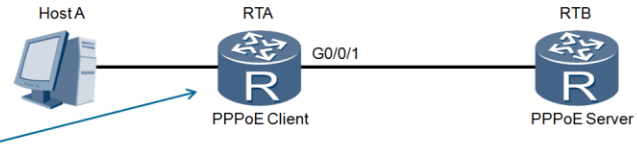
Three individual steps are required in the configuration of a PPPoE client, beginning with the configuration of a dialer interface. This enables the connection to be established on demand and a session connection to be disconnected after remaining idle for a period of time. The dialer-rule command enables the dialer-rule view to be accessed from which the dialer-rule can be set to define conditions for initiating the PPPoE connection.

The dialer user chooses a dialer interface on which to receive a call according to the remote user name negotiated by PPP. The dialer user enables the dial control center and indicates the remote end user name, which must be the same as the PPP user name on the remote end server. If the user name parameter is not specified when using the undo dialer user command, the dial control centre function is disabled and all of the remote user names are deleted. If this parameter is specified, only the specified user name is deleted. The dialer bundle <number> command in the AR2200E is used to bind physical interfaces and dialer interfaces.

PPP authentication parameters are defined for authentication of the client connection to the server along with the ip address ppp-negotiate command for negotiation on an interface, to allow the interface to obtain an IP address from the remote device.

PPPoE Session Binding




```
[RTA]interface GigabitEthernet 0/0/1
[RTA-GigabitEthernet0/0/1]pppoe-client dial-bundle-number 1 on-demand
[RTA-GigabitEthernet0/0/1]quit
[RTA]ip route-static 0.0.0.0 0 dialer 1
```

- A binding is performed of the PPPoE session with the dialer bundle, and associated with the PPPoE WAN interface.

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The second step involves the establishment of the PPPoE session binding of the dialer bundle to the interface over which negotiation is to take place for the configured dialer parameters. The pppoe-client dial-bundle-number <number> command is used to achieve this where the number refers to the bundle number configured as part of the dialer parameters.

If on-demand is not specified, the PPPoE session works in permanent online mode. If this parameter is specified, the PPPoE session works in on-demand dialing mode. The AR2200 supports the packet triggering mode for on-demand dialing. In permanent online mode, the AR2200 initiates a PPPoE session immediately after the physical link comes up. The PPPoE session persists until the undo pppoe-client dial-bundle-number command is used to delete it. In triggered online mode, the AR2200 does not initiate a PPPoE session immediately after the physical link comes up. Instead, the AR2200 initiates a PPPoE session only when data needs to be transmitted on the link. If no data is transmitted on the PPPoE link within the interval specified by dialer timer idle <seconds>, the AR2200 terminates the PPPoE session. When data needs to be transmitted on the PPPoE link, the AR2200 sets up the PPPoE session again.

The final step requires that a default static route be configured to allow any traffic for which a network destination is not defined as a longer match in the routing table to initiate the PPPoE session through the dialer interface.

Dialer Interface Configuration Validation

```
<Huawei>display interface Dialer 1
Dialer1 current state: UP
Line protocol current state: UP (spoofing)
Description: HUAWEI, AR Series, Dialer1 Interface
Route Port, The Maximum Transmit Unit is 1500, Hold timer is 10(sec)
Internet Address is negotiated, 192.168.10.254/32
Link layer protocol is PPP
LCP initial
Physical is Dialer
Bound to Dialer1:0:
Dialer1:0 current state : UP
Line protocol current state : UP

Link layer protocol is PPP
LCP opened, IPCP opened
```


The *display interface dialer* command is used to verify the current status of the dialer configuration and allows for the locating of faults on a dialer interface. The dialer current state of UP identifies that the physical status of the interface is active, while a DOWN state would confirm that a fault currently exists. The line protocol state refers to the link layer protocol status for which an UP status confirms the active connection.

A link that has no IP address assigned to the interface or is suppressed will show to be in a DOWN state, where suppression can be identified by dampening to the interface mainly due to a persistent interface flapping. The hold timers represents the heartbeat of the PPP dialer connection after PPP LCP negotiation transitions to Opened. The Internet address is negotiated from the IP pool that exists within the PPPoE server, where no address is present, the system will display “Internet protocol processing: disabled.“ The IP address is assigned when a connection is negotiated i.e. through a ping request in the pool range.

The LCP negotiation status defines the current state, where “initial” indicates that the physical layer is faulty or no negotiation has been started. An “Opened” state indicates that the system has sent a Configure-Ack packet to the peer device and has received a Configure-Ack packet from the peer device, as such confirming that the link layer is operating correctly.

PPPoE Session Validation

```
[RTA] display pppoe-client session summary
PPPoE Client Session:
ID    Bundle  Dialer  Intf          Client-MAC    Server-MAC    State
0     1       1       GE0/0/1       54899876830c  000000000000  IDLE
```

```
[RTA] display pppoe-client session summary
PPPoE Client Session:
ID    Bundle  Dialer  Intf          Client-MAC    Server-MAC    State
1     1       1       GE0/0/1       00e0fc0308f6  00e0fc036781  UP
```

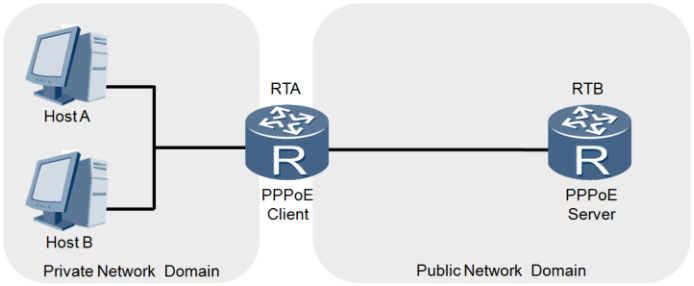
- The PPPoE client session status can be determined as either IDLE, in the discovery stage (PADI/PADR), or UP.

The *display pppoe-client session summary* command provides information regarding the PPPoE sessions on the Point-to-Point Protocol over Ethernet (PPPoE) client, including the session status and statistics. Two examples are given to highlight the difference between the PPPoE session states. The ID represents the PPPoE ID while the bundle ID and Dialer ID are related to the values in the dialer parameter configuration.

The interface defines the interface on which the client side negotiation is performed. The MAC address of the PPPoE client and server are also defined, however the Server-MAC is only determined after negotiation is established. The PPPoE has four states that are possible. An IDLE state indicates that the PPPoE session is currently not established and no attempt to establish the PPPoE connection has been made.

If the state is PADI, this indicates that the PPPoE session is at the Discovery stage and a PPPoE Active Discovery Initiation (PADI) packet has been sent. A PADR state indicates that the PPPoE session is at the Discovery stage and a PPPoE Active Discovery Request (PADR) packet has been sent. Finally, an UP state indicates that the PPPoE session has been established successfully.

PPPoE Application in Enterprise Networks.



- Privately addressed hosts cannot exist in the public domain
- Address translation along with PPPoE necessary.

Much of the implementation of PPPoE has focused on a general point-to-point connection reflective of a typical lab environment however in real world applications the PPPoE client often represents the gateway between an enterprise network and the Wide Area Network (WAN), to which external destinations and resources are accessed.

The internal network of an enterprise commonly employs a private network scheme in order to conserve addresses and these addresses cannot be used to establish IP communication over the public network infrastructure. This requires that the AR2200 provide the network address translation (NAT) function to translate private IP addresses into public IP addresses, and is a feature that is commonly applied to facilitate internal network communications over PPPoE.

Summary

- Why is it necessary to reduce the MTU/MRU size of PPPoE packets?
- What is the purpose of the dialer bundle command when establishing the PPPoE connection?

1. IP packets have a maximum payload size of 1500 bytes, however when used together with PPPoE, it requires an additional 6 bytes, as well as another 2 bytes for the PPP protocol ID, that causes the size of the packet to exceed the maximum supported payload size. As such the LCP negotiated MRU of a packet supporting PPPoE must be no larger than 1492 bytes.

2. The dialer bundle command binds the physical interface to the dialer interface that is used to establish the PPPoE connection.

Thank you

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Network Address Translation

HUAWEI TECHNOLOGIES CO., LTD.

Foreword

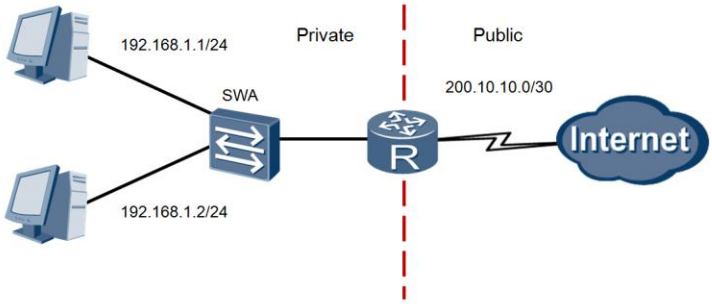
The continued growth of IP networks in general has resulted in an ever increasing pressure on the IPv4 address space, and the need for a way to prolong the depletion until long term solutions are founded. Network Address Translation has become well established as the existing solution and widely implemented within enterprise networks. Many variations of NAT have been developed thus conserving the public address space whilst enabling continued public network communication. This section introduces the concept of NAT along with examples of common NAT methods applied, for maintaining internetworking between the enterprise network and the public network domain.

Objectives

Upon completion of this section, trainees will be able to:

- List some of the different forms of Network Address Translation.
- Explain the general behavior of NAT.
- Configure NAT to suit application requirements.

Private & Public Networks



- A measure taken against rapid depletion of IP addresses.
- Gateway operates as a private/public address boundary.

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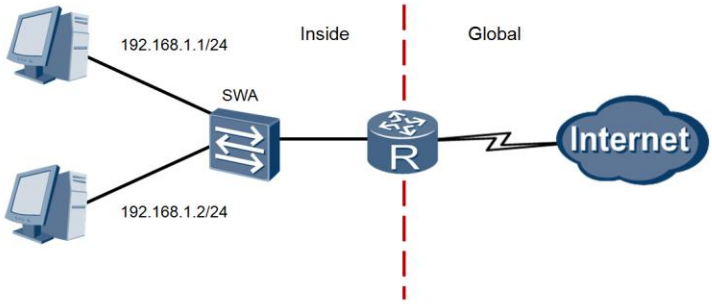
One of the main issues that has faced the expanding network has been the progressive depletion of IP addresses as a result of growing demand. The existing IPv4 addressing scheme has struggled to keep up with the constant growth in the number of devices that continue to make up the public IP network which is commonly recognized as the Internet. IPv4 addressing has already faced depletion from IANA, the industry body that is responsible for the allocation of addressing globally.

One makeshift solution was to allocate a range of private addresses based on the existing IP address classes that could be reused. This solution has allowed network domains to implement these addressing schemes based on the private address range, and in relation to the scale of the network domain. This allows for traffic that originates and is destined for locations in the same domain to communicate without consumption of valued public addresses.

A problem arises however on facilitating communication beyond the private network domain where destinations for traffic exist within the public domain or in another private domain beyond that public domain. Network Address Translation has become the standard solution to this issue allowing end stations to forward traffic via the public network domain from a private network.

NAT Behavior

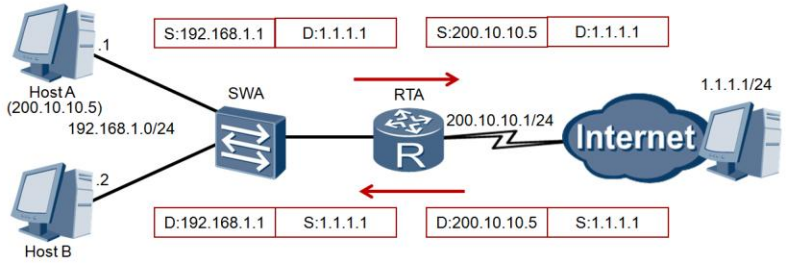


- NAT boundaries are represented as either inside or global.
- Translation of addresses is performed between boundaries.

Network Address Translation (NAT) uses the generally established boundary of the gateway router to identify network domains for translation. Domains are considered to be either internal private networks or external public networks between which NAT is performed. The main principle lies in the reception of traffic with a source address that is in the private network and a destination address which represents a location beyond the private network domain.

The router is expected to implement NAT to translate the private address to a public address to allow the public destination address to receive a valid return public address via which packets received can be replied. NAT must also create a mapping table within the gateway to allow the gateway to determine as to which private network destination address a packet received from the public network should be sent, again requiring address translation to be performed along the return path.

Static NAT



- One-to-one mapping of private to public addresses.
- Limits the need for address management with session flows.

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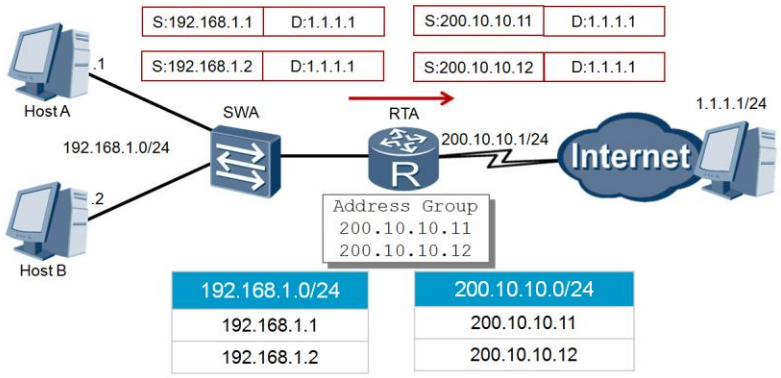
A number of implementations of NAT are possible and are capable of being applied to a variety of different situations. Static NAT represents a direct one-to-one mapping that allows the IP address of a specific end system to be translated to a specific public address. On a large scale the one-to-one mapping of static NAT does not do anything to alleviate the address shortage, however is applicable in cases such as where a host may wish to have certain privileges associated with an address to which the host is statically associated. This same principle may also apply to servers that may wish to be reached from the external network by a specific public address.

In the example given packets originating from source 192.168.1.1 are destined for the public network address of 1.1.1.1. The network gateway RTA, builds a mapping between the private address of 192.168.1.1 and a public address of 200.10.10.5 that is assigned as the source address of the packet before being forwarded by the gateway to the intended destination. Any return packet will be sent as a reply with the destination address of 200.10.10.5 to which the gateway will receive and perform the static translation, before forwarding the packet to the associated host of 192.168.1.1. The static mapping of addresses requires no real management of address allocation for users, since addressing is manually assigned.

Dynamic NAT



- Private address mapping based on an address resource pool.
- Allows users to utilize public addresses based on need.

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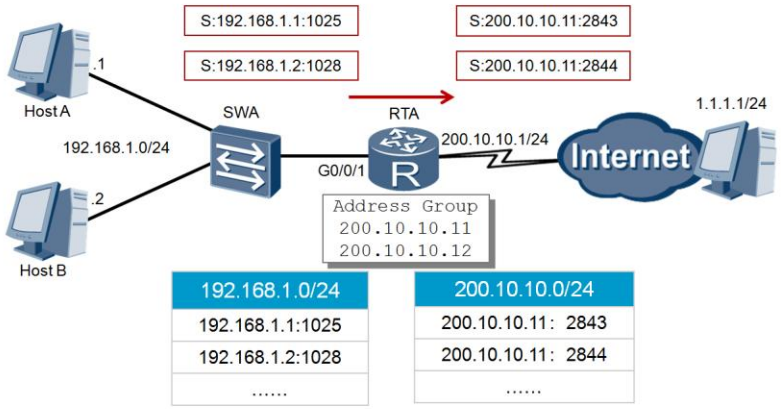
Dynamic NAT works on the principle of address pools by which internal end systems wishing to forward traffic across the public network are capable of associating with a public address from an address pool. End systems requiring to communicate with destinations in the public network domain must associate with a unique public address that is attainable from the public address range of the pool.

An address is assigned from the NAT server address pool as each end system attempts to forward traffic to a public network destination. The number of IP addresses owned by the NAT server is far less than the number of internal hosts because not all the internal hosts access external networks at the same time. This is usually determined according to the number of internal hosts that access external networks at peak hours.

The example demonstrates a case where two internal hosts generate packets intended for the destination 1.1.1.1/24, in which each internal host is allocated a unique address from the address pool, to allow each host to be distinguished in the public network from the other. Once communication is no longer required over the public network, the address mapping will be removed to allow the public address to be returned to the address pool.

Network Address Port Translation



- Port numbers distinguish mapping of the same public address

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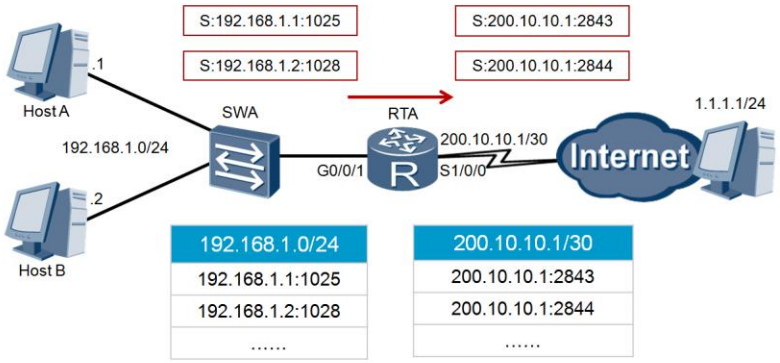
In addition to the many-to-many address translation found within Dynamic NAT, Network Address Port Translation (NAPT) can be used to implement concurrent address translation. NAPT allows multiple internal addresses to be mapped to the same public address. It is also called many-to-one address translation or address multiplexing. NAPT maps IP addresses and interfaces. The datagrams from different internal addresses are mapped to interfaces with the same public address and different port numbers, that is, the datagrams share the same public address.

The router receives a request packet sent from the host on the private network for accessing the server on the public network. The packet's source IP address is 192.168.1.1, and its port number is 1025. The router selects an idle public IP address and an idle port number from the IP address pool, and sets up forward and reverse NAPT entries that specify the mapping between the source IP address and port number of the packet and the public IP address and port number. The router translates the packet's source IP address and port number to the public IP address and port number based on the forward NAPT entry, and sends the packet to the server on the public network. After the translation, the packet's source IP address is 200.10.10.11, and its port number is 2843.

Easy IP



- The WAN interface address used as a single public address for all internal users, with port numbers used to distinguish sessions.

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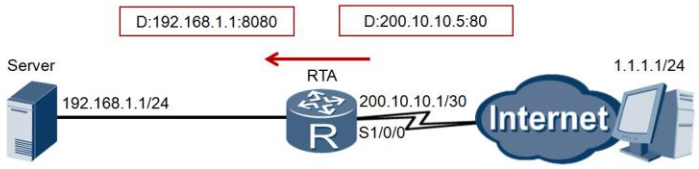
Easy IP is applied where hosts on small-scale local area networks require access to the public network or Internet. Small-scale LANs are usually deployed where only a few internal hosts are used and the outbound interface obtains a temporary public IP address through dial-up. The temporary public IP address is used by the internal hosts to access the Internet. Easy IP allows the hosts to access the Internet using this temporary public address.

The example demonstrates the Easy IP process. The router receives a request packet sent from the host on the private network for accessing a server in the public network. The packet's source IP address in this case is 192.168.1.1, and its port number is 1025. The router sets up forward and reverse Easy IP entries that specify the mapping between the source IP address and port number of the packet and the public IP address and port number of the interface connected to the public network. The router translates the source IP address and port number of the packet to the public IP address and port number, and sends the packet to the server on the public network. After the translation, the packet's source IP address is 200.10.10.1, and its port number is 2843.

After receiving a response from the server, the router queries the reverse Easy IP entry based on the packet's destination IP address and port number. The router translates the packet's destination IP address and port number to the private IP address and port number of the host on the private network, and sends the packet to the host. After the translation, the packet's destination IP address is 192.168.1.1, and its port number is 1025.

NAT Internal Server



- External sources can reach internal addresses.
- Mapping of both the IP address and port number is performed.

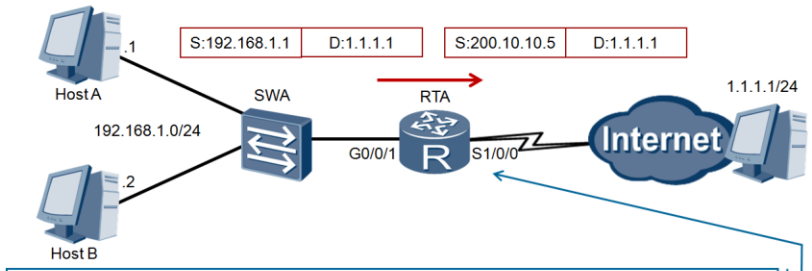
HUAWEI

NAT can shield hosts on private networks from public network users. When a private network needs to provide services such as web and FTP services for public network users, servers on the private network must be accessible to public network users at any time.

The NAT server can address the preceding problem by translating the public IP address and port number to the private IP address and port number based on the preconfigured mapping.

Address translation entries of the NAT server are configured on the router, after which the router receives an access request sent from a host on the public network. The router queries the address translation entry based on the packet's destination IP address and port number. The router translates the packet's destination IP address and port number to the private IP address and port number based on the address translation entry, and sends the packet to the server on the private network. The destination IP address of the packet sent by the host on the public network is 200.10.10.5, and the destination port number of 80. After translation is performed by the router, the destination IP address of the packet is 192.168.1.1, and its port number is 8080. After receiving a response packet sent from the server on the private network, the router queries the address translation entry based on the packet's source IP address and port number. The router translates the packet's source IP address and port number to the public IP address and port number based on the address translation entry, and sends the packet to the host on the public network. The source of the response packet sent from the host on the private network is 192.168.1.1, and its port number is 8080. After translation by the router, the source IP address of the packet is 200.10.10.5, and the port number is again port 80.

Static NAT Configuration




```
[RTA]interface GigabitEthernet0/0/1
[RTA-GigabitEthernet0/0/1]ip address 192.168.1.254 24
[RTA-GigabitEthernet0/0/1]interface Serial1/0/0
[RTA-Serial1/0/0]ip address 200.10.10.1 24
[RTA-Serial1/0/0]nat static global 200.10.10.5 inside 192.168.1.1
```


Static NAT indicates that a private address is statically bound to a public address when NAT is performed. The public IP address in static NAT is only used for translation of the unique and fixed private IP address of a host. The nat static [protocol {<tcp>|<udp>}global { <global-address >| current-interface <global-port>} inside {<host-address> <host-port >} vpn-instance <vpn-instance-name> netmask <mask> acl <acl-number> description <description >] command is used to create the static NAT and define the parameters for the translation.

The key parameters applied as in the example are the global parameter to configure the external NAT information, specifically the external address, and the inside parameter that allows for the internal NAT information to be configured. In both cases the address and port number can be defined for translation. The global port specifies the port number of the service provided for external access. If this parameter is not specified, the value of global-port is 0. That is, any type of service can be provided. The host port specifies the service port number provided by the internal server. If this parameter is not specified, the value of host-port is the same as the value of global-port.

Static NAT Configuration Validation

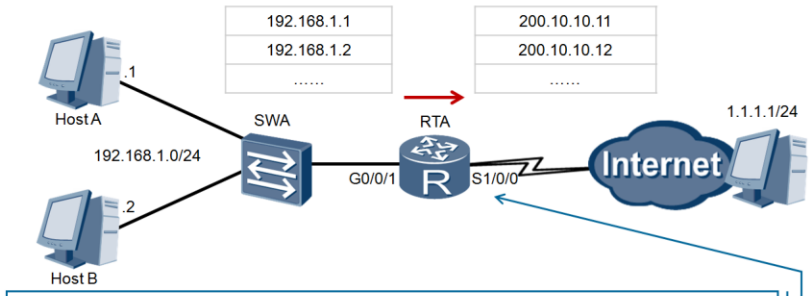
```
[RTA]display nat static
  Static Nat Information:
  Interface  : Serial1/0/0
    Global IP/Port     : 200.10.10.5/----
    Inside IP/Port     : 192.168.1.1/----
    Protocol : ----
    VPN instance-name  : ----
    Acl number         : ----
    Netmask  : 255.255.255.255
    Description : ----

  Total :    1
```

- Static inside and global address translation can be verified.

The configuration of static NAT can be viewed through the *display nat static* command. The command displays the network address translation information with regards to the interface through which the address translation is performed, the global and inside addresses which are translated along with the used ports. Where the ports are not defined, a null result will be displayed. The configuration for translation may be protocol specific to either TCP or UDP protocol traffic, in which case the Protocol entry will be defined.

Dynamic NAT Configuration




```
[RTA]nat address-group 1 200.10.10.11 200.10.10.16
[RTA]acl 2000
[RTA-acl-basic-2000]rule 5 permit source 192.168.1.0 0.0.0.255
[RTA-acl-basic-2000]quit
[RTA]interface serial1/0/0
[RTA-Serial1/0/0]nat outbound 2000 address-group 1 no-pat
```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The configuration of dynamic network address translations involves implementation of the nat outbound command. It relies on the prior configuration of a network access control list that is used to specify a rule to identify specific traffic to which an event or operation will be applied. The details regarding access control lists are covered in a later unit. An association is made between these access control list rules and the NAT address pool. In this manner, the addresses specified in the access control list can be translated by using the NAT address pool.

The example demonstrates how the nat outbound command has been associated with an access control list with a identifier of 2000 to allow traffic from the 192.168.1.0/24 network range to be translated as part of an address group referred to as address-group 1. This defines a pool range from 200.10.10.11 through to 200.10.10.16 which internal addresses will employ for address translation. The no-pat parameter in the command means that no port address translation will occur for the addresses in the pool, therefore each host must translate to a unique global address.

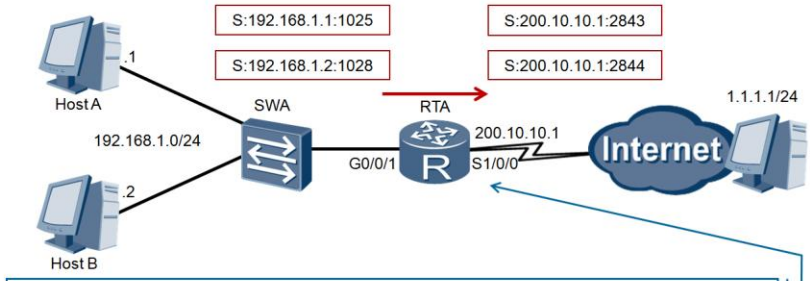
Dynamic NAT Configuration Validation

```
[RTA]display nat address-group 1
 NAT Address-Group Information:
 --------------------------------------
 Index    Start-address       End-address
 1        200.10.10.11        200.10.10.16
[RTA]display nat outbound
 NAT Outbound Information:
 --------------------------------------------------------------------
 Interface           Acl     Address-group/IP/Interface      Type
 --------------------------------------------------------------------
 Serial1/0/0         2000                        1          no-pat
 --------------------------------------------------------------------
  Total : 1
```

- Enables group binding parameter configuration to be verified.

Two specific display commands will enable the detailed information regarding the dynamic address translation to be verified. *The display nat address-group<group-index>* command allows the general network address translation pool range to be determined. In addition the *display nat outbound* command will provide specfic details for any dynamic network address translation configuration applied to a given interface. In the example it can be understood that the interface Serial1/0/0 is associated with an access control list rule together with the address group 1 for address translation on the given interface. The no-pat output confirms that port address translation is not in effect in this network address translation.

Easy IP Configuration




```
[RTA]acl 2000
[RTA-acl-basic-2000]rule 5 permit source 192.168.1.0 0.0.0.255
[RTA-acl-basic-2000]quit
[RTA]interface serial1/0/0
[RTA-Serial1/0/0]nat outbound 2000
```


The Easy IP configuration is very similar in configuration to that of dynamic network address translation, relying on the creation of an access control list rule for defining the address range to which translation is to be performed and application of the nat outbound command. The main difference is in the absence of the address group command since no address pool is used in the configuration of Easy IP. Instead the outbound interface address is used to represent the external address, in this case that being external address 200.10.10.1 of interface serial1/0/0. Additionally it is necessary that port address translation be performed, and as such the no-pat parameter cannot be implemented where an address group does not exist. The nat outbound 2000 represents a binding between the NAT operation and the access control list rule detailing the address range to which the translation will apply.

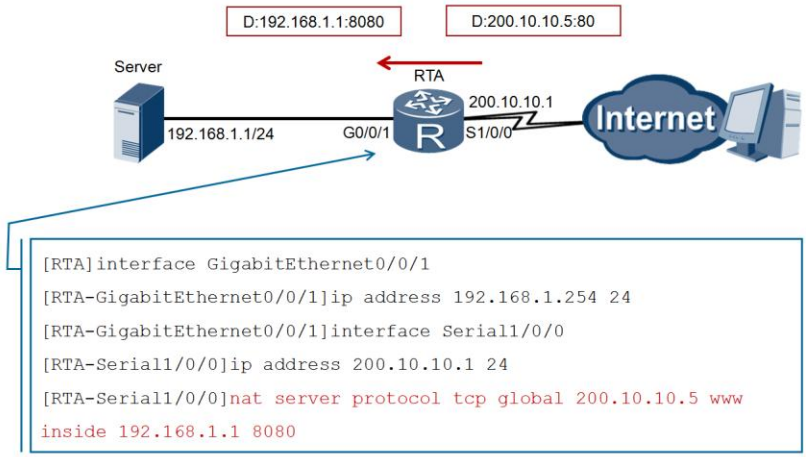
Easy IP Configuration Validation

```
[RTA] display nat outbound
 NAT Outbound Information:
 --------------------------------------------------------------------------
 Interface          Acl      Address-group/IP/Interface       Type
 --------------------------------------------------------------------------
 Serial1/0/0        2000       200.10.10.1                   easyip
 --------------------------------------------------------------------------
  Total : 1
```

- Associated outbound interface parameters are displayed.
- The type field verifies the successful configuration of Easy IP.

The same display nat outbound command can be used to observe the results of the nat outbound configuration and verify its correct implementation. The interface and access control list (ACL) binding can be determined as well as the interface (in this case) for the outbound translation. The type listing of easyip makes it clearly understood when Easy IP has been successfully configured.

NAT Internal Server Configuration



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Where it is necessary to provide internal access to external users such as in the case of a public server which is part of an internal network, the NAT server configuration can be performed to enable traffic destined for an external destination address and port number to be translated to an internal destination address and port number.

The nat server [protocol {<tcp >|<udp>}global {<global-address> | current-interface <global port>} inside {<host-address ><host-port> vpn-instance <vpn-instance-name> acl <acl-number> description <description >] command enables the external internal translation to be performed, where protocol identifies a specific protocol (either TCP or UDP depending on the service) to be permitted for translation along with the global address, indicating the external address for translation and the inside address relating to the internal server address.

The port number for the external address should be defined, and commonly relates to a specific service such as http (www) on port 80. As a means of further improving the overall shielding of internal port numbers from external threats, an alternative port number can be applied to the inside network and translated through the same means as is used for address translation.

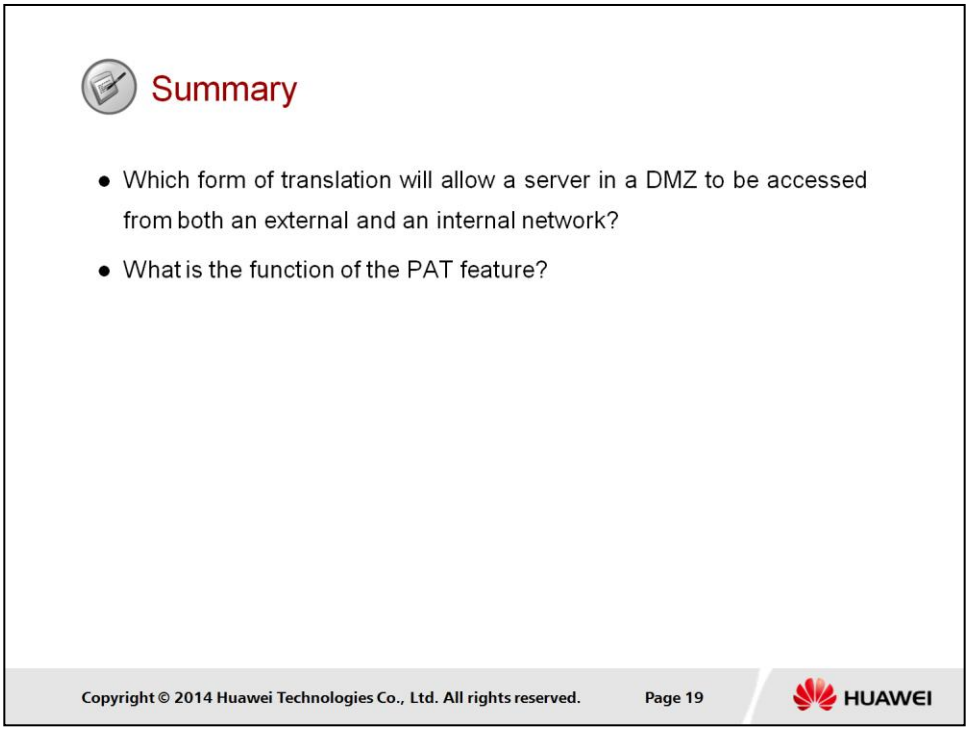
NAT Internal Server Configuration Validation

```
[RTA]display nat server
  Nat Server Information:
  Interface  : Serial1/0/0
    Global IP/Port     : 200.10.10.5/80(www)
    Inside IP/Port     : 192.168.1.1/8080
    Protocol : 6(tcp)
    VPN instance-name  : ----
    Acl number         : ----
    Description : ----

  Total :    1
```

- Successful translation of the IP address and port is achieved.

The display nat server command details the configuration results to verify the correct implementation of the NAT server. The interface defines the point at which the translation will occur. The global and inside IP addresses and associated port numbers can be verified. In this case the global address of 202.10.10.5 with a port number of 80 (www) will be translated to an inside server address of 192.168.1.1 with a port number of 8080 as additional security against potential port based attacks. Only TCP traffic that is destined for this address and port will be translated.



1. The NAT internal server configuration will allow a unique public address to be associated with a private network server destination, allowing inbound traffic flow from the external network after translation. Internal users are able to reach the server location based on the private address of the server.

2. The PAT feature will perform translation based on the port number as well as the IP addresses. It is used as a form of address conservation where the number of public addresses available for translation are limited, or insufficient to support the number of private addresses that require possible translation.

Thank you

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Establishing Enterprise Radio Access Network Solutions

HUAWEI TECHNOLOGIES CO., LTD.

Foreword

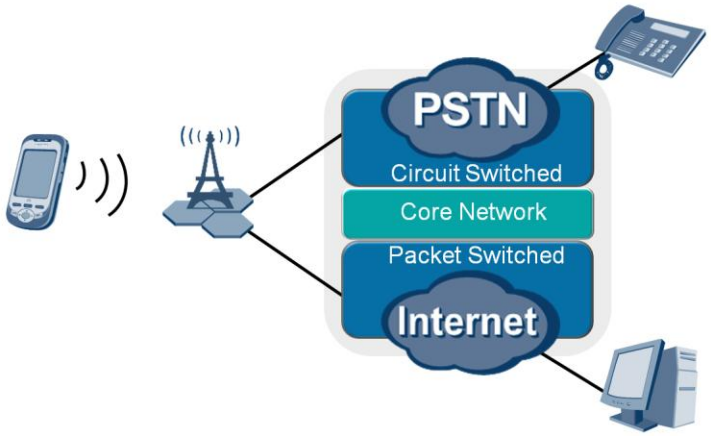
A large number of enterprise networks rely on a single network provider solution that may be in some cases protected by a service level agreement (SLA), as protection where downtime is likely to be critically damaging to a company's operation; and also where supporting multiple networks is unnecessarily costly. Traditional approaches involve failover solutions using technologies such as ISDN, however newer and more viable solutions in the form of cellular technologies provide effective failover measures in the event that primary networks fail. This section introduces how 2G and 3G cellular network failover solutions can be used to protect the enterprise network.

Objectives

Upon completion of this section, trainees will be able to:

- Explain the application of 2G and 3G networks as an enterprise failover solution.
- Explain the process for implementing cellular interface failover solutions.

Wireless WAN Overview



- Evolved Wireless WANs provide for both call and data traffic.

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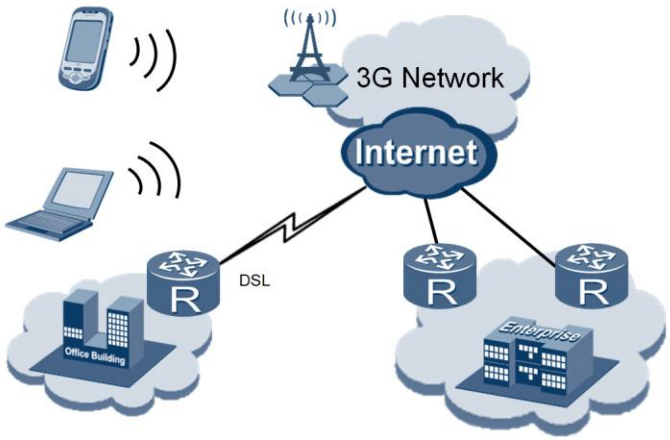
Wireless Wide Area Networks (WWAN) have become a central part of the worlds communications infrastructure, allowing for the evolution of the mobile network for which various call and data services are becoming increasingly prominent in everyday life. The WWAN is comprised of a multitude of technologies and standards that allow for near ubiquitous voice and data communication globally. Communication is commonly achieved through a mobile handset commonly referred to as Mobile Station (MS) or User Equipment (UE) for 3G (UMTS), and 4G (LTE) networks respectively, providing an interface to the Radio Access Network via which services are accessed. It should be clearly noted however that the architecture, although similar in design, is unrelated for 3G and 4G networks but involves some level of technology overlay. Internetworking between the technologies provides for seamless communication where one network becomes unavailable. Communication is achieved through a base station that operates as a cell for a given region and allows voice and data traffic to be transmitted to the core network for processing.

Communications will be handled over a circuit switched gateway (calls) or a packet switched gateway (data) via which transmission signals carrying information are used by the core for call & data processing.

The core network handles a range of services, and management of process. The core is made up of components that include home location registers for maintaining records of all SIM details authorized to use the network, visitor location registers for tracking location as the user roams between regions, SIM authentication, identity registration for banning and tracking (typically stolen) mobile handsets, services such as short message and multimedia messaging services voicemail systems and customer billing.

Wireless WAN and the Enterprise Network



- Increased data speeds allow for new Enterprise solutions.

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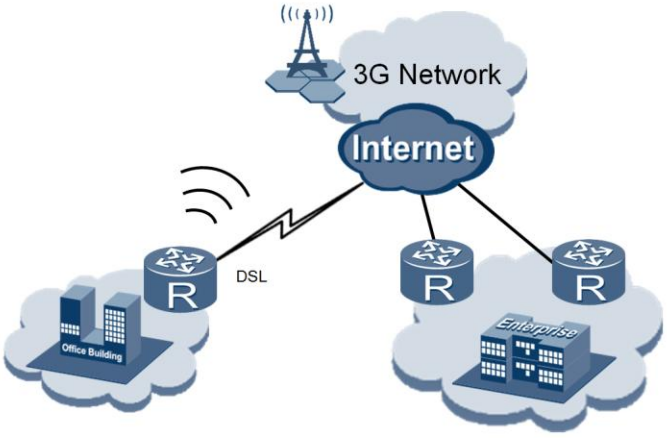
The evolved support of packet switching in mobile networks has provided a new avenue for communications with remote workers that may often be stationed beyond the range of an existing enterprise network and any WLAN solutions that may be implemented. One of the major concerns has often been with regards to the speed and services that are capable of being supported by WWAN solutions. As the evolution of mobile network continues, the supported speeds continue to grow allowing newer services to become available allowing for true mobility in enterprise business.

The integration of packet switched technologies into the mobile network has seen the evolution through 2G (GSM), the aptly known 2.5G (GPRS) and 2.75G (EDGE) to 3G (UMTS) for which evolutions in the form of HSPA and HSPA+ have occurred, the former supporting capacity of up to approximately 14Mbps and the latter supporting 168Mbps downlink. A continued evolution of higher capacity for services has now resulted in 4G (LTE) technologies with data transmission capability pushing the 1Gbps mark. This has enabled the relationship between mobile and enterprise networks to form. Remote users are able to utilize the mobile data networks for access to company resources and maintain communications through data channels without physical Restriction of location.

Enterprise Wireless WAN Solution



- Failover solutions can be applied over 2G and 3G networks.

HUAWEI

Enterprise networks are able to utilize the packet switched capabilities of the 3G network as a method of redundancy through which network failover can be supported in the event that the main service becomes unavailable. One of the limitations that exists with Wireless WAN solutions is the associated costs that limit the use as an “always on” solution, however where business continuity is paramount, it can enable services to be maintained during any unforeseen downtime. Huawei AR2200 series routers are capable of supporting 3G interfaces that can be implemented as a failover solution, ensuring that data costs rely on more cost efficient means primarily, but ensuring that a sound failover solution can be implemented when necessary over increasingly less favorable legacy technologies such as ISDN.

AR2200 Hardware Requirements

- The 3G-HSPA+7 Interface card enables 2G and 3G services.

Support for WWAN solutions on the AR2200 series router is achieved through the implementation of supported hardware including the 3G-HSPA+7 interface card that allows interfacing with 2G and 3G networks. The 3G-HSPA+7 interface card provides two 3G antenna interfaces to transmit and receive 3G service data. One interface is the primary interface, and the other is the secondary interface with capability for support of 2G GSM/GPRS/EDGE and 3G WCDMA, HSPA and HSPA+ standards. Whip antennas are directly installed on an AR router and are recommended when a router is desk installed or wall mounted. Indoor remote antennas have a 3 m long feed line and are recommended when an AR router is installed in a cabinet or rack.

GSM CS:	Upstream (Tx): 9.6kbit/s
	Downstream (Rx): 9.6kbit/s
GPRS/EDGE:	Multi-slot Class 12, Class B (236.8 kbit/s)
WCDMA CS:	Upstream (Tx): 64 kbit/s
	Downstream (Rx): 64 kbit/s
WCDMA PS:	Upstream (Tx): 384 kbit/s
	Downstream (Rx): 384 kbit/s
HSPA:	Upstream (Tx): 5.76 Mbit/s
	Downstream (Rx): 14.4 Mbit/s
HSPA+:	Upstream (Tx): 5.76 Mbit/s
	Downstream (Rx): 21 Mbit/s

Establishing The 3G Network


```
<Huawei>system-view
[Huawei]interface cellular 0/0/0
[Huawei-cellular0/0/0]ip address ppp-negotiate
[Huawei-cellular0/0/0]profile create 1 static 3GNET
[Huawei-cellular0/0/0]mode wcdma wcdma-precedence
[Huawei-cellular0/0/0]quit
```

- 3G network parameters are defined on the cellular interface.

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A 3G cellular interface is a physical interface supporting 3G technology. It provides users with an enterprise-level wireless WAN solution. After configuring 3G cellular interfaces, voice, video, and data services can be transmitted over the 3G network, providing a variety of WAN access methods for enterprises.

The 3G Cellular interface transmits radio signals and supports PPP as the link layer protocol and an IP network layer. The ip address ppp-negotiate command is used to allow an IP address to be obtained for the cellular interface from the remote device in the event where failover may occur. A parameter profile is created using the profile create <profile-number> {static <apn> | dynamic} command where the profile number refers to an identifier for the profile.

The static and dynamic options allow the dynamic allocation or static assignment of an access point name (APN). When a 3G modem has a universal subscriber identity module (USIM) installed, the mode wcdma command can be used to configure a WCDMA network connection mode for the 3G modem, where wcma-precedence allows WCDMA to be used preferentially over other modes. The 3G modem is connected to the USB module interface.

Setting The Dial Control Centre


```
[Huawei]dialer-rule
[Huawei-dialer-rule]dialer-rule 1 ip permit
[Huawei-dialer-rule]quit
[Huawei]interface cellular 0/0/0
[Huawei-cellular0/0/0]dialer enable-circular
[Huawei-cellular0/0/0]dialer-group 1
[Huawei-cellular0/0/0]dialer number *99#
```


The dial control centre (DCC) is implemented in order to allow the link to activate the cellular connection. The dialer-rule command initiates the dialer-rule view where the rules are defined to enable IPv4 traffic to be carried over the interface with which the dialer group is associated. The dialer-rule <number> command refers to the dialer access group number. Under the cellular interface the dialer control centre (DCC) is enabled.

The AR2200 supports two DCC modes: Circular DCC (C-DCC) and resource-shared DCC (RS-DCC). The two modes are applicable to different scenarios. The Circular-Dial Control Centre (C-DCC) is applicable to medium or large-scale sites that have many physical links where as the Resource Shared-Dial Control Centre (RS-DCC) is applicable to small or medium-scale sites that have a few physical links but many connected interfaces. The two ends in communication can adopt different modes.

If C-DCC is enabled on a physical interface, only this interface can initiate calls to remote ends. If C-DCC is enabled on a dialer interface, one or multiple interfaces can initiate calls to remote ends. The dialer-group <number> associates the dialer access group created under the dialer-rule command with the given interface. The dialer-number <number> configures a dialer number for calling the remote end.

Configure NAT Role & Static Route


```
[Huawei]acl number 3002
[Huawei-acl-adv-3002]rule 5 permit ip source 192.168.1.0 0.0.0.255
[Huawei-acl-adv-3002]quit
[Huawei]interface cellular 0/0/0
[Huawei-cellular0/0/0]nat outbound 3002
[Huawei-cellular0/0/0]quit
[Huawei]ip route-static 0.0.0.0 0 cellular 0/0/0
```


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NAT is required to allow packets generated with a source address in the private address range of internal users to be translated to the public address of the cellular interface. As only one cellular interface address exists, Easy IP is implemented to allow the range of internal users to make full use of a single interface address through port address translation.

An ACL is used to identify the private network range for which translation to the public interface address will occur and be bound to the network address translation, through the Easy IP *nat outbound* <*acl-number*> command. A default static route is also created to generate a route via the cellular 0/0/0 interface that will initiate the PPP negotiation and allow a public address to be assigned to the cellular interface.

Ultimately the enterprise intranet uses only one network segment 192.168.1.0/24 and has subscribed to the Wideband Code Division Multiple Access (WCDMA) service, and the router uses the DCC function to connect the enterprise to the Internet. The enterprise has obtained APN 3GNET and dial string *99# from a carrier.

Configuration Validation

```
<Huawei> display interface Cellular 0/0/0
Cellular0/0/0 current state : UP
Line protocol current state : UP (spoofing)
Description:HUAWEI, AR Series, Cellular0/0/0 Interface
Route Port, The Maximum Transmit Unit is 1500
Internet Address is negotiated, 203.161.70.97/32
Link layer protocol is PPP
LCP opened, IPCP opened
Last physical up time : 2013-06-08 10:53:15
Last physical down time : 2013-06-08 10:53:13
Current system time: 2013-06-08 11:35:23
Modem State: Present
.....
```


Following the successful configuration of the parameters for establishing the 3G network through the circular DCC and PPP negotiation, an IP address will be assigned to the cellular interface. The results of the established connection can be verified through the *display interface cellular* command where the state of the interface and the negotiated address can be determined. If no IP address is assigned to the interface, possibly due to no communication activity on the link or failure during link negotiate, the system will display "Internet protocol processing : disabled". The Modem State is used to determine whether a 3G modem has been connected to the 3G Cellular interface.

Configuration Validation

```
[Huawei] display nat outbound
 NAT Outbound Information:
 ----------------------------------------------------------------------
 Interface          Acl      Address-group/IP/Interface       Type
 ----------------------------------------------------------------------
 Cellular0/0/0      3002           203.161.70.97              easyip
 ----------------------------------------------------------------------
  Total : 1
```

- Easy IP address translation is applied to the cellular interface.
- Internal host addresses are mapped to the cellular IP address.

The *display nat outbound* command can again be used to validate the configuration of Easy IP in relation to the establishment of the cellular backup link. The output verifies that the cellular interface is implementing Easy IP for address translation, as well as providing verification of the external WAN link address to which internal (private network) addresses are being translated. Additionally the ACL enables verification of the address range to which the translation is applicable. The ACL 3002 is implemented in this case and as defined in the ACL rules, network 192.168.1.0/24 is the address range that is capable of being translated to the public cellular address.

Summary

- How is failover to the cellular network supported in the event of a failure of the primary network?

1. In the event that the primary route fails, a default static route will provide an alternative route via the cellular interface that will initiate the cellular connection. The dial control center will support the initiation of the connection that is negotiated over PPP.

Thank you

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Access Control Lists

HUAWEI TECHNOLOGIES CO., LTD.

Foreword

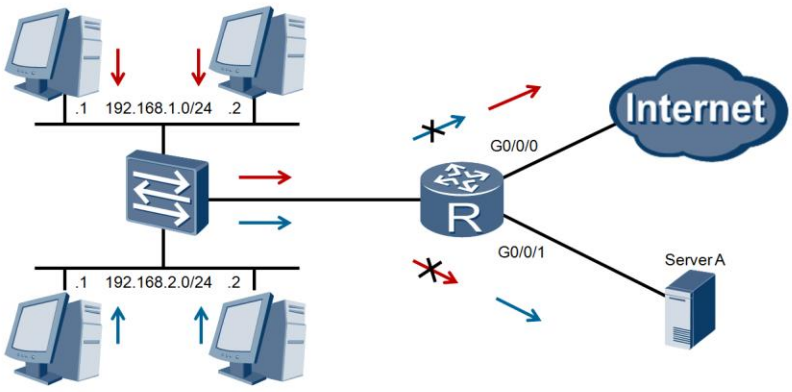
Many technologies and protocols depend on Access Control Lists (ACL) for greater management and filtering of traffic as part of security measures or application requirements. The implementation of ACL in support of other technologies, and as a form of security are required to be understood, and as such common forms of ACL solutions are introduced.

Objectives

Upon completion of this section, trainees will be able to:

- Describe the applications for ACL in the enterprise network.
- Explain the decision making behavior of Access Control Lists
- Successfully implement Basic and Advanced Access Control Lists.

Filtering Restricted Traffic



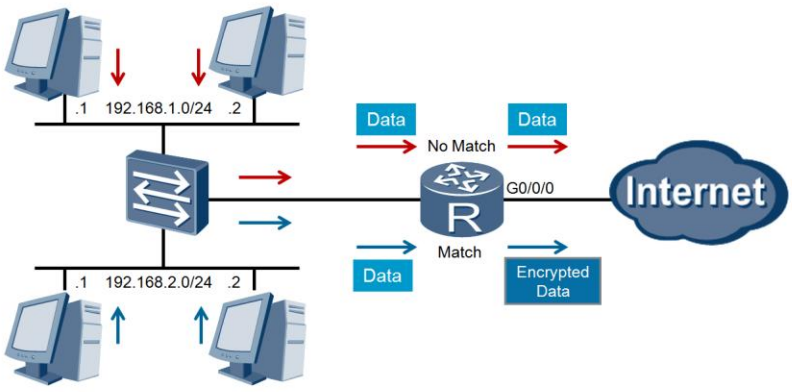
- Packets are filtered based on addresses and parameters.
- Rules allow packets to be either permitted or denied.

HUAWEI

An Access Control List (ACL) is a mechanism that implements access control for a system resource by listing the entities based on specific parameters that are permitted to access the resource, as well as the mode of access that is granted. In general, an ACL can be understood as a means for filtering, and can be applied to control the flow of traffic as well as identify traffic to which special operations should be performed.

A common application involves a gateway that may have a forwarding destination to multiple networks, however may contain an ACL that manages which traffic can flow to which destination. In the example given, the network 192.168.1.0/24 is generally seen as capable of accessing the external network, in this case the Internet, whereas hosts that are represented by the 192.168.2.0/24 network are unable to forward traffic in the same manner, and therefore resulting in a transmission failure. In the case of Server A, the reverse applies with permission for access being granted by the gateway to network 192.168.2.0/24 but restricted for all hosts that are part of the 192.168.1.0/24 network.

Filtering Interesting Traffic



- Packets can be filtered to manipulate behavior and actions.
- Parameters and forwarding behavior can be altered as a result.

HUAWEI

Where filtering is performed based on interesting traffic, there is no general restriction made but instead additional operations are likely to be performed which affects the current data. The example demonstrates a scenario where inbound data is filtered based on certain criteria such as in this case, the source IP address, and where an access control list is found to apply to data, associated actions are taken. Common actions may involve the changing of parameters in routed IP traffic for protocols such as the route metrics in RIP and OSPF, and also in initiating encrypted network communications for the interesting traffic, as is often applied as part of technologies such as Virtual Private Networks (VPN).

ACL Types

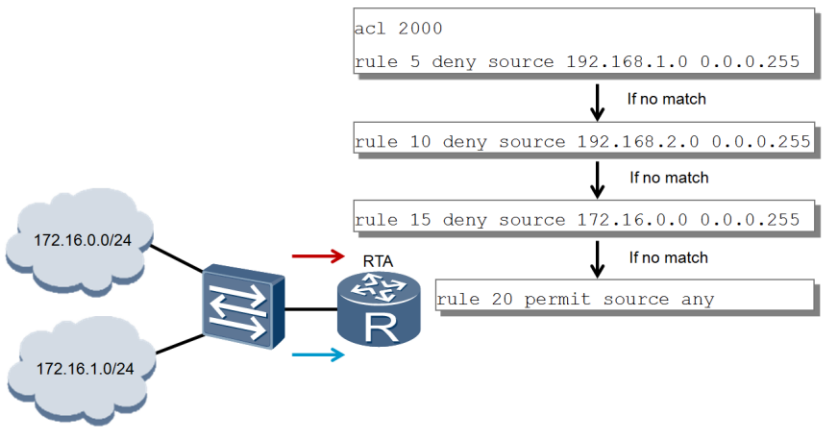
Types	Value Ranges	Parameters
Basic	2000-2999	Source IP
Advanced	3000-3999	Source & Destination IP, Protocol, Source & Destination Port
Layer 2 ACL	4000-4999	MAC Address

- Three forms of ACL can be applied to AR2200 series routers.
- Parameters for packet filtering vary for each ACL type.

There are three general ACL types that are defined as part of the ARG3 series, including basic, advanced and layer2 access control list types. A basic ACL matches packets based on information such as source IP addresses, fragment flags, and time ranges, and is defined by a value in the range of 2000-2999. An advanced ACL provides a greater means of accuracy in parameter association, and matches packets based on information such as source and destination IP addresses, source and destination port numbers, and protocol types.

Advanced ACL are associated with a value range from 3000-3999. Lastly is the layer 2 ACL which matches packets based on packet based Layer 2 information, such as source MAC addresses, destination MAC addresses, and Layer 2 protocol types. Traffic is filtered based on rules containing the parameters defined by each type of ACL.

ACL Rule Management

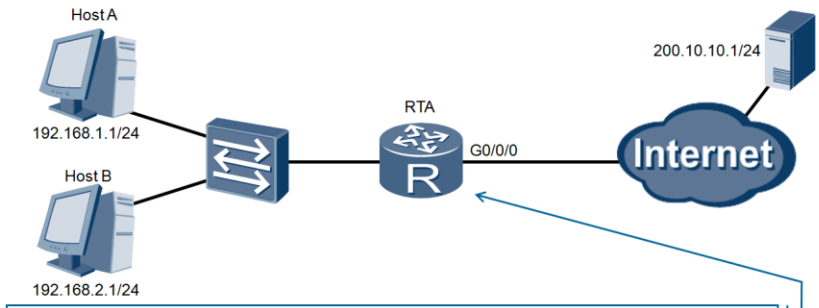


- Rules are used to manage the decision process for each ACL

Access Control Lists work on the principle of ordered rules. Each rule contains a permit or deny clause. These rules may overlap or conflict. One rule can contain another rule, but the two rules must be different. The AR2200 supports two types of matching order: configuration order and automatic order. The configuration order indicates that ACL rules are matched in ascending order of rule identifiers, while the automatic order follows the depth first principle that allows more accurate rules to be matched first. The configuration order is used by default and determines the priorities of the rules in an ACL based on a rule ID. Rule priorities are as such able to resolve any conflict between overlapping rules. For each rule ID the ACL will determine whether the rule applies. If the rule does not apply, the next rule will be considered. Once a rule match is found, the rule action will be implemented and the ACL process will cease. If no rule matches the packet, the system does not process the packet.

In the example, packets originating from two networks are subjected to an ACL within RTA. Packets from networks 172.16.0.0 and 172.17.0.0 will be assessed based on rule ID (configuration) order by default. Where the rule discovers a match for the network based on a wildcard mask, the rule will be applied. For network 172.16.0.0, rule 15 will match any packets with the address of 172.16.0.X where X may refer to any binary value in the octet. No specific rule matching the network 172.17.0.0 is found in the access control list and so will not be subjected to the ACL process, however in the interests of good ACL design practice, a catch all rule has been defined in rule 20 to ensure that all networks for which there is no specifically defined rule, are permitted to be forwarded.

Basic ACL




```
[RTA]acl 2000
[RTA-acl-basic-2000]rule deny source 192.168.1.0 0.0.0.255
[RTA-acl-basic-2000]rule permit source 192.168.2.0 0.0.0.255
[RTA]interface GigabitEthernet 0/0/0
[RTA-GigabitEthernet0/0/0]traffic-filter outbound acl 2000
```


The creation of a basic access control list requires that the administrator first identify the traffic source to which the ACL is to apply. In the example given, this refers to the source locations containing an IP address in the 192.168.1.0/24 range for which all packets containing a source IP address in this range will be discarded by the gateway. In the case of hosts that make up the 192.168.2.0/24 network range, traffic is permitted and no further action is taken for these packets. The basic ACL is applied to the interface Gigabit Ethernet 0/0/0 in the outbound direction, therefore only packets that meet both the interface and direction criteria will be subjected to ACL processing.

Configuration Validation

```
Host A> ping 200.10.10.1
Ping 200.10.10.1: 32 data bytes, Press Ctrl_C to break
Request timeout!
Request timeout!
Request timeout!
...
```

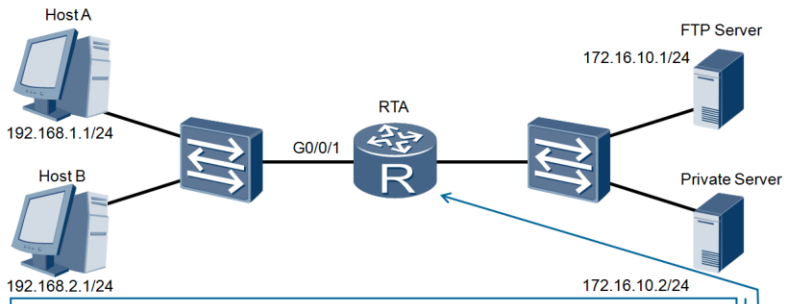
```
[RTA]display acl 2000
Basic ACL 2000, 2 rules
Acl's step is 5
 rule 5 deny source 192.168.1.0 0.0.0.255 (5 matches)
 rule 10 permit source 192.168.2.0 0.0.0.255
```

- The rules and matching order can be verified for each ACL.
- Basic ACL rules are matched based on each source IP address.

The validation of the configured basic ACL can be achieved through the *display acl <acl-number>* where the acl-number refers to the basic ACL number that has been assigned to the configured ACL. The resulting output confirms the rules that have been created to deny (drop) any IP packets with the source IP address in the range 192.168.1.0/24 and permit addressing in the range 192.168.2.0/24.

It should also be noted that each rule is automatically assigned a rule number as part of the access control list creation. The rule number defines the order in which the rules are processed and set in increments of 5 by default in Huawei ARG3 series routers. There is an ACL step between rule numbers. For example, if an ACL step is set to 5, rules are numbered 5, 10, 15, and so on. If an ACL step is set to 2 and rule numbers are configured to be automatically generated, the system automatically generates rule IDs starting from 2. The step makes it possible to add a new rule between existing rules. It is possible to configure the rule number as part of the basic ACL where required.

Advanced ACL




```
[RTA]acl 3000
[RTA-acl-adv-3000]rule deny tcp source 192.168.1.0 0.0.0.255
destination 172.16.10.1 0.0.0.0 destination-port eq 21
[RTA-acl-adv-3000] rule deny ip source 192.168.2.0 0.0.0.255
destination 172.16.10.2 0.0.0.0
[RTA-GigabitEthernet0/0/1]traffic-filter inbound acl 3000
```


Advanced access control lists enable filtering based on multiple parameters to support a greater detailed route selection process. While a basic ACL provides filtering based on the source IP address, Advanced ACL are capable of filtering based on the source and destination IP, source and destination port numbers, protocols of both the network and transport layer and parameters found within each layer such as IP traffic classifiers and TCP flag values (SYN|ACK|FIN etc).

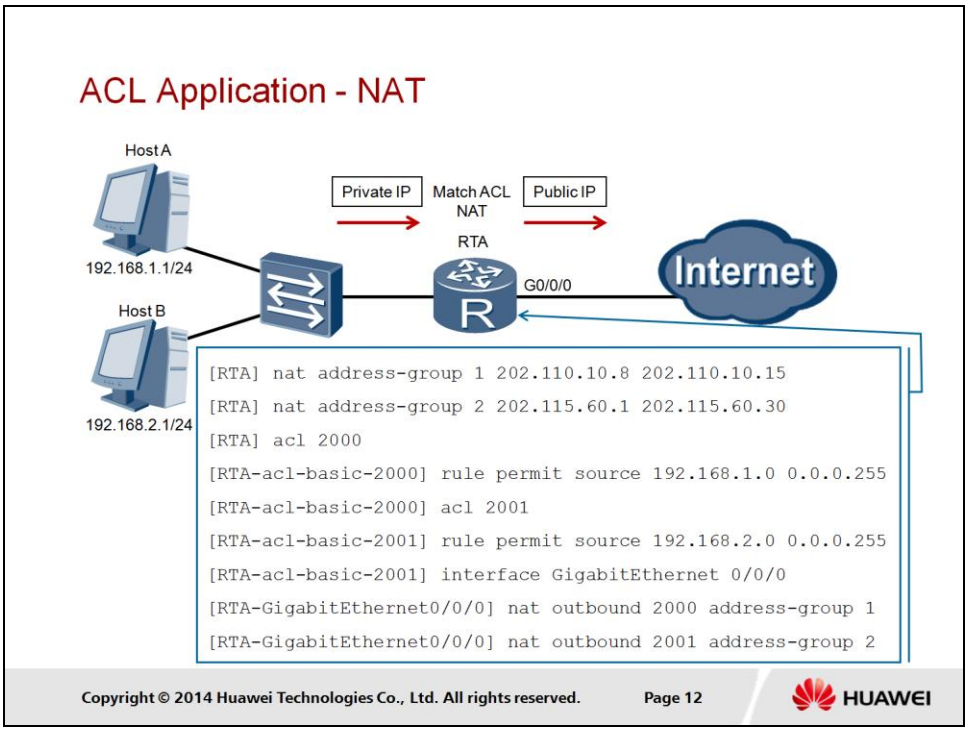
An advanced ACL is defined by an ACL value in the range of 3000-3999 as displayed in the example, for which rules are defined to specify restriction of TCP based packets that originate from all source addresses in the range of 192.168.1.1 through to 192.168.1.255 where the destination IP is 172.16.10.1 and the destination port is port 21. A similar rule follows to define restriction of all IP based packets originating from sources in the 192.168.2.0/24 range from reaching the single destination of 172.16.10.2. A catch all rule may generally be applied to ensure that all other traffic is processed by the ACL, generally through a permit or deny statement for all IP based packets.

Configuration Validation

```
[RTA]display acl 3000
Advanced ACL 3000, 2 rules
Acl's step is 5
rule 5 deny tcp source 192.168.1.0 0.0.0.255 destination 172.16.10.1 0
destination-port eq ftp
rule 10 deny ip source 192.168.2.0 0.0.0.255 destination 172.16.10.2 0
```

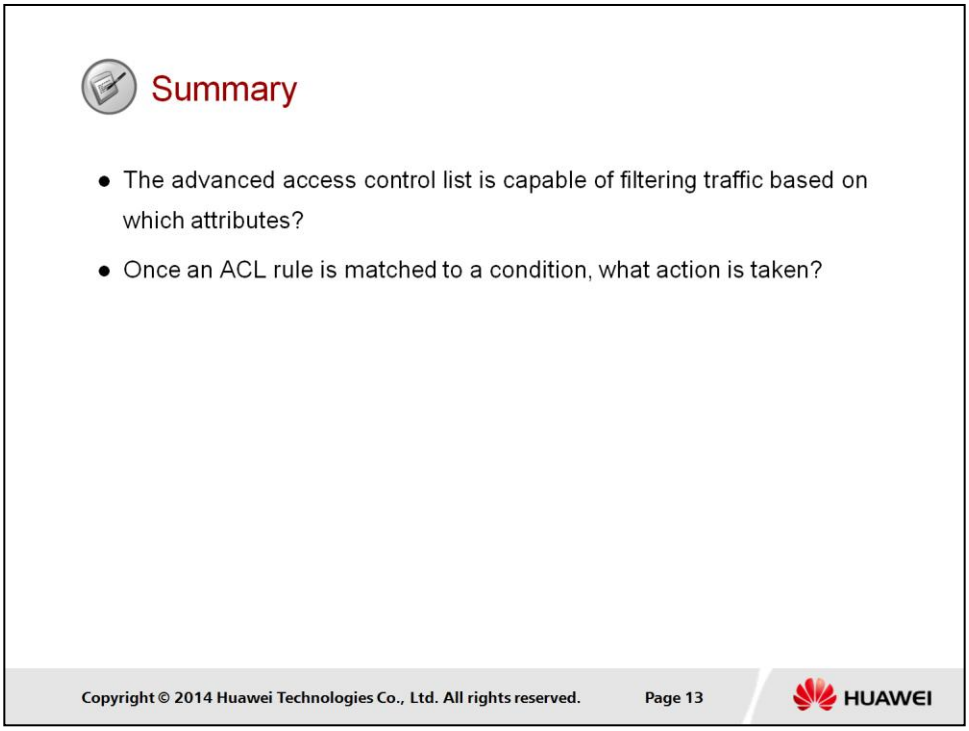
- Advanced ACL rules defined in the range of 3000-3999 add complexity due to the number of parameters used for filtering.

The validation of the configured advanced ACL can be achieved through the *display acl <acl-number>* where the acl-number refers to the advanced ACL number that has been assigned to the configured ACL. The resulting output confirms that three rules have been created to deny any TCP packets with the source IP address in the range 192.168.1.0/24 destined for 172.16.10.1 from reaching port 21(ftp), and from any source IP address in the range of 192.168.2.0/24 from reaching the destination IP address of 172.16.10.2 , while permitting all other IP traffic.



ACL can also be applied to the Network Address Translation (NAT) operation to allow filtering of hosts based on IP addresses to determine which internal networks are translated via which specific external address pools should multiple pools exist. This may occur where an enterprise network is a customer to connections from multiple service providers for which various internal users that are considered part of different networks/sub-networks wish to be translated and forwarded based on a specific address group, potentially occurring over alternative router uplink interfaces to the different service provider networks.

In the example given, a simplified example of this is recreated where hosts within the internal network are to be filtered based on basic ACL rules for which a dynamic NAT solution is applied that allows translation to a given public address of a certain address group. In particular hosts originating from the 192.168.1.0/24 network will be translated using public addresses in the pool associated with address group 1, while hosts in the 192.168.2.0/24 network will be filtered based on the pool associated with address group 2. The nat outbound <acl-number> address-group <address-group number> command is implemented under the Gigabit Ethernet interface view to bind NAT in the outbound direction with the ACL, and the related IP address range is referenced by the specified address group.



1. Advanced ACL are capable of filtering based on the source and destination IP, source and destination port numbers, protocols of both the network and transport layer and parameters found within each layer such as IP traffic classifiers and TCP flag values (SYN|ACK|FIN etc).

2. Once a rule match is found in the access control list to a tested condition, the rule action will be implemented and the remaining ACL process will not continue.

Thank you

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AAA

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Foreword

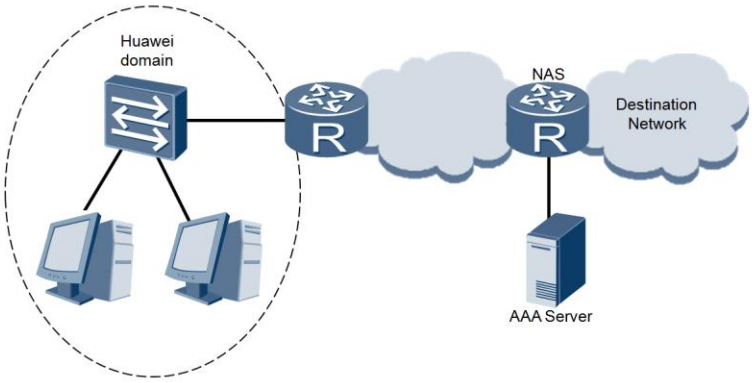
AAA defines a security architecture that is comprised of three functions referred to as Authentication, Authorization and Accounting. Each of these functions represents a modular component which can be applied as components of the security framework implemented by an enterprise, and often managed through the use of client/server based protocols such as RADIUS and HWTACACS. Implementation of the AAA architecture as a solution for enhanced functionality is introduced to reinforce the overall security framework of the enterprise network.

Objectives

Upon completion of this section, trainees will be able to:

- Describe the schemes of the AAA security architecture.
- Successfully configure Authentication and Authorization schemes.

AAA Application

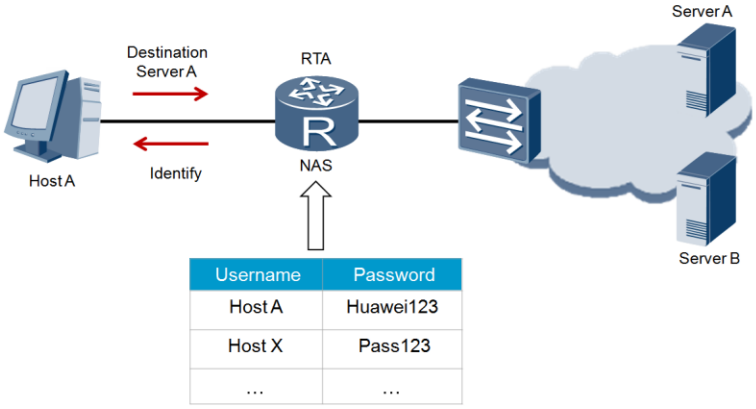


- AAA enables the authentication, authorization and accounting of users attempting to access destination network resources.

HUAWEI

Authentication, Authorization, and Accounting (AAA) is a technology that is used to check whether a user has permission to access a network, authorizes exactly what a user is allowed to access, and makes records regarding the network resources used by a user. VRP is capable of supporting the AAA authentication and authorization services locally within the ARG3 series of routers, which is commonly referred to as a Network Access Server or NAS, however accounting services are generally supported through an external AAA accounting server. The example here demonstrates how users that are considered part of the Huawei domain are able to gain access to resources that are located within the displayed destination network. The Network Access Server (NAS) operates as the gateway device that may perform authentication and authorization of users, or support the AAA server's authentication and authorization of users. In the case of the AAA server, those users that are authenticated and authorized to access the destination network may also initiate accounting within the AAA server for the duration of a users active session.

Authentication



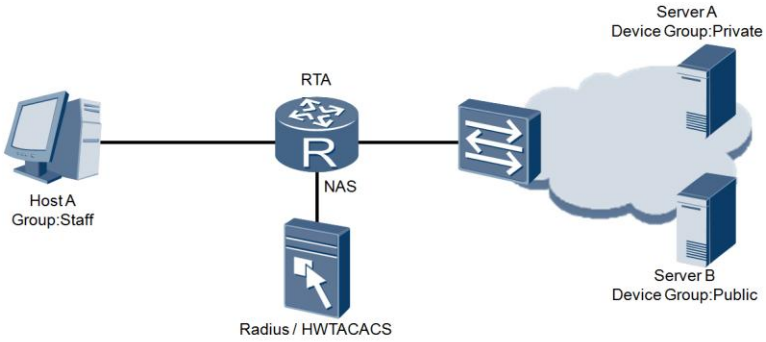
- User access is managed based on an authentication scheme.

HUAWEI

AAA supports three authentication modes. Non-authentication completely trusts users and does not check their validity. This is seldom used for obvious security reasons. Local authentication configures user information, including the user name, password, and attributes of local users, on a Network Access Server (NAS). Local authentication has advantages such as fast processing and low operation costs. The disadvantage of local authentication is the limited information storage because of the hardware. Remote authentication configures user information including the user name, password, and attributes on the authentication server. AAA can remotely authenticate users using the Remote Authentication Dial In User Service (RADIUS) protocol or the Huawei Terminal Access Controller Access Control System (HWTACACS) protocol. As the client, the NAS communicates with the RADIUS or HWTACACS server.

If several authentication modes are used in an authentication scheme, these authentication modes take effect in the sequence with which the configuration modes were configured. If remote authentication was configured before local authentication and if a login account exists on the local device but is unavailable on the remote server, the AR2200 considers the user using this account as having failed to be authenticated by the remote authentication, and therefore local authentication is not performed. Local authentication would be used only when the remote authentication server did not respond. If non-authentication is configured, it must be configured as the last mode to take effect.

Authorization

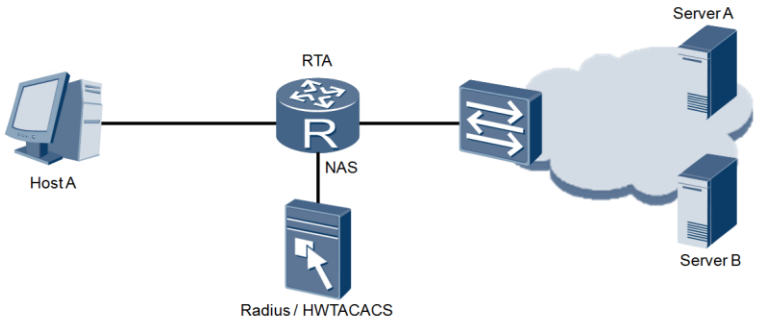


Device Group	User Group	Time	Privilege
Private	Admin	09:00-12:00	15
Public	Admin	09:00-18:00	15
Public	Staff	09:00-18:00	2

The AAA Authorization function is used to determine the permission for users to gain access to specific networks or devices, as such AAA supports various authorization modes. In non-authorization mode users are not authorized. Local authorization however authorizes users according to the related attributes of the local user accounts configured on the NAS. Alternatively, HWTACACS can be used to authorize users through a TACACS server.

An If-authenticated authorization mode can be used where users are considered authorized in the event that those users are able to be authenticated in either the local or remote authentication mode. RADIUS authorization authorizes users after they are authenticated using a RADIUS authentication server. Authentication and authorization of the RADIUS protocol are bound together, so RADIUS cannot be used to perform only authorization. If multiple authorization modes are configured in an authorization scheme, authorization is performed in the sequence in which the configuration modes were configured. If configured, non-authorization must be the last mode to take effect.

Accounting

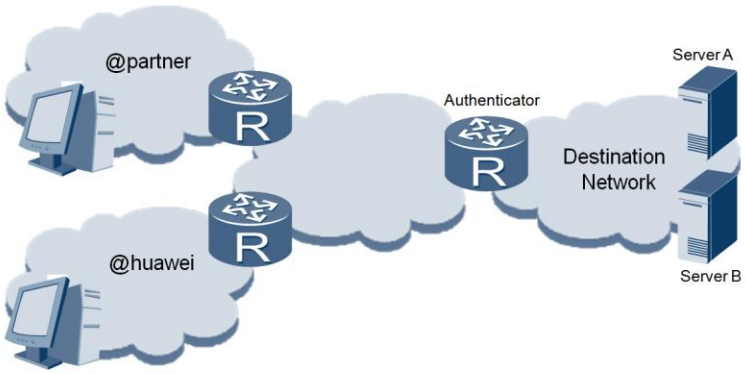


Login Time	Username	Uptime	Bandwidth Up/Down
May/01/2013 03:20:55	Host A	01:22:15	496.2KB / 21MB
Apr/16/2013 12:40:51	Host X	00:30:12	123KB / 1MB

The accounting process can be used to monitor the activity and usage of authorized users who have gained access to network resources. AAA accounting supports two specific accounting modes. Non-accounting can be used, and provides free services for users without any record of users, or activity logs.

Remote accounting on the other hand supports accounting using the RADIUS server or the HWTACACS server. These servers must be used in order to support accounting due to the requirement for additional storage capacity necessary to store information regarding access and activity logs of each authorized user. The example demonstrates a very general representation of some of the typical information that is commonly recorded within user accounting logs.

AAA Domains



- Different schemes can be applied to users in different domains.

HUAWEI

The device uses domains to manage users. Authentication, authorization, and accounting schemes can be applied to a domain so that the device can authenticate, authorize, or charge users in the domain using the schemes. Each user of the device belongs to a domain. The domain to which a user belongs is determined by the character string suffixed to the domain name delimiter that can be @, |, or %.

For example, if the user name is user@huawei, the user belongs to the huawei domain. If the user name does not contain an @, the user belongs to the default domain named default in the system. The device has two default domains: default (global default domain for common access users) and default_admin (global default domain for administrators). The two domains can be modified but cannot be deleted.

If the domain of an access user cannot be obtained, the default domain is used. The default domain is used for access users such as NAC access users. Local authentication is performed by default for users in this domain. The default_admin domain is used for administrators such as the administrators who log in using HTTP, SSH, Telnet, FTP, and terminals. Local authentication is performed by default for users in this domain. The device supports a maximum of 32 domains, including the two default domains.

AAA Local Configuration


```
[RTA]aaa
[RTA-aaa]local-user huawei password cipher hello123
[RTA-aaa]authentication-scheme auth1
[RTA-aaa-authen-auth1]authentication-mode local
[RTA-aaa-authen-auth1]quit
[RTA-aaa] authorization-scheme auth2
[RTA-aaa-author-auth2]authorization-mode local
[RTA-aaa-author-auth2]quit
[RTA-aaa]domain huawei
[RTA-aaa-domain-huawei]authentication-scheme auth1
[RTA-aaa-domain-huawei]authorization-scheme auth2
```

- Authentication and authorization can be applied on the AR2200E

  HUAWEI

The AR2200 router can be used as a Network Access Server (NAS) in order to implement authentication and authorization schemes. The example demonstrates the typical process that is necessary in order to successfully implement local AAA. Users for authentication must be created using the local-user <user-name> password [cipher \simple]<password> privilege level <level > command. This command specifies a user name. If the user-name contains a domain name delimiter such as @, the character before @ is the user name and the character behind @ is the domain name. If the value does not contain @, the entire character string is the user name and the domain name is the default domain.

An authentication scheme is created in order to authenticate users and must be created before additional authentication-relevant configuration can be performed. The authentication scheme must be defined as either local, radius, hwtacacs or none. With the exception of the none parameter, the other authentication modes can be listed in the order in which authentication is to be attempted, for example should the authentication-mode hwtacacs local command be used, and if HWTACACS authentication fails, the AR2200E router will start local authentication. The authorization scheme must also be created to authorize users (except in the case of Radius server support), by creating an authorization scheme defining the authorization-mode. The authorization-mode command supports modes for hwtacacs, local, if-authenticated and none authorization.

The domain <domain-name> command is used to create a new domain, and the implementation of the authentication-scheme <authentication-scheme> and the authorization-scheme <authorization-scheme> under the domain view will apply the authentication and authorization schemes to that domain.

AAA Local Configuration Verification

```
[Huawei]display domain name huawei
  Domain-name                     : huawei
  Domain-state                    : Active
  Authentication-scheme-name      : auth1
  Accounting-scheme-name          : default
  Authorization-scheme-name       : auth2
  Service-scheme-name             : -
  RADIUS-server-template          : -
  HWTACACS-server-template        : -
  User-group                      : -
```

- Local AAA schemes are associated with individual domains.

The configuration of the local AAA domain and schemes for both authentication and authorization can be verified through the *display domain* or *display domain name <domain-name>* commands. Using the *display domain* command provides brief information regarding all domains that have been created, including the domain name and a domain index that is used to reference each created domain.

The display domain name <domain-name> command provides specific configuration details in reference to the domain defined under the domain-name parameter. Along with the domain-name is the domain-state which presents as either Active or Block, where block refers to a domain that is in blocking state, and prevents users in this domain from being able to log in. This is implemented through an optional *state* [*active* | *block*] command implemented under the AAA domain view. A domain is in an active state after being created by default.

The authentication-scheme-name associates the created authentication-scheme with the domain; the same applies for the authorization-scheme. The accounting-scheme is not configured locally and therefore an accounting scheme has not been associated with the created domain, and as such the default accounting scheme is listed for the domain by default. In the event that non-local (i.e RADIUS or HWTACACS) configuration is implemented to support AAA services, these will be associated with the domain under the server-template fields.

Summary

- Which two AAA schemes are supported when configuring VRP to support the local mode?
- If no domain is defined for users, what action is taken?

1. The configuration of VRP in local mode will supports both authentication and authorization schemes, the accounting scheme requires the support of remote management through a HWTACACS or RADIUS server.

2. If a user is created without defining the domain to which the user belongs, the user will be automatically associated with the default domain, named default.

Thank you

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Securing Data with IPsec VPN

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Foreword

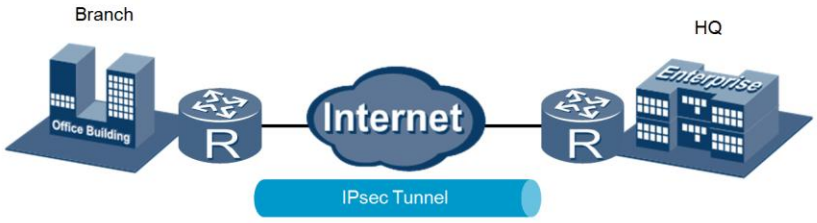
Early TCP/IP protocol development did very little for ensuring the security of communications between peering devices. As networks evolved so did the need for greater protection of the data transmitted. Solutions for data protection were developed, from which IPsec emerged as a security architecture for the implementation of confidentiality, integrity and data origin authentication, primarily through the support of underlying protocols. IPsec remains a key framework in the protection of data, which has seen an integration of IPsec components adopted into the next generation of TCP/IP standards.

Objectives

Upon completion of this section, trainees will be able to:

- Explain the basic principles of the IPsec security architecture.
- Configure IPsec peering between two devices.

IPsec VPN Application



- Facilitates the establishment of private network communication over a public network infrastructure.

HUAWEI

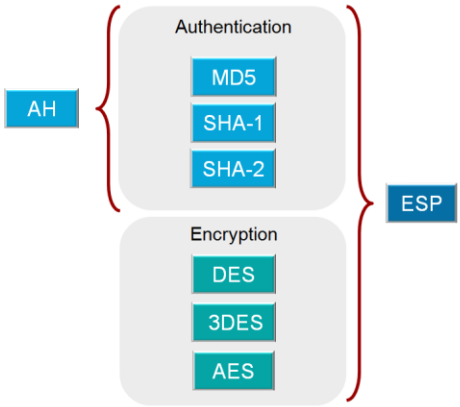
Internet Protocol security (IPsec) is a protocol suite defined by the Internet Engineering Task Force (IETF) for securing Internet Protocol (IP) communication by authenticating and/or encrypting each IP packet of a communication session. Two communicating parties can encrypt data and/or authenticate the data originating at the IP layer to ensure data confidentiality, integrity and service availability.

Confidentiality is the security service that protects the disclosure of typically application level data, but also encompasses disclosure of communication which also can be a concern in some circumstances. Traffic flow confidentiality is the service that is applied to conceal source and destination addresses, message length, or frequency of communication.

IPsec supports two forms of integrity; connectionless and a form of partial sequence integrity. Connectionless integrity is a service that detects modification of an individual IP datagram, without regard to the ordering of the datagram in a stream of traffic. The form of partial sequence integrity offered in IPsec is referred to as anti-replay integrity, and it detects arrival of duplicate IP datagrams (within a constrained window). This is in contrast to connection-oriented integrity, which imposes more stringent sequencing requirements on traffic, e.g., to be able to detect lost or re-ordered messages. Although authentication and integrity services often are cited separately, in practice they are intimately connected and almost always offered in tandem.

Availability, when viewed as a security service, addresses the security concerns engendered by attacks against networks that deny or degrade service. For example, in the IPsec context, the use of anti-replay mechanisms in the underlying protocols, specifically AH and ESP, support availability to prevent attacks that malicious users initiate by resending captured packets.

IPsec VPN Architecture



- Confidentiality and integrity of services are supported through authentication and encryption based protocols.

HUAWEI

IPsec uses two protocols to provide traffic security, Authentication Header (AH) and Encapsulating Security Payload (ESP). The IP Authentication Header (AH) provides connectionless integrity, data origin authentication, and an optional anti-replay service. The Encapsulating Security Payload (ESP) protocol may provide confidentiality (encryption), and limited traffic flow confidentiality.

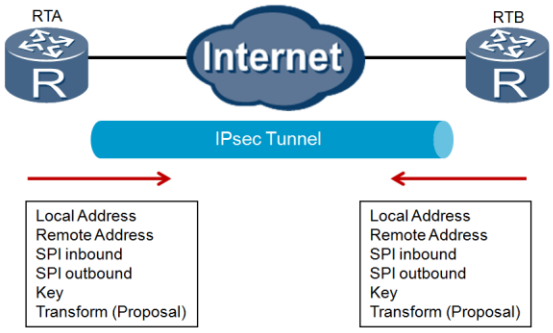
ESP optionally provides confidentiality for traffic. The strength of the confidentiality service depends in part on the encryption algorithm employed, for which three main forms of encryption algorithm are possible. ESP may also optionally provide authentication, however the scope of the authentication offered by ESP is narrower than for AH since the external IP header (tunnel mode) and the ESP header is/are not protected under ESP authentication.

Data Encryption Standard with Cipher Block Chaining (DES-CBC) is a symmetric secret key algorithm that uses a key size of 64-bits, but is commonly known as a 56-bit key as the key has 56 significant bits; the least significant bit in every byte is the parity bit. Its use today is limited due to the capability for computational power to perform brute force attacks within a significantly limited time frame. Triple Data Encryption Standard (3DES) is a 168 bit encryption algorithm that involves an iteration of the DES process with the addition of an initialization vector (IV), a value used to disguise patterns in encrypted data to improve the overall confidentiality of data. The Advanced Encryption Standard (AES) supports up to 256 bit encryption employing again the CBC and IV for additional strength of encryption. As encryption becomes additionally more complex, so does the processing time needed to achieve encryption and decryption.

AH supports an MD5 algorithm that takes as input, a message of arbitrary length and produces as output a 128-bit "fingerprint" or "message digest" of that input, while the SHA-1 produces a 160-bit message digest output. SHA-2 represents a next generation of authentication algorithms to extend security to authentication following discovery of certain weaknesses within SHA-1.

The term SHA-2 is not officially defined but is usually used to refer to the collection of the algorithms SHA-224, SHA-256, SHA-384, and SHA-512. VRP currently supported by the AR2200E however provides support only to SHA-256, SHA-384 and SHA-512, where the value represents the bit digest length.

Security Association



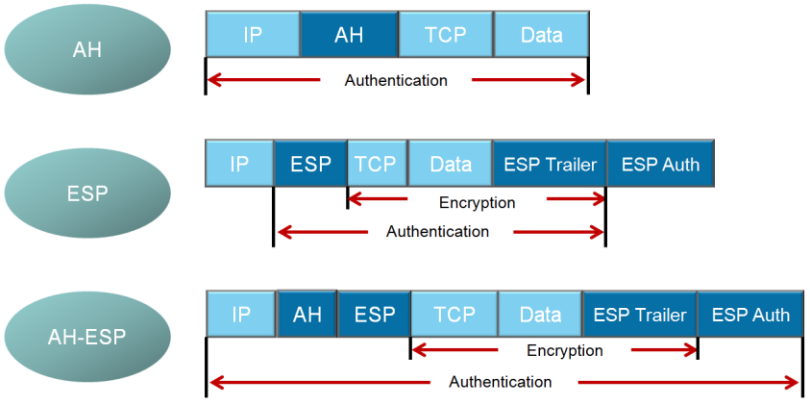
- Specifies parameters for connection establishment
- A Security Association defines parameters in only one direction.

HUAWEI

A Security Association (SA) denotes a form of connection that is established in a single direction through which security services relevant to the traffic are defined. Security services are attributed to an SA in the form of either AH, or ESP, but not both. If both AH and ESP based protection is applied to a traffic stream, then two (or more) SAs are created to attribute protection to the traffic stream. In order to secure bi-directional communication between two hosts, or two security gateways as shown in the example, two Security Associations (one in each direction) are required.

IPsec SAs are established in either a manual mode or Internet Key Exchange (IKE) negotiation mode. Establishing SAs in manual mode requires all information such as those parameters displayed in the example, be configured manually. The SAs established in manual mode however will never age. Establishing SAs using IKE negotiation mode is simpler as IKE negotiation information needs to be configured only on two peers and SAs are created and maintained by means of IKE negotiation, for which the complexity exists mainly in the IKE automated negotiation process itself, and as such will not be covered in detail here. The SA established in IKE negotiation has a time-based or traffic-based lifetime. When the specified time or traffic volume is reached, an SA becomes invalid. When the SA is about to expire, IKE will negotiate a new SA.

IPsec Transport Mode

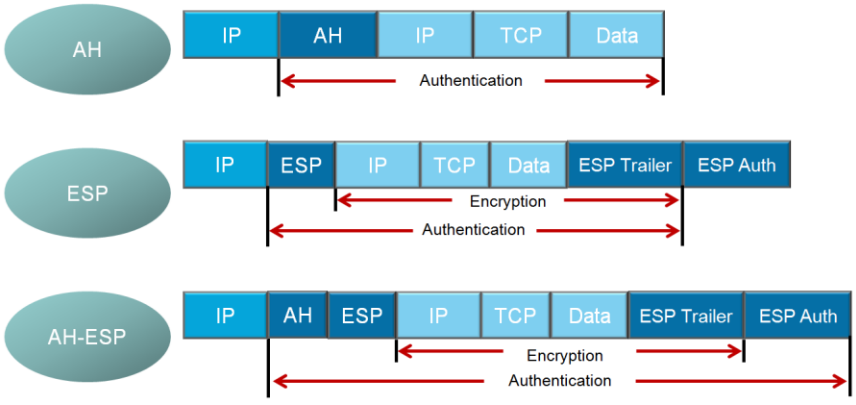


- Encapsulation modes are defined in Security Associations
- Transport mode secures only the payload of the packet.

HUAWEI

A transport mode SA is a security association between two hosts. In IPv4, a transport mode security protocol header appears immediately after the IP header, any options, and before any higher layer protocols (e.g., TCP or UDP). In transport mode the protocols provide protection primarily for upper layer protocols. An AH or ESP header is inserted between the IP header and the transport layer protocol header. In the case of ESP, a transport mode SA provides security services only for these higher layer protocols, not for the IP header or any extension headers preceding the ESP header. In the case of AH, the protection is also extended to selected portions of the IP header, as well as selected options.

IPsec Tunnel Mode



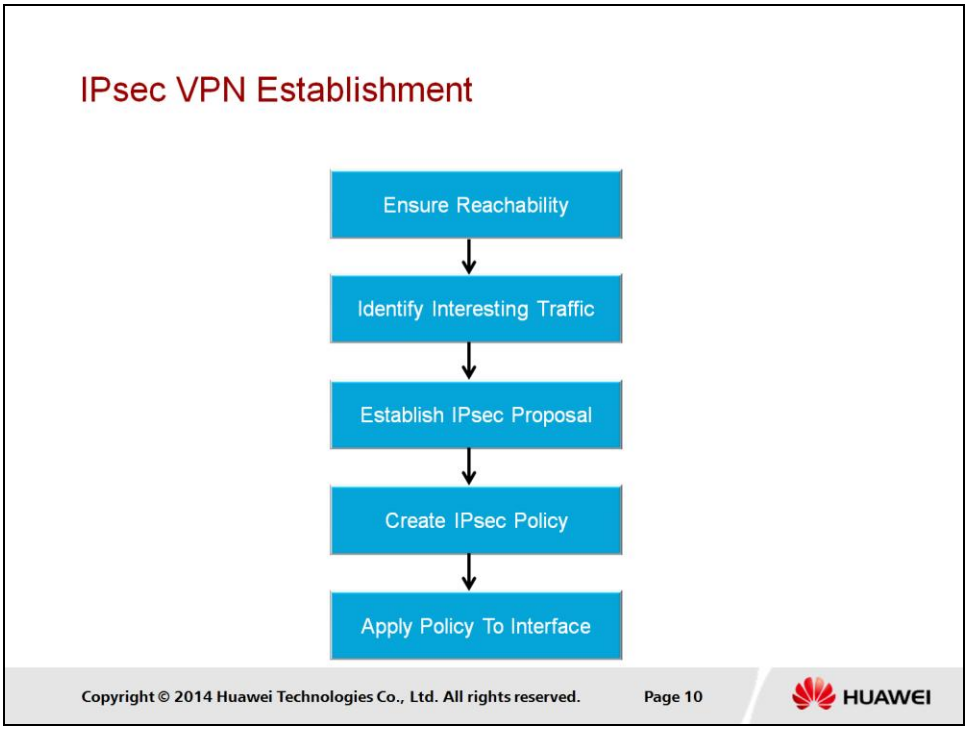
- Tunnel mode encapsulates packets in a second IP header.
- Security is extended to the inner IP header and packet payload

HUAWEI

In the IPsec context, using ESP in tunnel mode, especially at a security gateway, can provide some level of traffic flow confidentiality. The outer IP header source address and destination address identify the endpoints of the tunnel. The inner IP header source and destination addresses identify the original sender and recipient of the datagram, (from the perspective of this tunnel), respectively.

The inner IP header is not changed except to decrement the TTL, and remains unchanged during its delivery to the tunnel exit point. No change occurs to IP options or extension headers in the inner header during delivery of the encapsulated datagram through the tunnel. An AH or ESP header is inserted before the original IP header, and a new IP header is inserted before the AH or ESP header.

The example given shows the IPsec tunnel mode during TCP based packet transmission. If AH is also applied to a packet, it is applied to the ESP header, Data Payload, ESP trailer, and ESP Authentication Data (ICV), if fields are present.



The implementation of an IPsec Virtual Private Network (VPN) requires that network layer reachability between the initiator and the recipient is verified to ensure non-IPsec communication is possible before building any IPsec VPN. Not all traffic is required to be subjected to rules of integrity or confidentiality, and therefore traffic filtering needs to be applied to the data flow to identify the interesting traffic for which IPsec will be responsible. A data flow is a collection of traffic and can be identified by the source address/mask, destination address/mask, protocol number, source port number, and destination port number. When using VRP, data flows are defined using ACL groups. A data flow can be a single TCP connection between two hosts or all traffic between two subnets. The first step to configure IPsec involves defining these data flows.

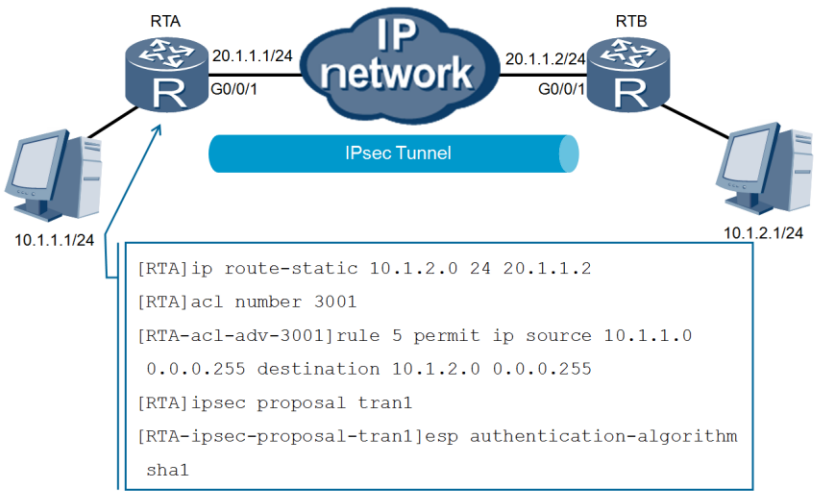
An IPsec proposal defines the security protocol, authentication algorithm, encryption algorithm, and encapsulation mode for the data flows to be protected. Security protocols AH and ESP can be used independently or together. AH supports MD5, SHA-1 and SHA-2 authentication algorithms. ESP supports three authentication algorithms (MD5, SHA-1 and SHA-2) and three encryption algorithms (DES, 3DES, and AES). IPsec also supports both transport and tunnel encapsulation modes.To Transmit the same data flow, peers on both ends of a security tunnel must use the same security protocol, authentication algorithm, encryption algorithm, and encapsulation mode. To implement IPsec between two gateways, it is advised to use tunnel mode to shield the actual source and destination IP addresses used in communication.

An IPsec policy defines the security protocol, authentication algorithm, encryption algorithm, and encapsulation mode for data flows by referencing an IPsec proposal. The name and sequence number uniquely identify an IPsec policy. IPsec policies are classified into IPsec policies used for manually establishing Sas, and IPsec policies used for establishing SAs through IKE negotiation.

To configure an IPsec policy used for manually establishing SAs, set parameters such as the key and SPI. If the tunnel mode is configured, the IP addresses for two endpoints of a security tunnel also must be set. When configuring an IPsec policy used for establishing SAs through IKE negotiation, parameters such as the key and SPI do not need to be set as they are generated through IKE negotiation automatically. IPsec policies of the same name but different sequence numbers comprise an IPsec policy group.

In an IPsec policy group, an IPsec policy with a smaller sequence number has a higher priority. After an IPsec policy group is applied to an interface, all IPsec policies in the group are applied to the interface. This enables different SAs to be used for different data flows.

IPsec VPN Configuration



  HUAWEI

Communication at the network layer represents the initial prerequisite of any IPsec VPN connection establishment. This is supported in this example through the creation of a static route pointing to the next hop address of RTB. It is necessary to implement static routes in both direction to ensure bidirectional communication between networks. An advanced ACL is created to identify the interesting traffic for which the IPsec VPN will be initiated, whereby the advanced ACL is capable of filtering based on specific parameters and will choose to either Discard, Bypass or Protect the filtered data.

The *ipsec proposal* command creates an IPsec proposal and enters the IPsec proposal view. When configuring an IPsec policy, it is necessary to reference an IPsec proposal for specifying the security protocol, encryption algorithm, authentication algorithm, and encapsulation mode used by both ends of the IPsec tunnel. A new IPsec proposal created using the *ipsec proposal* command by default uses the ESP protocol, DES encryption algorithm, MD5 authentication algorithm, and tunnel encapsulation mode. These can be redefined using various commands under the IPsec proposal view. The *transform* [*ah* | *ah-esp* | *esp*] will enable the current transform set to be altered, the *encapsulation-mode* {*transport* | *tunnel* } can alter the means used to encapsulate packets.

The authentication algorithm used by the ESP protocol can be set using the esp authentication-algorithm [md5 | sha1 | sha2-256 | sha2-384 | sha2-512] and esp encryption-algorithm [des | 3des | aes-128 | aes-192 | aes-256] for ESP encryption assignment. The AH protocol ah authentication-algorithm [md5 | sha1 | sha2-256 | sha2-384 | sha2-512] command enables AH based authentication to be set.

IPsec VPN Proposal Verification

```
[RTA]display ipsec proposal
 Number of proposals : 1
 IPSec proposal name : tran1
 Encapsulation mode  : Tunnel
 Transform           : esp-new
 ESP protocol        : Authentication SHA1-HMAC-96
                       Encryption     DES
```

- Displays the parameters of an IPsec proposal.
- Proposal parameters must match for both peering interfaces.

Verification of the parameters for the IPsec proposal can be achieved through the *display ipsec proposal* [*name <proposal-name>*] command. As a result it is possible to view select proposals or all proposals that have been created. The name defines the name given to the IPsec proposal created, while the encapsulation mode lists the current mode that is being used for this given proposal, which may either be transport or tunnel. Transform refers to the algorithms being applied where this may be AH, ESP or a combination of AH and ESP transforms. Depending on the transform defined, the associated algorithms will be listed.

IPsec Policy Creation

```
[RTA]ipsec policy P1 10 manual
[RTA-ipsec-policy-manual-P1-10]security acl 3001
[RTA-ipsec-policy-manual-P1-10]proposal tran1
[RTA-ipsec-policy-manual-P1-10]tunnel remote 20.1.1.2
[RTA-ipsec-policy-manual-P1-10]tunnel local 20.1.1.1
[RTA-ipsec-policy-manual-P1-10]sa spi outbound esp 54321
[RTA-ipsec-policy-manual-P1-10]sa spi inbound esp 12345
[RTA-ipsec-policy-manual-P1-10]sa string-key outbound esp simple huawei
[RTA-ipsec-policy-manual-P1-10]sa string-key inbound esp simple huawei
```

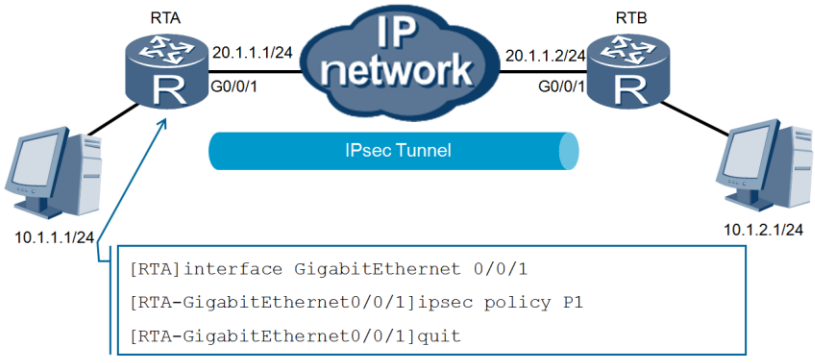
- IPsec policy defines parameters for establishing an IPsec SA
- An IPsec policy binds the proposal parameters and traffic filters.

The *policy-name* and *seq-number* parameters identify an IPsec policy. Multiple IPsec policies with the same IPsec policy name constitute an IPsec policy group. An IPsec policy group contains a maximum of 16 IPsec policies, and an IPsec policy with the smallest sequence number has the highest priority. After an IPsec policy group is applied to an interface, all IPsec policies in the group are applied to the interface to protect different data flows. Along with the policy-name and seq-number, the policy must define the creation of SA either manually or through IKE negotiation.

If IKE negotiation is used, parameters must be set using the *ipsec-policy-template* command, while where set manually parameters are configured as shown in the example. The created ACL is bound with the policy along with the created proposal. The *tunnel local* and *tunnel remote* commands define the interface at which the IPsec tunnel will establish and terminate. A source parameter index (SPI) is defined both inbound and outbound.

The inbound SPI on the local end must be the same as the outbound SPI on the remote end. The outbound SPI on the local end must be the same as the inbound SPI on the remote end. This number is used to reference each SA, bearing in mind that an SA applies in only one direction therefore requiring SPI in both directions to be specified. Finally authentication keys must be defined again both inbound and outbound. The outbound authentication key on the local end must be the same as the inbound authentication key on the remote end. Where IKE negotiation is used, both the SPI and authentication keys are automatically negotiated.

Applying Policies to Interfaces



- The IPsec policy is bound to the physical interface via which the IPsec peer is reachable.

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Following the creation of a policy and the binding of the proposal and ACL to the policy, the policy itself can be applied to the physical interface upon which traffic will be subjected to IPsec processing. In the example given an IPsec tunnel is to be established between interface Gigabit Ethernet 0/0/1 of RTA and Gigabit Ethernet 0/0/1 of RTB. Under the interface view, the *ipsec policy* command is used to apply the created policy to the interface.

One interface can only use one IPsec policy group. To apply a new IPsec policy group to the interface, the previous policy group must be firstly removed. An IPsec policy group that establishes an SA through IKE negotiation can be applied to multiple interfaces, whereas an IPsec policy group that establishes an SA in manual mode can be applied only to one interface. When sending a packet from an interface, the AR2200 matches the packet with each IPsec policy in the IPsec policy group. If the packet matches an IPsec policy, the AR2200 encapsulates the packet according to the policy. If not, the packet is sent without encapsulation.

IPsec Policy Verification

```
[RTA]display ipsec policy
==========================================
IPSec policy group: "P1"
Using interface: GigabitEthernet0/0/1
==========================================
    Sequence number: 10
    Security data flow: 3001
    Tunnel local  address: 20.1.1.1
    Tunnel remote address: 20.1.1.2
    Qos pre-classify: Disable
    Proposal name:tran1
...
```

- Policy must associate with the policy of the peering interface.

Using the *display ipsec policy* [*brief* | *name policy-name* [*seq-number*]] command, a specific IPsec policy or all IPsec policies can be viewed. The parameters of the IPsec policy displayed include the policy name and the sequence number of the policy, typically used to distinguish the priority of policies in a group where a lower sequence number represents a higher priority. The policy bindings such as the name of the proposal and ACL that is used to filter the traffic in a policy is displayed along with the local and remote tunnel addresses for the IPsec policy.

IPsec Policy Verification

```
...
Inbound ESP setting:
      ESP SPI: 12345 (0x3039)
      ESP string-key: huawei
      ESP encryption hex key:
      ESP authentication hex key:
   Outbound ESP setting:
      ESP SPI: 54321 (0xd431)
      ESP string-key: huawei
      ESP encryption hex key:
      ESP authentication hex key:
...
```

- Policy Key strings must match for communication to establish.

Specific parameter settings are also defined within the *display ipsec policy* command for SA in both the inbound and outbound directions. The SPI references the SA in each direction which can be used as part of the troubleshooting process to ensure that the SPI on the outbound local interface matches to that set for the inbound remote interface on the peer interface (that matches the tunnel remote address). The key string will also be defined for both the inbound and outbound SA to which the same local and remote configuration assessment can be performed.

Summary

- What is meant by a Security Association (SA)?
- What are the three possible actions that may be applied to IPsec filtered traffic?

1. A security association can be understood as a unidirectional connection or management construct that defines the services that will be used in order to negotiate the connection's establishment. The connection relies on matching SA in both directions in order to successfully establish secure bidirectional communication.

1. All traffic that is destined to be forwarded via the outbound interface on which IPsec is established will firstly be subjected to filtering via a Security Policy Database (SPD). This is generally in the form of an ACL that will determine whether the traffic should be either dropped (Discard), forwarded normally (Bypass), or forwarded over a secure IPsec boundary (Protect).

Thank you

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Generic Routing Encapsulation

HUAWEI TECHNOLOGIES CO., LTD.

Foreword

Limitations within IPsec VPN restrict the ability for routes to be carried between disparate site-to-site based networks, and allowing only for static route solutions. GRE provides a mechanism for the encapsulation of packets of one protocol into packets of another protocol. The application of GRE is as such implemented as a primary solution to the IPsec VPN limitations, for which knowledge of GRE is necessary to compliment the existing knowledge of IPsec VPN.

Objectives

Upon completion of this section, trainees will be able to:

- Explain how GRE can be applied to provide various solutions.
- Describe the principle behavior of GRE
- Configure GRE over IPsec.

GRE Application

- Supports encapsulation of protocols over other protocols.
- Enables routing between remote and disparate networks

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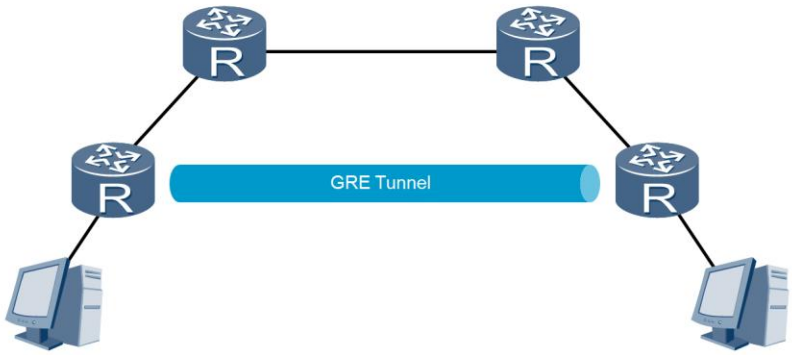
Cost effective solutions for private internetwork communication have utilized technologies such as IPsec to enable shared public networks to act as a medium for bridging the gap between remote offices. This solution provides secure transmission to IP packet payloads but does not enable routing protocols such as RIP and OSPF to be carried between the two tunnel endpoints. GRE was originally developed as a means of supporting the transmission of protocols such as IPX through IP networks, however over time the primary role of GRE has transitioned towards the support of routing based protocol tunneling.

GRE Scaling Solution for IGP



- Application allows for increased scalability of IGP networks.
- Capable of building a tunnel to resolve hop count limitations.

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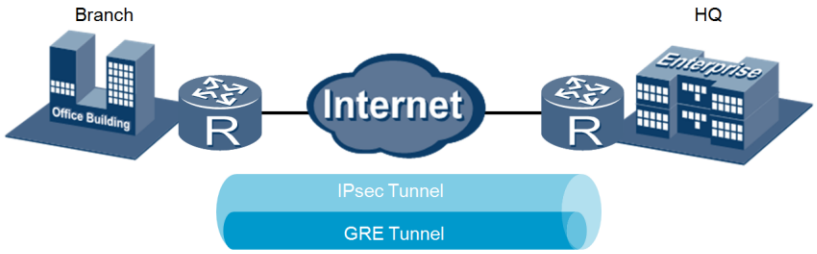
GRE can be applied within an autonomous system to overcome certain limitations found in IGP protocols. RIP routes offer for example a hop limit of 15 hops beyond which all routes are subjected to the count to infinity rule. The application of GRE in such environments will allow for a tunnel to be created over which routing updates can be carried, allowing the scale of such distance vector routing to be increased significantly where necessary.

IPsec VPN support for GRE



- GRE contains no means for confidentiality of GRE payloads.
- IPsec can be employed to provide confidentiality to GRE.

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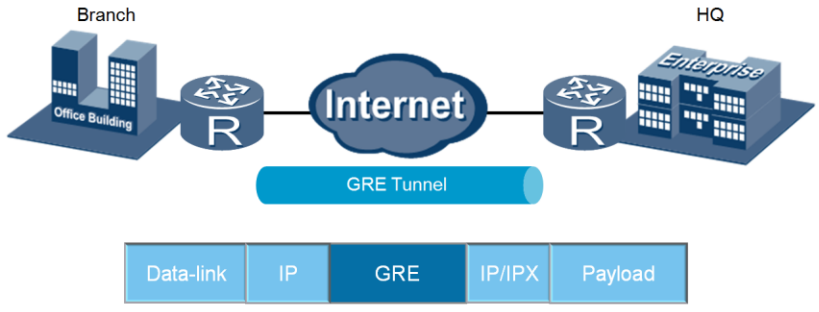
One of the major limitations of GRE is in its lack of ability to secure packets as they are carried across a public network. The traffic carried within a GRE tunnel is not subjected to encryption since such features are not supported by GRE. As a result IPsec solutions are employed together with GRE to enable GRE tunnels to be established within IPsec tunnels to extend features including integrity and confidentiality to GRE.

GRE Packet Encapsulation & Decapsulation



- A GRE header is inserted into the packet to build a tunnel.
- A virtual network is built over the physical network.

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After receiving a packet from the interface that is connected to the private network, the packet is delivered to the private network protocol module for processing. The private network protocol module checks the destination address field in the private network packet header, searches the outgoing interface in the routing table or forwarding table of the private network, and determines how to route this packet. If the outgoing interface is the tunnel interface, the private network protocol module sends the packet to the tunnel module.

After receiving the packet, the tunnel module firstly encapsulates the packet according to the protocol type of the passenger protocol and checksum parameters are configured for the current GRE tunnel. That is, the tunnel module adds a GRE header to the packet. It next adds an IP header according to the configuration. The source address of this IP header is the source address of the tunnel; the destination address of the IP header is the destination address of the tunnel, following which the packet is delivered to the IP module. The IP module searches for the appropriate outgoing interface in the public network routing table based on the destination address in the IP header, and forwards the packet. The encapsulated packet is then transmitted over the public network.

After receiving the packet from the interface that is connected to the public network, the egress interface analyzes the IP header, determines the destination of the packet and discovers the Protocol Type field is 47, indicating that the protocol is GRE.

The egress interface delivers the packet to the GRE module for processing. The GRE module removes the IP header and the GRE header, and learns from the Protocol Type field in the GRE header that the passenger protocol is the protocol run on the private network, the GRE module then delivers the packet to this protocol. The protocol itself handles the packet as with any ordinary packet.

GRE Key Authentication

C	0	K	0	0	Recursion	Flags	Version	Protocol Type
Checksum (Optional)								0
Key (Optional)								

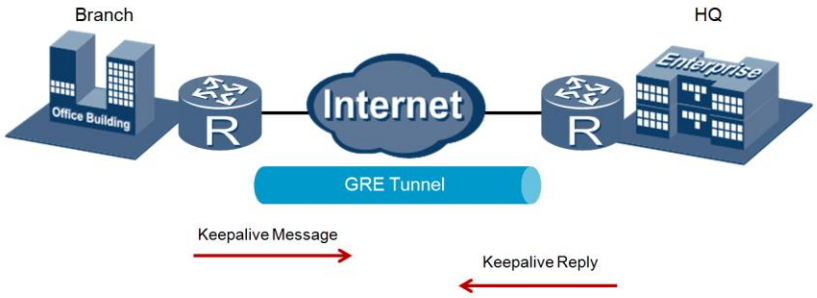
- Key field in GRE provides a means of optional authentication.

HUAWEI

Key authentication indicates the authentication on a tunnel interface. This security mechanism can prevent the tunnel interface from incorrectly identifying and receiving the packets from other devices. If the K bit in the GRE header is set to 1, the Key field is inserted into the GRE header. Both the receiver and the sender perform the key authentication on the tunnel.

The Key field contains a four-byte value, which is inserted into the GRE header during packet encapsulation. The Key field is used to identify the traffic in the tunnel. Packets of the same traffic flow have the same Key field. When packets are decapsulated, the tunnel end identifies the packets of the same traffic according to the Key field. The authentication can be passed only when the Key fields set on both ends of the tunnel are consistent, otherwise the packets are discarded.

GRE Keepalive



- Allows the status of a GRE tunnel to be monitored for changes.
- Keepalives that are not replied result in GRE tunnel tear down.

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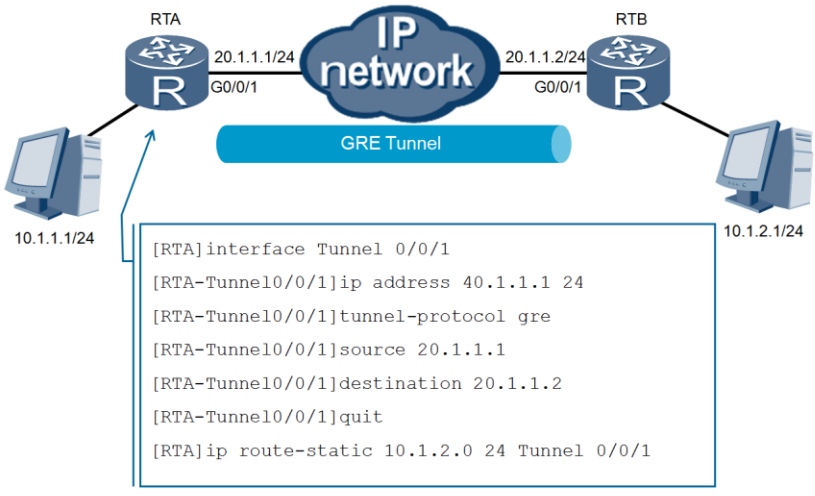
The keepalive detection function is used to detect whether the tunnel link is in the keepalive state at any time, that is, whether the peer of the tunnel is reachable. If the peer is not reachable, the tunnel is disconnected to prevent black holes occuring. After the Keepalive function is enabled, the local end of the GRE tunnel periodically sends a keepalive detection packet to the peer. If the peer is reachable, the local end receives a reply packet from the peer. The keepalive function will operate as long as at least one end is configured with the keepalive function, the peer does not need to have the keepalive function enabled. If the peer receives a keepalive detection packet, it sends a reply packet to the local end, irrespective of whether it is configured with the keepalive function.

After the keepalive function is enabled, the source of a GRE tunnel creates a counter, periodically sends the keepalive detection packets, and counts the number of detection packets. The number increments by one after each detection packet is sent.

If the source receives a reply packet before the counter value reaches the preset value, the source considers that the peer is reachable. If the source does not receive a reply packet before the counter reaches the preset value that defines the number of retries, the source considers that the peer is unreachable and will proceed to close the tunnel connection.

GRE Configuration



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The establishment of GRE requires initially the creation of a tunnel interface. After creating a tunnel interface, specify GRE as the encapsulation type, set the tunnel source address or source interface, and set the tunnel destination address. In addition, set the tunnel interface network address so that the tunnel can support routes. Routes for a tunnel must be available on both the source and destination devices so that packets encapsulated with GRE can be forwarded correctly. A route passing through tunnel interfaces can be a static route or a dynamic route.

One other key point that should be taken into account during the configuration phase is the MTU. GRE results in an additional 24 bytes of overhead being applied to the existing headers and payload, resulting in the potential for unnecessary fragmentation to occur. This can be resolved by adjusting the MTU size using the *mtu <mtu>* command to allow packets to compensate for the additional overhead created. An MTU of 1476 is considered a sufficient adjustment to the MTU, to reduce additional load on the interface.

Configuration Validation

```
[RTA]display interface Tunnel 0/0/1
Tunnel0/0/1 current state : UP
Line protocol current state : UP
Last line protocol up time : 2016-03-21 13:37:38
Description:HUAWEI, AR Series, Tunnel0/0/1 Interface
Route Port, The Maximum Transmit Unit is 1476
Internet Address is 40.1.1.1/24
Encapsulation is TUNNEL, loopback not set
Tunnel source 20.1.1.1 (GigabitEthernet0/0/1), destination 20.1.1.2
Tunnel protocol/transport GRE/IP, key disabled
keepalive disabled
Checksumming of packets disabled
.....
```

- Enables confirmation of tunnel status and parameters.

The running status and routing information for the GRE tunnel interface can be observed following the creation of the tunnel interface. An active tunnel interface can be confirmed when the tunnel's current state and link layer (line) protocol state are both showing as UP. Any adjustment to the existing MTU can be identified to ensure that additional overhead is not created as a result of fragmentation. The Internet address represents the configured tunnel IP address at the egress interface. The tunnel source and destination displays the IP addresses of the physical interface that are being used, over which the GRE tunnel is established.

GRE Routing Table Validation

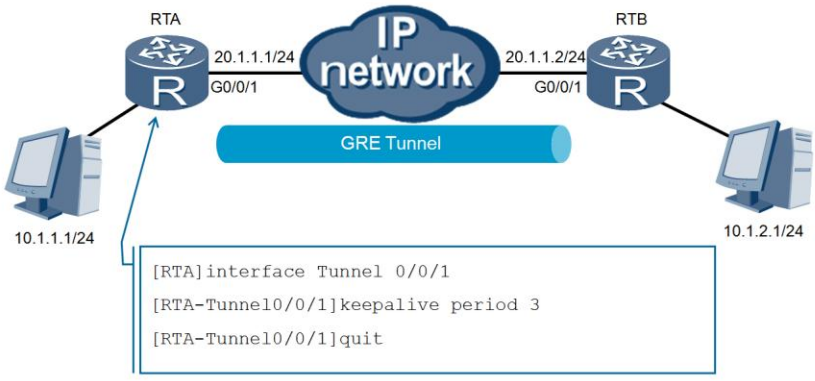
```
[RTA]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public         Destinations : 13        Routes : 14
Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

......
10.1.2.0/24         Static  60   0           RD  40.1.1.2        Tunnel 0/0/1
......
```

- An entry in the routing table verifies the tunnel establishment.
- Routes for GRE can be static or dynamic.

The reachability of networks over the GRE tunnel can be determined based on the IP routing table that is viewed using the display ip routing table command. In this case it is possible to identify the internal source network address of a local network, and its ability to reach the destination network address of a remote network over a GRE based tunnel interface. The destination address refers to the network address that is reached over the GRE tunnel, while the next hop address references the IP address of the GRE remote tunnel interface.

Enabling the Keepalive Function



- Keepalives can define message interval and number of retries.
- Function only required to be configured on one tunnel interface.

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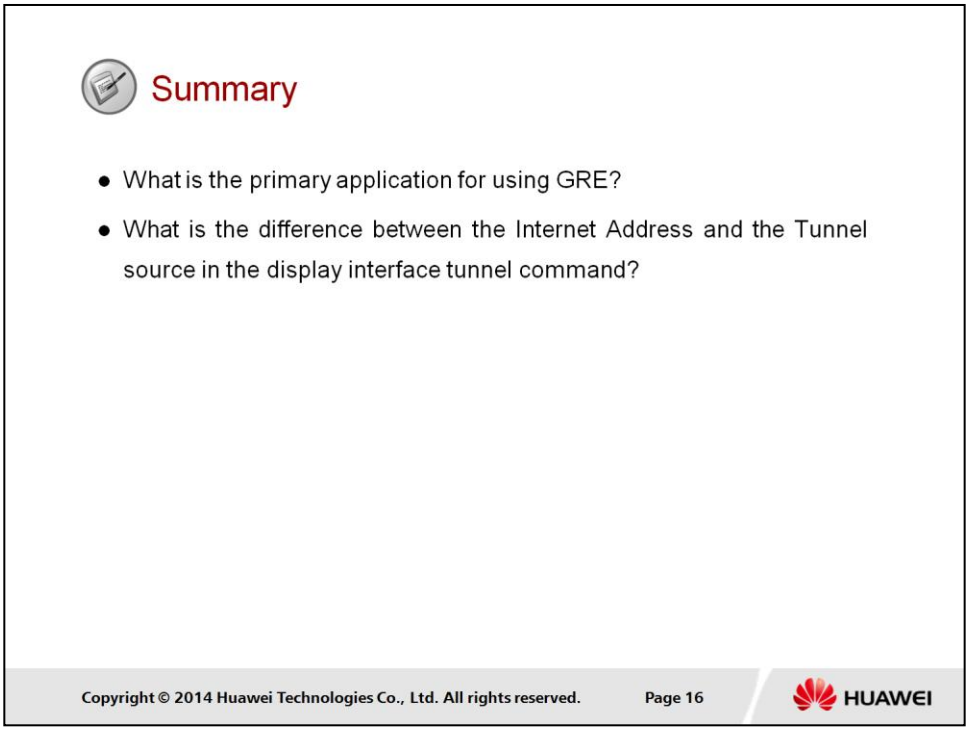
The keepalive function can enabled on the GRE tunnel interface by specifying the keepalive [period <period> [retry-times <retry-times>]] command, where the period determines the number of seconds taken before each keepalive is sent, this by default is set to a period of 5 seconds. The number of times for which a keepalive will be sent is defined using the retry-times <retry-times> parameter, which by default is set to 3 tries. If the peer fails to respond within the number of retries defined, communication between the two ends of the tunnel will be considered to have failed and the GRE tunnel will proceed to be torn down.

Configuration Validation

```
[RTA]display interface Tunnel 0/0/1
Tunnel0/0/1 current state : UP
Line protocol current state : DOWN
Description:HUAWEI, AR Series, Tunnel0/0/1 Interface
Route Port, The Maximum Transmit Unit is 1476
Internet Address is 40.1.1.1/24
Encapsulation is TUNNEL, loopback not set
Tunnel source 20.1.1.1 (GigabitEthernet0/0/1), destination 20.1.1.2
Tunnel protocol/transport GRE/IP, key disabled
keepalive enable period 3 retry-times 3
Checksumming of packets disabled
……
```

- Keepalive enablement can be verified from the tunnel interface.

The *display interface tunnel* command can again be applied to assess whether the tunnel is still active following a loss of communication between the GRE tunnel endpoints. In the example it is found that the link layer status of the GRE tunnel has transitioned to a down state denoting that a failure in communication has occurred. The keepalive function is currently enabled and displays a keepalive period of three seconds between each message sent. The number of retries has also been determined as allowing a loss of replies up to three times.



1. GRE provides a means for establishing dynamic routing between remote networks that commonly belong to a single administrative domain such as in the case of branch offices. IPsec VPN is generally used to provide a site-to-site private tunnel over which routing dynamic information may wish to be transmitted, however IPsec VPN tunnels will not support the forwarding of routing updates over IPsec directly, therefore GRE is implemented.

2. The internet address represents a virtual tunnel network address over which the GRE is established, while the tunnel source references the entry-point at which the tunnel is established.

Thank you

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Simple Network Management Protocol

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Foreword

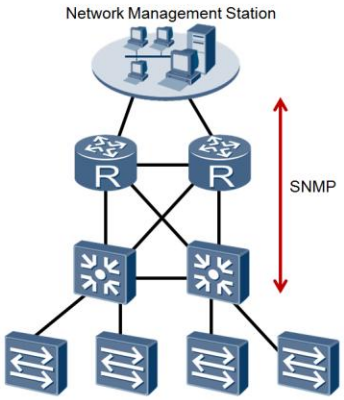
Management framework solutions for TCP/IP networks were introduced as hardware and software increased, in order to support rapid network growth. SNMP was originally adapted from a more simpler SGMP protocol for use as the basis for common network management throughout the system. SNMP has since experienced version revisions, however remains the standard protocol for network management. The SNMP framework, as well as the supporting Management Information Base act as the foundation for network management, and are introduced in support of a well rounded understanding of the network management framework for TCP/IP.

Objectives

Upon completion of this section, trainees will be able to:

- Describe the SNMP architecture and messaging behavior.
- Describe the function of the Management Information Base (MIB).
- Configure general SNMP parameters and traps.

SNMP Application



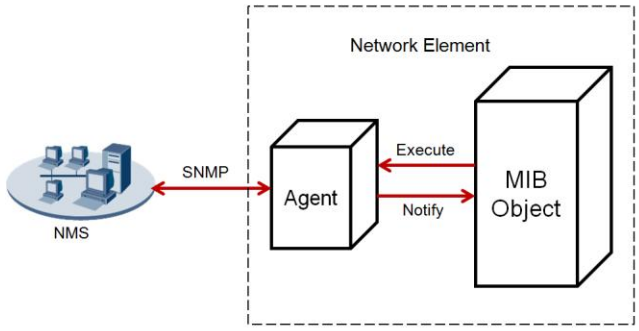
- SNMP is used to communicate management information between network management stations and network elements.

The Simple Network Management Protocol (SNMP) is a network management protocol widely used in the TCP/IP network. SNMP is a method of managing network elements using a network console workstation which runs network management software.

SNMP may be used to achieve a number of communicative operations. The Network Management Station (NMS) relies on SNMP to define sources for network information and obtain network resource information. SNMP is also used to relay reports in the form of trap messages to the NMS so that the station can obtain network status in near real time, to allow the network administrator to quickly take action in the event of system discrepancies and failures.

SNMP is largely used to manage application programs, user accounts, and write/read permissions (licenses) etc, as well as to manage the hardware that makes up the network, including workstations, servers, network cards, routing devices, and switches. Commonly, these devices are located far from the central office where the network administrator is based. When faults occur on the devices, it is expected that the network administrator can be notified automatically of the faults. SNMP effectively operates as a communications medium between the network elements and the network administrator/NMS.

SNMP Architecture

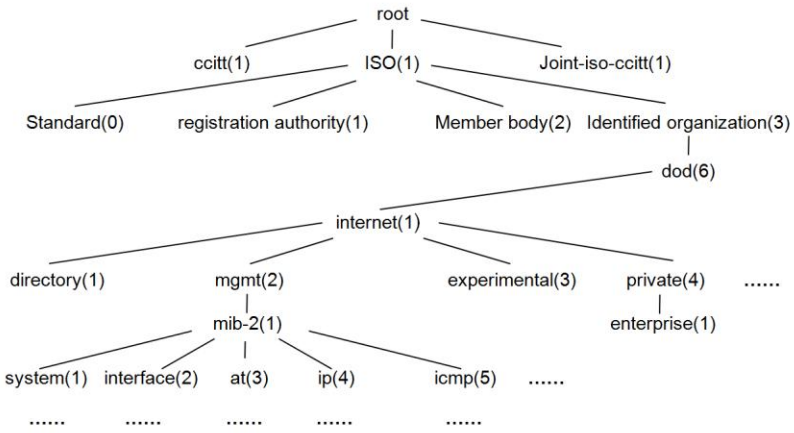


- Agents exist within network elements through which NMS interact to retrieve or alter parameter variables in the MIB

Network elements such as hosts, gateways, terminal servers etc, contain two important components that support the network management functions requested by the network management stations. The management agent resides on the network element in order to retrieve (get) or alter (set) variables.

Network Management Stations (NMS) associate with management agents that are responsible for performing the network management functions requested by the NMS. The MIB stores a number of variables associated with the network element, with each of these variables being considered an MIB object. The exchange of SNMP messages within IP requires only the support of UDP as an unreliable datagram service for which each message is independently represented by a single transport datagram.

MIB Objects

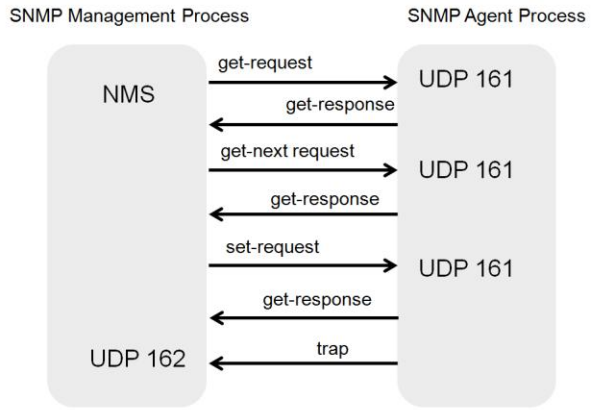


- The MIB acts as a virtual store for the management of objects.

A Management Information Base (MIB) specifies the variables maintained by network elements. These variables are the information that can be queried and set by the management process. A MIB presents a data structure, collecting all possible managed objects over the network. The SNMP MIB adopts a tree structure similar to that found in a Domain Name System (DNS).

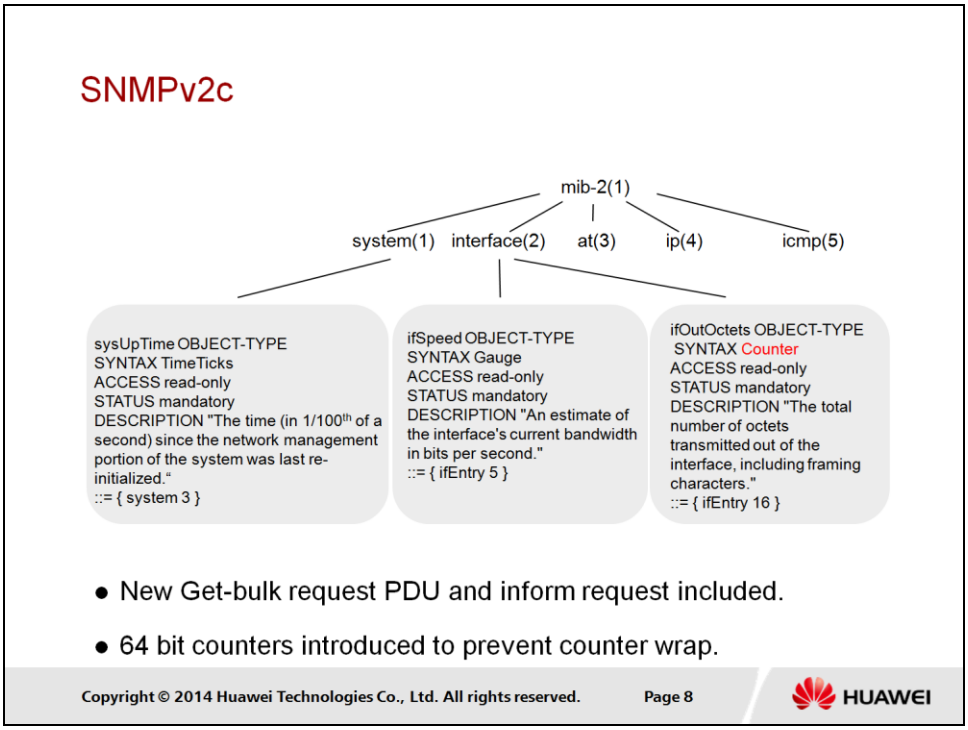
The object naming tree has three top objects: ISO, ITU-T (originally CCITT), and the joint organizations branch. Under the ISO, there are four objects among which number 3 is the identified organization. A sub-tree of the US Department of Defense dod (6) is defined under the identified organization (3) under which the Internet (1) sub tree is located. The object under the Internet is mgmt (2). What follows mgmt (2) is MIB-II, originally MIB until 1991 when the new edition MIB-II was defined. The tree path itself can be defined as an object identifier (OID) value {1.3.6.1.2.1}.

SNMP Operation



- Requests are received by an SNMP agent on UDP port 161.

SNMP defines five types of Protocol Data Units (PDUs), namely, SNMP packets, to be exchanged between the management process and the agent process. The get-request operation indicates that the management process reads one or more parameter values from the MIB of the agent process. The get-next-request indicates that the management process reads the next parameter value in the lexicographic order from the MIB of the agent process. The set-request indicates that the management process sets one or more parameter values in the MIB of the agent process. The get-response returns one or more parameter values. This operation is performed by the agent process. It is the response to the preceding three operations. Lastly is the trap function which is actively sent by the agent process to inform the management process of important or critical events.



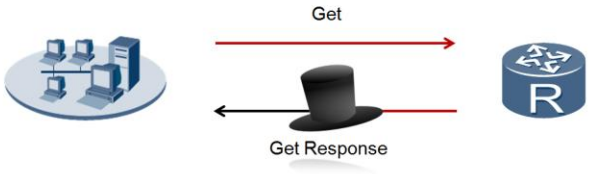
SNMPv1 is the original application protocol by which the variables of an agent's MIB may be inspected or altered. The evolution of SNMP involved not only changes to the protocol but also the MIB that was used. New objects were defined in the MIB resulting in MIB-II (or MIB-2) being defined, including for example sysContact. sysName, sysLocation, sysServices to provide contact, administrative, location, and service information regarding the managed node in the system group, and ipRouteMask, ipRouteMetric5, and ipRouteInfo objects included as part of the IP route table object.

The transition to SNMP version 2 involved a number of revisions that resulted in SNMPv2c being developed including the introduction of a new PDU type in the form of GetBulkRequest-PDU to allow information from multiple objects to be retrieved in a single request and the Inform Request, a manager to manager communication PDU, used where one manager sends information from an MIB view to another manager. Specific objects also use counters as a syntax which in SNMP version 1 represented a 32 bit value. This meant that in given objects such as the byte count of interfaces it was easy for the counter to complete a full cycle of the values and wrap, similar to the odometer that measures mileage in vehicles.

Using the 32 bit counter, octets on an Ethernet interface transmitting at 10Mbps would wrap in 57 minutes, at 100Mbps the counter would wrap in 5.7 minutes, and at 1Gbps it would take only 34 seconds before the counter fully cycled. Objects are commonly polled (inspected) every 1 or 5 minutes, and problems arise when counters wrap more than once between object polling as a true measurement cannot be determined.

To resolve this, new counters were defined in SNMP version 2c in the form of 64 bit counters for any situations where 32 bit counters wrap too fast, which translated to any interface that counts faster than 650 million bits per second. In comparison, using a 64 bit counter for counting octets on a 1Tbps (1,000 Gbps) will wrap in just under 5 years, and it would take an 81,000,000 Tbps link to cause a 64-bit counter to wrap in 30 minutes.

SNMPv3



- SNMPv3 security mechanisms support data integrity, data origin authentication, confidentiality and timely message delivery

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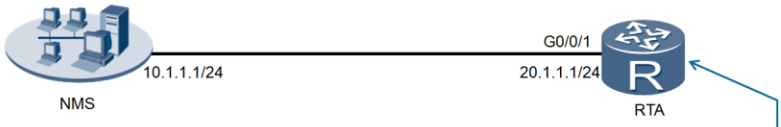
One of the key improvements to SNMPv3 is with regards to security of the transmission of MIB object information. Various threats can be identified. These include modification of object information from an unauthorized entity during transit, the performing of unauthorized management operations by users masquerading as another authorized user; eavesdropping on message exchanges and the modification of the message stream through means such as message replay.

SNMP enhances security through applying four principle measures. Data integrity is applied to ensure that data has not been altered or destroyed in an unauthorized manner, nor have data sequences been altered to an extent greater than can occur non-maliciously.

Data origin authentication is supported to ensure that the claimed identity of the user on whose behalf received data was originated is corroborated using MD5 and SHA-1. Data confidentiality is applied to ensure information is not made available or disclosed to unauthorized individuals, entities, or processes. Additionally, solutions for limited replay protection provide a means of ensuring that a message, whose generation time is outside of a specified time window, is not accepted.

SNMP Configuration




```
[RTA]snmp-agent
[RTA]snmp-agent sys-info version v2c
[RTA]snmp-agent trap enable
Info: All switches of SNMP trap/notification will be open. Continue?
[Y/N]:Y
[RTA]snmp-agent trap source GigabitEthernet 0/0/1
```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The SNMP agent is an agent process on a device on the network. The SNMP agent maintains managed network devices by responding to NMS requests and reporting management data to the NMS. To configure SNMP on a device, the SNMP agent must be enabled, for which the *snmp-agent* command is applied.

The *snmp-agent sys-info* command sets the SNMP system information and is also used to specify the version(s) of SNMP that are supported, where *snmp-agent sys-info version* [[*v1* | *v2c* | *v3*] * | *all*] is used to achieve this, and should be noted that all versions of SNMP are supported by default. The *snmp-agent trap enable* command, activates the function of sending traps to the NMS, following which the device will proceed to report any configured events to the NMS.

In addition it is necessary to specify the interface via which trap notifications will be sent. This should be the interface pointing towards the location of the NMS, as in the example where the NMS is reached via interface Gigabit Ethernet 0/0/1.

Configuration Validation

```
[RTA]display snmp-agent sys-info
  The contact person for this managed node:
          R&D Shenzhen, Huawei Technologies Co., Ltd.

  The physical location of this node:
          Shenzhen China

  SNMP version running in the system:
          SNMPv2c
```


Using the *display snmp-agent sys-info* command displays contact information of personnel responsible for the system maintenance, the physical location of the device, and currently supported SNMP version(s). The given information in the example represents the typical default system information found within Huawei AR2200 series routers, however this can be altered through the use of the *snmp-agent sys-info* [*contact* | *location* | *version*] parameters to reflect contact and location details relevant to each individual device.

1. In the Huawei AR2200 series router, all versions of SNMP (SNMPv1, SNMPv2c and SNMPv3) are enabled by default.

2. The agent forwards trap messages to the Network Management Station (NMS) using UDP destination port 162.

Thank you

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eSight Network Management Solutions

HUAWEI TECHNOLOGIES CO., LTD.

Foreword

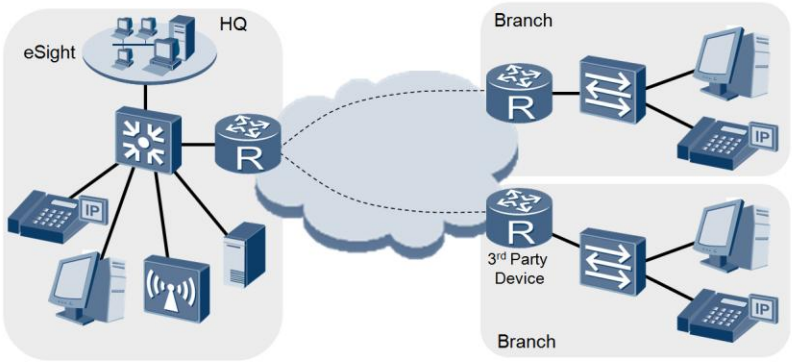
As the network scales and the number of enterprise network applications continue to grow, more and more devices require support, including multi-service routers, security gateways, and WLAN Access Points (AP) that implement communication and collaboration services in decentralized networks, like enterprise campus networks and branch office networks. An enterprise network is also increasingly comprised of multi-vendor devices. Each device may have its own management system, creating a nightmare for system and network administrators. This section introduces the eSight Unified Network Management Platform as an effective unified network management station (NMS) solution for the monitoring and management of all network and system resources.

Objectives

Upon completion of this section, trainees will be able to:

- Explain the application of eSight in the enterprise network
- Describe the services provided by eSight as part of a complete network management solution.

Huawei NMS Solution



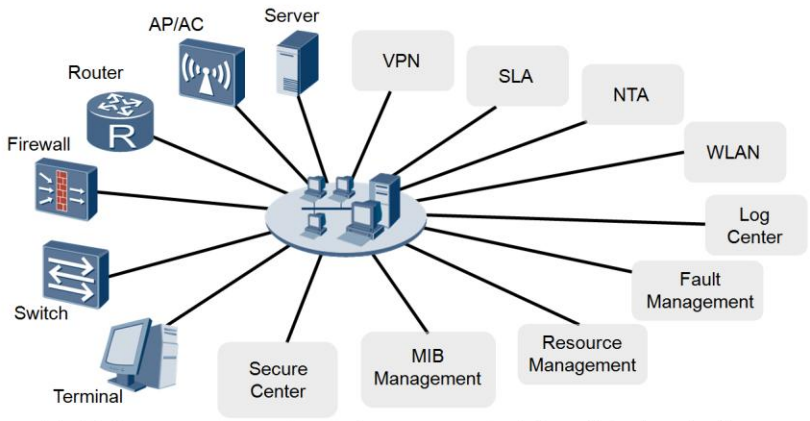
- Monitors and manages local and remote enterprise networks.
- NMS is capable of supporting multi vendor network equipment.

The eSight system is developed by Huawei for the management of enterprise networks, such as enterprise park, campus, branch, and data center networks. It implements unified management of - and intelligent interaction between - enterprise resources, services and users. In addition, eSight can manage devices from multiple manufacturers, including network devices from Huawei, H3C, Cisco, and ZTE, and IT devices from IBM, HP, and Sun Microsystems.

Three editions of eSight exist to support enterprise networks of various scales and complexity, referred to as compact, standard and professional. The compact edition offers alarm management, performance management, topology management, configuration file management, network element (NE) management, link management, log management, physical resources, electronic labeling, IP topology, smart configuration tools, custom device management, security management, terminal access management, system monitoring tools, database backup/restoration tools, fault collection tools, and MIB management.

In addition to the functions of the compact edition, the standard edition offers support for WLAN management, network traffic analysis (NTA), service level agreement (SLA) management, quality of service (QoS) management, MPLS VPN Management, MPLS tunnel management, IPsec VPN management, report management, LogCenter, Secure Center, and SNMP alarm northbound interface (NBI). The professional edition provides all functions of the standard edition as well as Data center nCenter management, hierarchical network management, and support for Linux two-node cluster hot standby.

eSight Component Introduction



- Multiple management services supported for all technologies
- Management of a wide range of Network Elements (NE).

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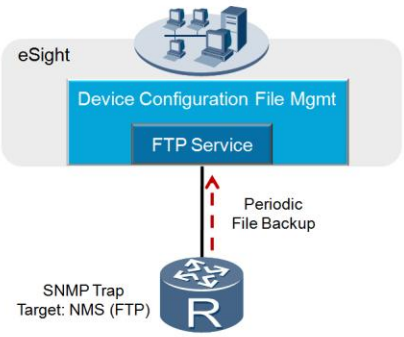
eSight can manage devices from multiple manufacturers, monitor and analyze and manage network services and elements. The SLA Manager for example diagnoses network links immediately or at the scheduled time through SLA tasks, which facilitates assessment of network service quality. The Network Traffic Analyzer (NTA) analyzes network traffic packets based on the packet source, destination, protocol, and application, which enables clear understanding of the distribution of network traffic. The eSight Log Center is a unified security service management system developed by Huawei for telecom carriers and industry customers. Characterized by high integration and reliability, eSight Log Center offers comprehensive network element (NE) management, security service analysis, and security audit over Huawei security products.

Fault management provides measures such as real-time alarm browsing, alarm operations, alarm rule settings (alarm masking rule and alarm sound setting), and remote alarm notification to monitor exceptions on the network in real time. This helps the network administrator take timely measures to recover network operation. Resource Management enables devices to be divided into different subnets based on their actual locations on the network, as well as classify devices into groups and perform batch operations on devices in a same Group, as well as configure and query resources such as device systems, frames, boards, subcards, and ports. eSight offers the management information base (MIB) tool that can read, compile, store, and use .mib files. eSight reads and monitors MIB data through SNMP v1, v2c, or v3, which helps perform effective network management. eSight Secure Center allows the management of large-scale security policies for Huawei firewalls or devices deployed in Unified Threat Management (UTM) environments.

Configuration File Management



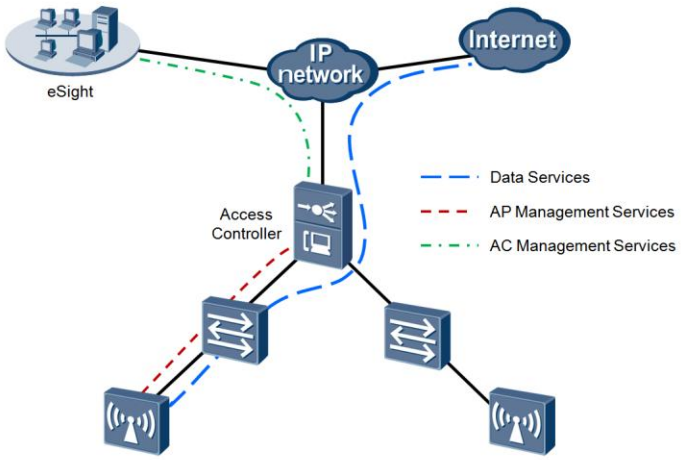
- Management of basic services such as configuration file backup.
- Service operations are controlled centrally through eSight.

HUAWEI

eSight allows administrators to ensure the security of device configuration files by providing the functions for backing up and restoring device configuration files. FTP operates as a service within eSight and from which the FTP service parameters are configured. This includes parameters such as the username and password used to access the FTP service, the location within eSight where received configuration files are stored as well as the FTP service type (FTP, SFTP and TFTP are supported) for which the default is FTP.

An SNMP trap is defined within the Network Element (NE), which in this case refers to the router. The NE will define the parameters for the SNMP trap using the *snmp-agent trap enable* command, and following which the parameters can be set for sending traps to the target NMS, to perform periodic file backup. eSight can be configured to periodically (daily, weekly, or monthly) perform back up of the configuration files of devices specified in a backup task, at a specified time. It can also be configured to trigger a backup upon the generation of a device configuration change alarm, as well as perform instant backups.

WLAN Management



- NMS provides solutions for enterprise WLAN management.

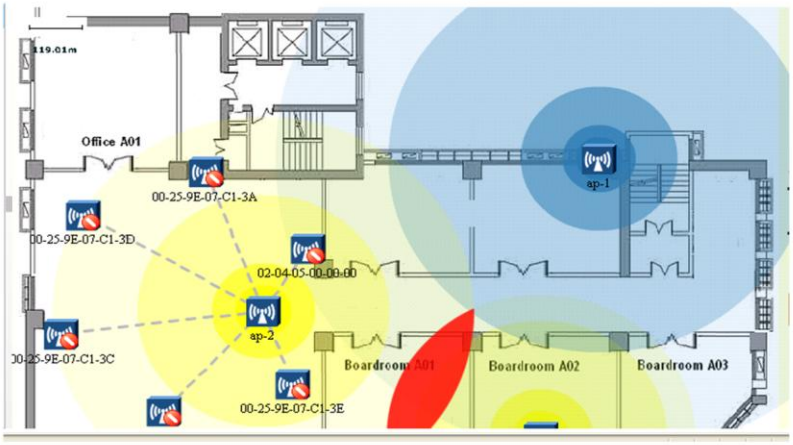
HUAWEI

As part of the standard edition, the WLAN Manager manages wireless resources, for example, access controllers (ACs) and access points (APs) and configurations of wireless campus networks, diagnoses device and network faults, and displays both wired and wireless resources in topology views.

The WLAN Manager is capable of delivery and deployment of AP services end to end, which improves the deployment efficiency by approximately 90% compared to manual deployment. An access controller (AC) is used to control and manage access points (AP) in the Wireless LAN. With AC management, it is possible to connect an AP to the WLAN and confirm AP identities, add an AP in offline mode and add those AP to a white list to allow the AP authorization to become active in the WLAN.

Unauthorized or rogue AP can be detected as a result of not being listed in the white list, and be prevented from becoming active in the WLAN, or can be authorized by being added to the white list. Details regarding each AP and AC can be observed from eSight, including AC status, name, type, IP address, AP authentication mode, region information and performance statistics. This information is communicated through AC management service data generated by each AC.

WLAN Management

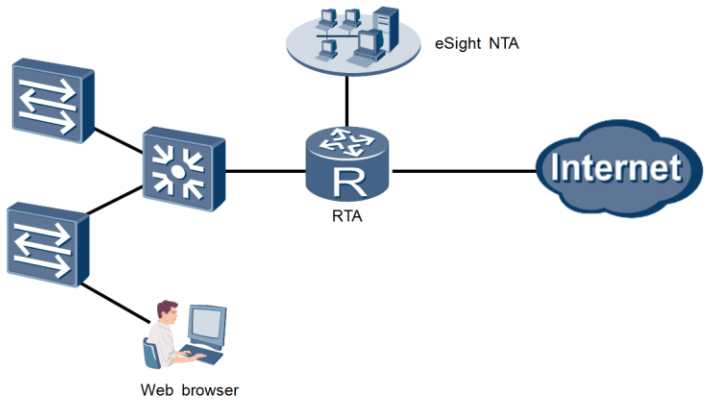


- Monitoring tools can be applied to maintain network operations.

Each AP generates radio spectrum signals that are susceptible to interference. After the AP radio spectrum function is enabled on devices, users can view the signal interference information around APs in the NMS. Users are able to judge the channel quality and surrounding interference sources on spectrum charts. Spectrum charts include real-time, depth, channel quality, channel quality trend, and device percentage charts.

Furthermore users can deploy APs in regions, view the hotspot coverage, and detect signal coverage blind spots and conflicts promptly, similarly to that displayed in the given example. In regions where location is enabled, the topology refreshes the latest location of users and unauthorized devices in real time. It is then possible to view the hotspot location and radio signal coverage in the location topology and mark conflict regions, as well as pre-deploy APs, view the simulated radio coverage, and review the actual radio coverage after APs are brought online.

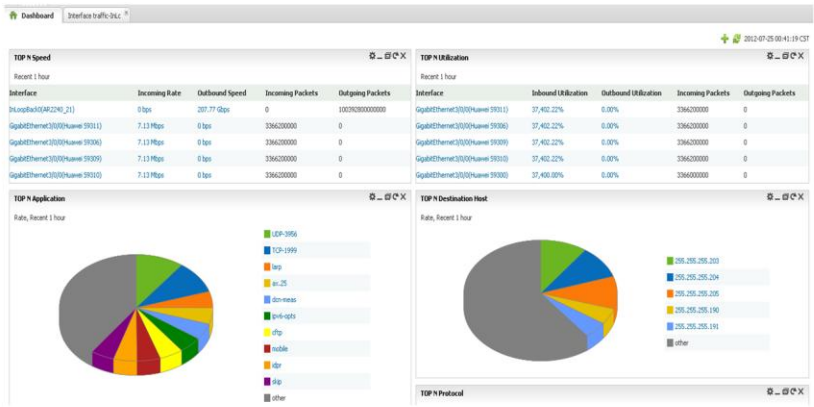
eSight Network Traffic Analyzer



- Abnormal traffic behavior can be detected through NTA.
- Collates information for devices, interfaces, protocols etc.

eSight Network Traffic Analyzer (NTA) enables users to detect abnormal traffic in a timely manner based on the real-time entire-network application traffic distribution, and plan networks based on the long-term network traffic distribution. As such NTA can implement transparent network management. eSight NTA allows users to configure devices, interfaces, protocols, applications, IP groups, application groups, interface groups etc.

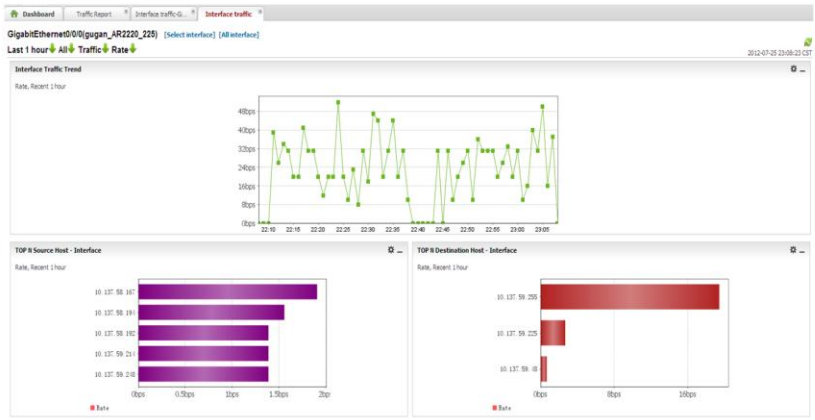
eSight Network Traffic Analyzer



- NTA statistics can be monitored in real time using dashboards
- Analysis allows for high level or detailed inspection of results.

NTA provides the traffic dashboards function, and displays the real-time traffic for the entire-network. The dashboard offers rankings for interface traffic, interface utilization, device traffic, application traffic, host traffic, DSCP traffic, and session traffic, for which it is possible to customize the display format and view specific content, by drilling down through the network traffic analysis details, and generate detailed traffic reports.

eSight Network Traffic Analyzer



- Information can be output using various data display formats.
- Results can be used to generate instant or periodic reports.

The eSight NMS allows report information to be represented in a number of formats for representation of traffic and other analysis data. Report formats such as Pie, Chart, Table, Line, Graph, and Region can be supported for displaying the report information. General summary types are also defined such as Application summary, Session summary, DSCP summary, Source host summary, Destination host summary, and Interface summary, however filtering conditions can also be applied to filter traffic by source address, destination address, application etc.

Information may be output as an instant report or periodically based on a period defined by the administrator, after which the status is displayed on the page, and reports detailed traffic statistics, which may also be exported as a batch report, or forwarded as an email.

Summary

- What are the three editions of the eSight network management platform?

1. The eSight network management platform editions include compact, standard, and professional editions.

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Introducing IPv6 Networks

HUAWEI TECHNOLOGIES CO., LTD.

Foreword

With the gradual exhaustion of the IPv4 address space, new solutions for continued address space were needed. Temporary measures in the form of NAT were applied, however long term solutions were required. The IPv6 addressing architecture is a developing solution for IP to provide for the next generation of networks and beyond. The transition to an all IPv6 architecture, while progressive, requires a major overhaul of many protocols and applications as well as standards. The IPv6 network however aims to resolve many limitations within the current TCP/IP suite, most notably addressing the need for integrated security measures and the streamlining of protocols to minimize overhead. A deep knowledge of the IPv6 architecture is required by engineers as IPv6 continues to evolve as an integral part of the enterprise network.

Objectives

Upon completion of this section, trainees will be able to:

- Explain the characteristics of IPv6
- Explain the IPv6 address format and addressing types.
- Describe the process for IPv6 stateless address autoconfiguration.

IPv6 Addressing

Version	Address size	Total Number of Addresses
IPv4	32 bit	4,294,967,296
IPv6	128 bit	340,282,366,920,938,463,374,607,431,768,211,456

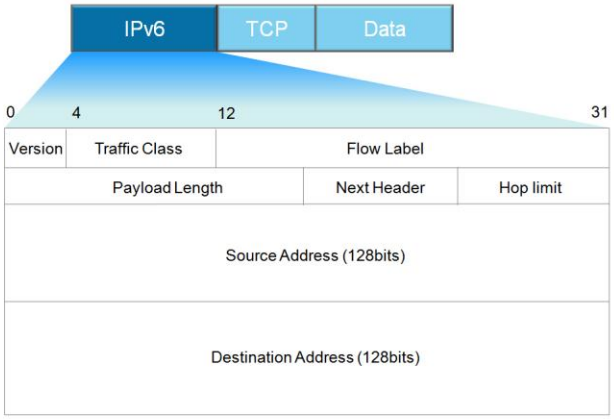
- Exhaustion of the limited IPv4 address space.
- IPv6 addressing implemented to resolve address shortages.

As a set of specifications defined by the Internet Engineering Task Force (IETF), Internet Protocol version 6 (IPv6) is the next-generation network layer protocol standard and the successor to Internet Protocol version 4 (IPv4). The most obvious difference between IPv6 and IPv4 is that IP addresses are lengthened from 32 bits to 128 bits. In doing so, IPv6 is capable of supporting an increased number of levels of addressing hierarchy, a much greater number of addressable nodes, and simpler auto-configuration of addresses.

The existing IPv4 address range was implemented at a time when such networks as ARPANET and the National Science Foundation Network (NSFNET) represented the mainstream backbone network, and at a time when IPv4 was considered more than ample to support the range of hosts that would connect to these forming networks. The unforeseen evolution of the Internet from these ancestral networks resulted in the rapid consumption of the IPv4 address space of 4.3 billion addresses (of which many are reserved), for which counter measures in the form of NAT and CIDR were put in place to alleviate the expansion, and give time for a more permanent solution to be formed. Additionally, early IPv4 network address allocation was highly discontiguous making it difficult for addressing to be clustered into effective address groups and ease the burden on global IP routing tables used in autonomous system based routing protocols such as BGP.

Eventually however the IP network is expected to shed it's IPv4 addressing to make way for IPv6 and provide the addressing capacity of over 340 undecillion unique addresses, considered more than necessary for continued IP network growth. Along with this, address allocation by the Internet Assigned Numbers Authority (IANA) ensures that address allocation for IPv6 is contiguous for efficient future management of IP routing tables.

IPv6 Header Format



- IPv6 header has been streamlined to reduce overhead.

The IPv6 header required some level of expansion to accommodate the increased size of the IP address, however many other fields that were considered redundant in many cases of packet forwarding were removed in order to simplify the overall design of the IPv6 header, and optimize the level of overhead that is necessary during each packet that is forwarded across the network. In comparison with the IPv4 packet header, the IPv6 packet header no longer contains an Internet Header Length (IHL), identifier, flags, fragment offset, header checksum, options, or padding fields, but instead carries a flow label field.

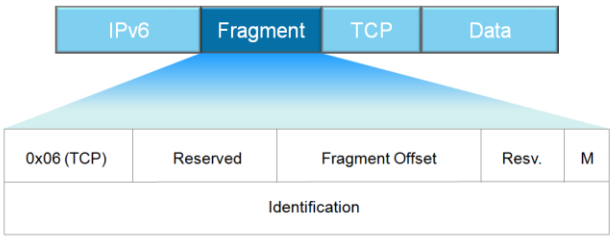
The term flow can be understood as a continuous stream of unicast, multicast or anycast packets relating to a specific application or process, that originate from a given source and are transmitted to a given destination or multiple destinations. The natural behavior of a packet switched network means that such traffic flows may be carried over multiple paths and arrive at the intended destination out of sequence. System resources are then required to re-sequence the packet flow before it can be processed by the upper layers.

The flow label intends to identify such traffic flows, together with the source and destination address fields, to maintain a common path across networks for all packets associated with the traffic flow. In doing so packets are capable of maintaining sequence over the IP network, and this optimizes process efficiency.

As IP network convergence introduces technologies such as voice that relies on a circuit switched traffic flow behavior and near real time performance, the importance of the flow label field becomes more paramount.

Various options can also now be supported without changing the existing packet format, with the inclusion of extension header information fields. These extension header fields are referenced through the Next Header field that replaces the protocol field found in IPv4, in order to provide additional flexibility in IPv6.

IPv6 Extension Header



- Extension headers are used to support parameters that are not required in every IP packet, such as fragmentation and IPsec.

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The extension header is one of the primary changes to IPv6 for enabling the IPv6 header to be more streamlined. There are a number of extension headers that exist in IPv6 and are referenced directly through a hexadecimal value in the IPv6 Next Header field, in the same way that ICMP, TCP, UDP headers are referenced in the protocol field of the IPv4 header. Each extension header also contains a next header field to reference the next header following the processing of the extension header. Multiple extension headers can be associated with a packet and each referenced in sequence. The list of extension headers and the sequence in which the extension headers are processed are as follows.

IPv6 header

Hop-by-Hop Options header

Destination Options header

Routing header

Fragment header

Authentication header

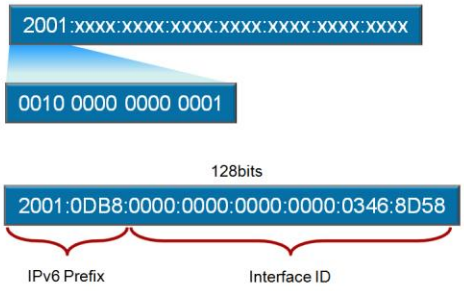
Encapsulating Security Payload header

Destination Options header

Upper-layer header (as in IPv6 tunneling)

Each extension header should occur at most once, except for the Destination Options header which should occur at most twice (once before a Routing header and once before the upper-layer header). Another key aspect of the extension headers is the introduction of IPsec protocols in the form of AH and ESP to enhance the overall security of IPv6.

IPv6 Address Architecture

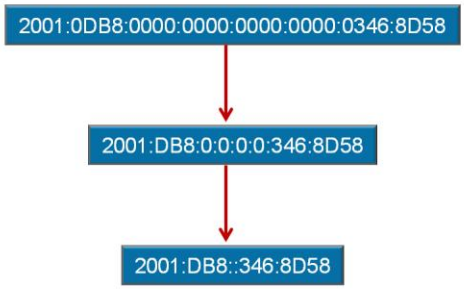


- IPv6 address consists of a prefix and an interface identifier.
- Addresses are commonly displayed in hexadecimal format.

The IPv6 address is a 128 bit identifier that is associated with an interface or a set of interfaces as (in the case of anycast address assignment covered later). The address notation due to size is commonly defined in hexadecimal format and written in the form of xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:xxxx, where the xxxx relates to the four hexadecimal digits that translate to a 16 bit binary value. The set of 8*16 bit grouped hexadecimal values comprises the 128 bit IPv6 address.

The address itself is made up of an IPv6 prefix that is used to determine the IPv6 network, followed by an interface ID. The basic addressing scheme represents a two layer architecture of prefix and interface ID, however IPv6 address types may contain many sublevels that enable an extensive hierarchical addressing architecture to be formed in the IPv6 network, to support effective grouping and management of users and domains.

IPv6 Address Condensing



- Addresses can be condensed by removing the leading zeroes
- The :: operator will further condense strings of zero values.

The extensive 128 bit size of the IPv6 address means that the general written notation can be impractical in many cases. Another factor that will remain common for quite some time is the presence of long strings of zero bits, primarily due to the unfathomable enormity of the address scale involved. This however brings a means for simplification and practicality when writing IPv6 addresses that contain zero bits. One initial means of simplification of the address scope is through the removal of any leading zero values that are found in each set of 16 bit hexadecimal values.

A special syntax is available to further compress the zeros and is represented in the form of a double colon or "::“. This value indicates one or more 16 bit groups of zeros. In order to enable the string size to be determinable however, the "::" can only appear once in an address. The double colon "::" can be used to compress leading zeros in an address as displayed in the given example.

IPv6 Address Reservations

Address Range	Description
2000::/3	Current Global Unicast Range
2001:0DB8::/32	Reserved for Documentation
FE80::/10	Link Local Unicast Address Range
FF00::/8	Multicast Address Range
::/128	Unspecified Address
::1/128	Loopback Address

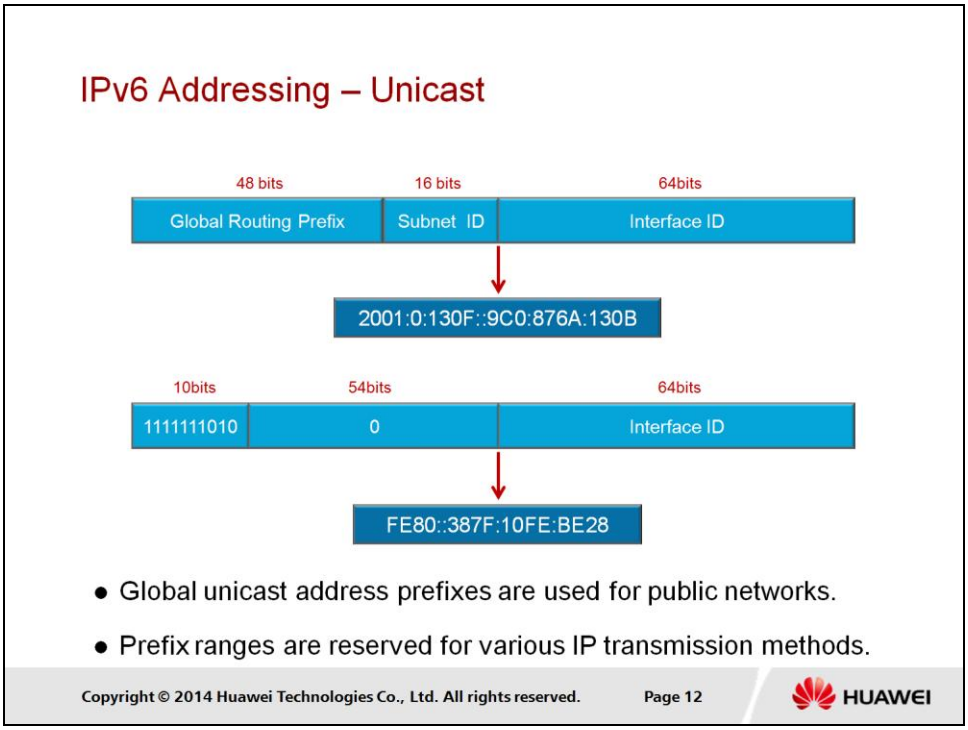
- Address ranges have been allocated in IPv6 for unicast and multicast, along with special addresses for operational support.

The IPv6 address space has yet to be completely defined firstly due to the magnitude of the addressing space, for which it is not likely to be required anytime in the near future, secondly the formulation of addressing schemes is still somewhat in an infancy stage with much discussion occurring with regards to the address types that should be applied.

Currently a fraction of the address range has been sectioned for use in the form of a 2000::/3 address range that represents a global unicast address range. This can be understood to be any address that is routable in the public IP network. The governing body IANA (now a part of ICANN) is responsible for distributing portions of this address range to various Regional Internet Registries (RIR) that manage addressing for one of five regions in the world. Supersets of IPv6 addresses in the form of 2400::/12 (APNIC), 2600::/12 (ARIN), 2800::/12 (LACNIC), 2A00::/12 (RIPE NCC) and 2C00::/12 (AfriNIC) have been allocated, allowing the potential for addressing for a given region to be referenced and managed in the mean time using a single address prefix. Also contained within the 2000::/3 prefix range are reserved address fields, including 2001:0DB8::/32 that is used to reference fictional addressing within documentation.

Multicast addressing is defined within IPv6 as FF00::/8, with much of the addressing scope being reserved to specific address ranges (such as link local) and in support of routing protocols, in a manner similar to how multicast addresses are used in IPv4. One major change to IPv6 is that there are no broadcast addresses, their function being superseded by multicast addresses, which reduces unnecessary processing by end stations at the MAC layer within IPv6 networks, since hosts are able to filter multicast MAC address groups.

Some special addresses also exist within IPv6 including the unspecified address ::/128 which represents an interface for which there is no IP address currently assigned. This should not be confused however with the default IP address ::/0 which is used as a default address value for any network in the same way the 0.0.0.0/0 default address is used within IPv4. For the loopback address (127.0.0.1), this is defined in IPv6 as the reserved address ::1/128.



Unicast addressing comprises primarily of global unicast and link local unicast address prefixes, however other forms also exist. All global unicast addresses have a 64 bit interface ID field, with exception to addresses for which the first three bits in the address are 000. For such addresses there is no constraint on the size or structure of the interface ID field. The address format for global unicast addresses comprise of a hierarchy in the form of a global routing prefix and a subnet identifier, followed by the interface identifier. The global routing prefix is designed to be structured hierarchically by the Regional Internet Registries (RIR) and the Internet Service Providers (ISP) to whom the RIR distribute IP address prefixes. The subnet field is designed to be structured hierarchically by site administrators to provide up to 65'535 individual subnets.

In terms of the Link Local unicast address, the FE80::/10 means that the first 10 bits of the link local address is clearly distinguishable as 1111111010. The 64 bit interface address range is more than sufficient for the addressing of hosts, and therefore the remaining 54bits within the Link Local address are maintained as 0. The example displays the address formats that can be typically associated with each of the common unicast address types.

It should be noted also that a third unicast addressing scheme, referred to as site local addressing (FC00::/7) was originally proposed in RFC3513 and may appear in some implementations of IPv6, however the addressing range has been deprecated as of RFC4291 and should be avoided as part of future implementations.

IPv6 Addressing – Multicast

Address Range	Description
FF02::1	All Nodes Addresses (Link Local)
FF02::2	All Routers Addresses (Link Local)

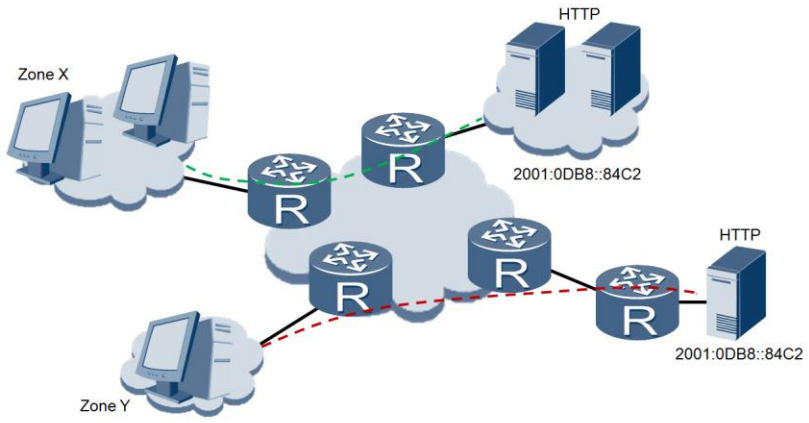
- Multicast addresses are distinguished by an FF00::/8 prefix.
- Select multicast address groups are reserved for protocol use.

A multicast address is an identifier for a set of interfaces (typically belonging to different nodes). A packet sent to a multicast address is delivered to all interfaces identified by that address. The multicast address range is determined from a FF00::/8 address prefix and is clearly distinguishable from the first 8 bits which are always set to 11111111. The address architecture for multicast addresses comprises of flags, scope and group ID fields.

The flags field though 4 bits, is currently used to support identification of whether a multicast address is well known (as in assigned and recognized by the global internet numbering authority) or transient, meaning the multicast address is temporarily assigned. A second bit value is used within the flags field to determine whether or not the multicast address is based on the network prefix. The remaining higher order two bits are reserved and remain set to 0.

The scope defines a number of potential ranges to which the multicast is applied. Generally this may refer to a node local scope FF01::, or to the link local scope FF02:: which refers to the listeners within the scope of the link-layer, such as an Ethernet segment for which a gateway defines the boundary. Common well known link local multicast addresses include FF02::1 which is used to forward to all nodes, and FF02::2 that allows multicast transmission to all router addresses.

IPv6 Addressing – Anycast



- Anycast allows multiple instances of a service to be associated with a single address, enabling a variety of service applications.

Anycast represents an identifier for a set of interfaces (typically belonging to different nodes). A packet sent to an anycast address is delivered to one of the interfaces identified by that address (the "nearest" one, according to the routing protocols' measure of distance). The anycast architecture commonly involves an anycast initiator and one or multiple anycast responders.

The anycast initiator may commonly be a host that is enquiring to a service such as in the case of a DNS lookup, or requesting the retrieval of specific data, such as HTTP web page information. Anycast addresses are in no way distinguishable from unicast addresses, with the exception that multiple instances of the same address are applied to a given device.

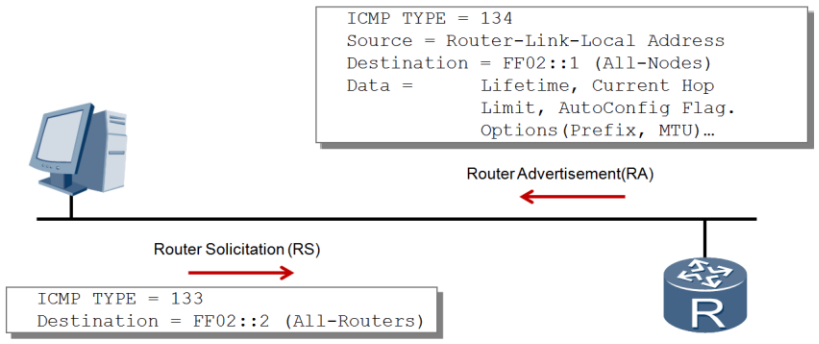
The application for anycast over traditional methods of addressing brings many potential benefits to enterprise network operation and performance. Service redundancy is one such application for anycast that allows a service such as HTTP to be used across multiple servers, for which the same address is associated with one or more servers that operate as anycast responders. In the event that service failure occurs on one server, clients would need traditionally to search for the address of another server and then restart/reestablish communication.

Using anycast addressing, the anycast initiator automatically establishes communication with another server that is using the same address, providing an effective redundancy solution.

In terms of performance, multi-server access can be applied, where an anycast initiator establishes a connection to the same unicast address, each connection automatically establishes to multiple servers that specify the same anycast address such as in the case of a client browsing a company web page.

The client will download the html file and individual image files from separate mirror servers. As a result, the anycast initiator untilizes bandwidth from multiple servers to download the web page much more quickly than is possible with a unicast approach.

IPv6 Stateless Address Autoconfiguration



- Hosts are capable of generating IPv6 addresses independently.
- Router Advertisements deliver network parameter information.

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Upon physically establishing with an IPv6 network, hosts must establish a unique IPv6 address and associated parameters such as the prefix of the network. Routers send out Router Advertisement messages periodically, and also in response to Router Solicitations (RS) to support router discovery, used to locate a neighboring router and learn the address prefix and configuration parameters for address auto-configuration.

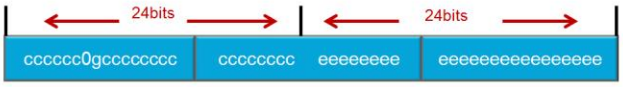
IPv6 supports stateless address autoconfiguration (SLAAC) that allows hosts to obtain IPv6 prefixes and automatically generate interface IDs without requiring an external service such as DHCP. Router Discovery is the basis for IPv6 address auto configuration and is implemented through two message formats.

Router Advertisement (RA) messages allow each router to periodically send multicast RA messages that contain network configuration parameters, in order to declare the router's existence to Layer 2 hosts and other routers. An RA message is identified by a value of 134 in the type field of the message. Router Solicitation (RS) messages are generated after a host is connected to the network.

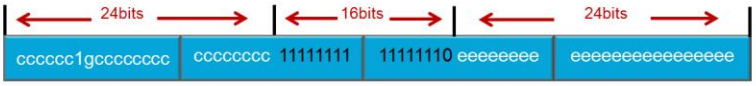
Routers will periodically send out RA messages however should a host wish to prompt for an RA message, the host will send an RS message. Routers on the network will generate an RA message to all nodes to notify the host of the default router on the segment and related configuration parameters. The RS message generated by a host can be distinguished by the type field which contains a value of 133.

EUI-64 for IP Stateless Address Autoconfiguration

48-bit MAC address



EUI-64 generated interface ID



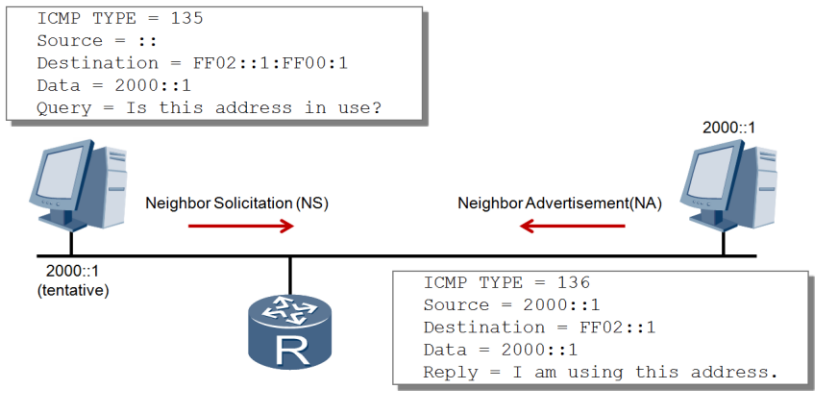
- A host MAC address is injected with 16 bit 'FF' 'FE' values to generate a 64 bit interface identifier for the IPv6 address.

In order to facilitate communication over an IPv6 network, each interface must be assigned a valid IPv6 address. The interface ID of the IPv6 address can be defined either through manual configuration by a network administrator, generated through the system software, or generated using the IEEE 64-bit Extended Unique Identifier (EUI-64) format.

Due to practicality, the most common means for IPv6 addressing is to generate the interface ID using the EUI-64 format. IEEE EUI-64 standards use the interface MAC address to generate an IPv6 interface ID. The MAC address however represents a 48-bit address whilst the required interface ID must be composed of a 64 bit value. The first 24 bits (expressed by c) of the MAC address represent the vendor (company) ID, while the remaining 24 bits (expressed by e) represents the unique extension identifier assigned by the manufacturer.

The higher seventh bit in the address represents a universal/local bit to enable interface identifiers with universal scope. Where this value is 0, the MAC address is unique locally. During conversion, the EUI-64 process inserts two octet "0xFF" and "0xFE" values totaling 16 bits between the vendor identifier and extension identifier of the MAC address, and the universal/local bit 0 is changed to 1 to indicate that the interface ID now represents a globally unique address value. A 64 bit interface ID is created and associated with the interface prefix to generate the IPv6 interface address.

IPv6 Stateless Address Autoconfiguration DAD



- Duplicate Address Detection (DAD) is used in IPv6 to verify that an address is unique before it is applied to the host interface.

Before an IPv6 unicast address is assigned to an interface, Duplicate Address Detection (DAD) is performed to check whether the address is used by another node. DAD is required if IP addresses are configured automatically. An IPv6 unicast address that is assigned to an interface but has not been verified by DAD is called a tentative address. An interface cannot use the tentative address for unicast communication but will join two multicast groups: ALL-nodes multicast group and Solicited-node multicast group.

A Solicited-Node multicast address is generated by taking the last 24 bits of a unicast or anycast address and appending the address to the FF02:0:0:0:0:1:FF00::/104 prefix. In the case where the address 2000::1 is used, the address solicited node multicast address FF02::1:FF00:1 would be generated.

IPv6 DAD is similar to the gratuitous ARP protocol used in IPv4 to detect duplicated IPv4 host addresses upon address assignment or connection of the host to the network. A node sends a neighbor solicitation (NS) message that requests the tentative address be used as the destination address to the Solicited-node multicast group.

If the node receives a neighbor advertisement (NA) reply message, the tentative address is confirmed as being used by another node and the node will not use this tentative address for communication, following which manual assignment of an address by an administrator would be necessary.

Summary

- What is the smallest condensed IPv6 value possible for the address 2001:0DB8:0000:0000:0000:0000:032A:2D70
- How is it possible for an end station to independently generate an IPv6 address?

1. The address 2001:0DB8:0000:0000:0000:0000:032A:2D70 can be condensed to 2001:DB8::32A:2D70. The double colon can be used to condense strings of zeroes that are often likely to exist due to the unfathomable size of the IPv6 address space, but may only be used once. Leading zero values can be condensed, however trailing zero values in address strings must be maintained.

2. The 64-bit Extended Unique Identifier (EUI-64) format can be used to generate a unique IPv6 address. This is achieved by inserting two ‘FF’ and ‘FE’ octet values into the existing 48-bit MAC address of the interface, to create a unique 64-bit value that is adopted as the IPv6 address of the end station interface. Validation of the address as a unique value is confirmed through the Duplicate Address Detection (DAD) protocol.

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IPv6 Routing Technologies

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Foreword

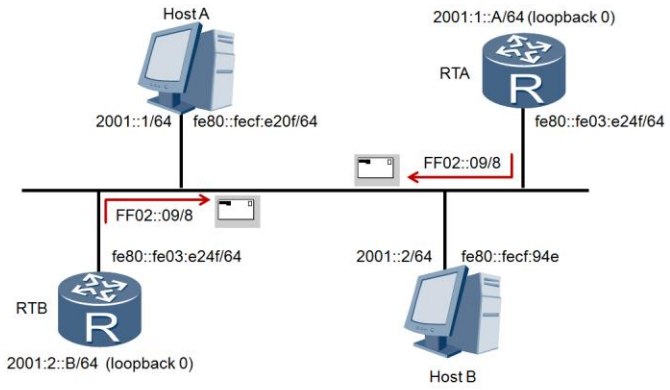
The changes to the address architecture have introduced the need for routing protocols that are capable of supporting IPv6. Two such routing protocols include RIPng and OSPFv3. The characteristics and operation of each of these protocols generally reflects those used in IPv4, however contain some distinct differences that are required to be understood to support the implementation of IPv6 based routing protocols within an IPv6 founded enterprise network.

Objectives

Upon completion of this section, trainees will be able to:

- Describe the characteristics and operation of RIPng
- Describe the characteristics and operation of OSPFv3
- Configure RIP and OSPF routing protocols for IPv6

RIPng



- RIPng updates carried using IPv6 multicast address FF02::9.
- Link-local addressing used by default as next hop address.

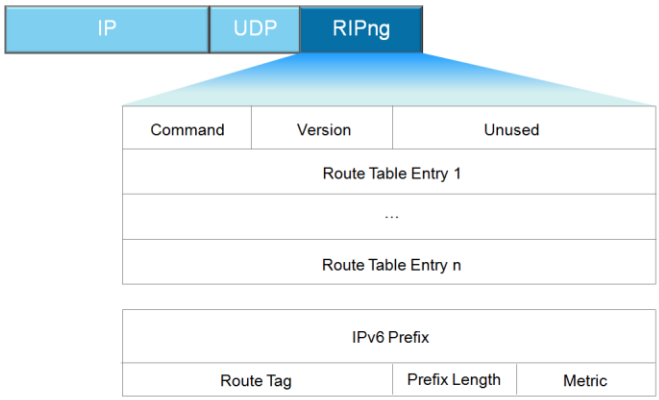
RIPng represents the next generation of distance vector routing for IPv6. It is largely based on the distance vector principles associated with prior IPv4 versions of RIP and applies the same distance vector principles. The protocol maintains many of the same conditions including a network diameter of 15 hops beyond which networks become “unreachable” as a result of the “count to infinity” principle. Each hop in RIPng is defined with a cost metric value of 1.

The major differences within RIPng boil down to the addressing mechanisms used in order to support communication between peering routers that participate in RIPng based distance vector routing. Periodic updates are transmitted using the IPv6 multicast address range of FF02:: while for RIPng, the reserved multicast address of FF02::9 is specified as a logical translation from the RIPv2 multicast address of 224.0.0.9.

The addressing features of most routing protocols within IPv6 rely more heavily on the use of link local addresses than within IPv4. The equivalent link local address within IPv4 is taken from the range of 169.254.0.0/16 in order to facilitate communication where no address is defined and no DHCP server is available. IPv4 based routing protocols rely on public or privately defined address ranges to determine the next hop, whereas in IPv6 routing protocols default to specifying the link local address as the next hop. The example demonstrates communication between routers on the same broadcast segment in which RTA and RTB are configured with loopback interfaces using global unicast addresses. The physical interfaces however depend only on the link local address to define the next hop when communicating routing information. For example, the destination address of 2001::B of RTB will be defined by RTA as reachable via the next hop of fe80::fe03:e24f.

One of the main concerns with this is that where EUI-64 is used to define the link local address, the link local address may change any time that an interface card is replaced since the MAC of the interface will also change. It is possible however to manually define the link local address and is generally recommended to provide stability, or alternatively the global unicast addressing can be manually defined. If a global unicast address is applied to the logical interface, the link local addressing may not be automatically defined on the physical interfaces by the router. Where this occurs the ipv6 address auto link-local command can be used on the physical interface.

RIPng Format

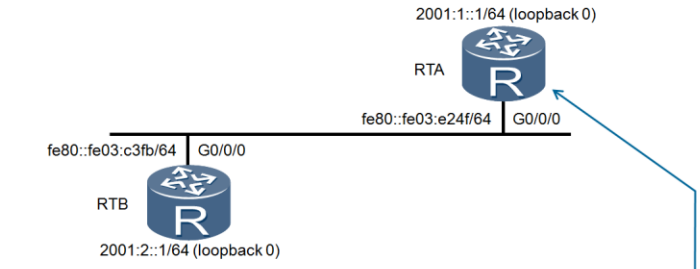


- Route table entries are carried in RIPng, each containing route prefix, prefix length, and route metric parameters.

RIPng is, as with prior IPv4 versions, a UDP-based protocol with a RIPng routing process on each router that sends and receives datagrams on UDP port number 521. All routing update messages are communicated between the RIPng ports of both the sender and the receiver, including commonly periodic (unsolicited) routing update messages. There may be specific queries sent from ports other than the RIPng port, but they must be directed to the RIPng port on the target machine. The command field of the RIPng header defines a request for routing table information either in part or in full of the responding peer, or as a response message that contains all or part of the sender's routing table. The message may be carried as a result of a response to a request or as part of the periodic (unsolicited) routing update. The version field refers to the version of RIPng, which currently is defined as version 1.

Each message may contain one, or a list of Routing Table Entries (RTE) that define RIPng routing information, including the destination prefix, the length of the prefix and also the metric value that defines the cost, in order to reach the destination network defined in the prefix.

Enabling RIPng




```
[RTA]ipv6
[RTA-GigabitEthernet0/0/0]ipv6 enable
[RTA-GigabitEthernet0/0/0]ipv6 address auto link-local
[RTA-GigabitEthernet0/0/0]ripng 1 enable
[RTA-LoopBack0]ipv6 enable
[RTA-LoopBack0]ipv6 address 2001:1::1/64
[RTA-LoopBack0]ripng 1 enable
```

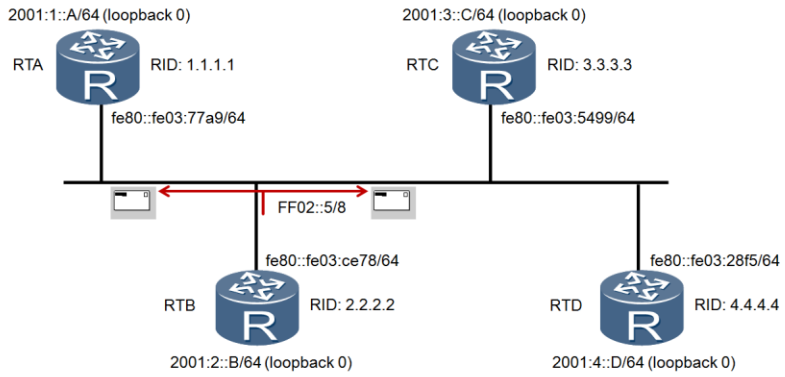

In order to implement RIPng on the router it is first necessary that the router establish support for IPv6 at the system view. The system view command *ipv6* should be implemented to achieve this. At the interface view IPv6 capability is disabled by default, therefore the *ipv6 enable* command must be used to enable IPv6 for each interface and allow the forwarding of IPv6 unicast packets as well as the sending and receiving of link local IPv6 packets. The *ripng* [*process-id*] at the interface level associates the router interface with a process instance of the RIPng protocol. The process ID can be any value between 1 and 65535, but should be the same for all router interfaces associated with a single RIPng protocol database.

Configuration Validation

```
[RTA]display ripng
Public vpn-instance
    RIPng process : 1
        Preference    : 100            Checkzero     : Enabled
        Default-cost  : 0
        Maximum number of balanced paths : 8
        Update time   : 30 sec     Age time    : 180 sec
        Garbage-collect time : 120 sec
        Number of periodic updates sent : 217
        Number of trigger updates sent  : 1
        Number of routes in database    : 1
        Number of interfaces enabled    : 2
        Total number of routes : 0
        Total number of routes in ADV DB is : 1
  ......
```


Using the *display ripng* command, the process instance will be shown along with the parameters and the statistics for the instance. RIPng supports a preference of 100 by default and maintains an update period of 30 seconds as found in IPv4 instances of RIP. The operation of RIPng can be verified by the sending of periodic updates, however these alone may not contain any routes if only link local addressing is enabled on the peering interface. The number of routes in the database should represent a value greater than zero to show that RIPng is actively aware of the route, and that it is advertising routes, through the total number of routes in the advertising database.

OSPFv3

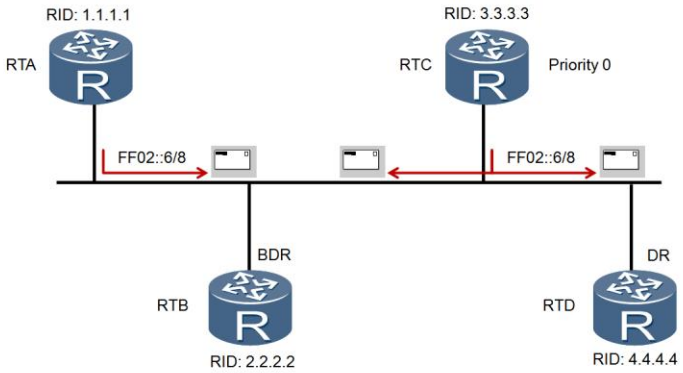


- OSPFv3 updates sent to the AllSPFRouters address FF02::5.
- Link-local addressing used by default to define the next hop.

OSPFv3 is the version of OSPF that is used over IPv6 networks, and in terms of communication, assumes that each router has been assigned link-local unicast addresses on each of the router's attached physical links. OSPF packets are sent using the associated link-local unicast address of a given physical interface as the source address. A router learns the link-local addresses of all other routers attached to its links and uses these addresses as next-hop information during packet forwarding. This operation is true for all physical links with the exception of virtual links which are outside the scope of this material.

A reserved “AllSPFRouters” multicast address has been assigned the value FF02::5, reflecting the multicast address 224.0.0.5 used in OSPFv2, for which it should be noted that the two versions are not compatible. All routers running OSPFv3 should be prepared to receive packets sent to this address. Hello packets are always sent to this destination, as well as certain OSPF protocol packets during the flooding procedure.

OSPFv3 Router ID



- Not based on any IP address, must be manually defined.
- Router ID continues to be used to support DR and BDR election.

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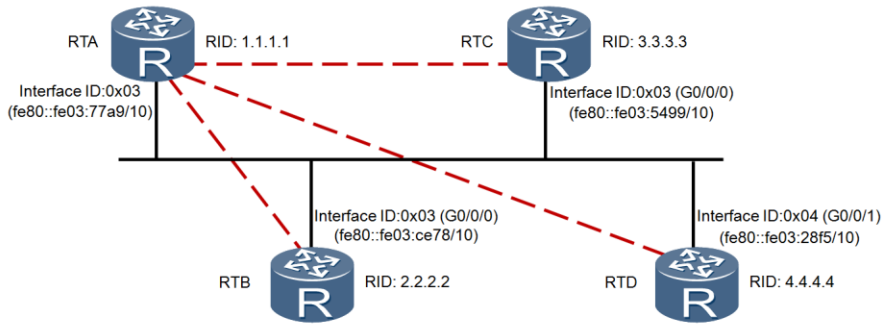
The router ID plays a prominent role in OSPFv3 and is now always used to identify neighboring routers. Previously, they had been identified by an IPv4 address on broadcast, NBMA (Non-Broadcast Multi-Access), and point-to-multipoint links. Each router ID (as well as the area ID) is maintained as a 32 bit dotted decimal value and cannot be configured using an IPv6 address.

The router ID also continues to actively act as a tie breaker in the event that the priority associated with each OSPFv3 enabled router is equal. In such cases the Designated Router (DR) is identified as the router possessing the highest router ID. Hello messages sent will contain a router ID set to 0.0.0.0 if there is no Designated Router. The same principle applies for the Backup Designated Router, identified by the next highest router ID. A priority of 0 set on a router interface participating in OSPFv3 will deem the router as ineligible to participate in DR/BDR elections. Router Priority is only configured for interfaces associated with broadcast and NBMA networks.

The multicast address “AllDRouters“ has been assigned the value FF02::6, the equivalent of the 224.0.0.6 multicast address used in OSPFv2 for IPv4. The Designated Router and Backup Designated Router are both required to be prepared to receive packets destined to this address.

OSPFv3 Per Link Behavior



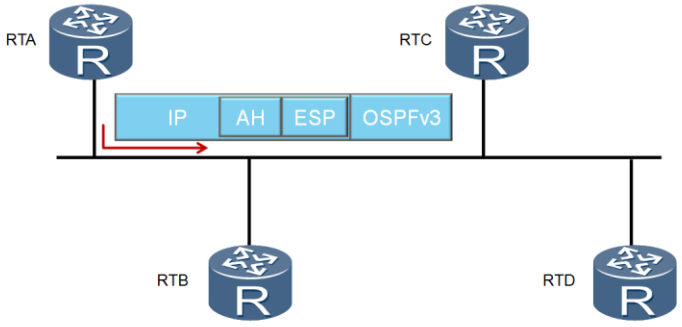
- OSPFv3 operates on the principle of per-link as opposed to the per-network or per-subnet concept used in IPv4.

IPv6 refers to the concept of links to mean a medium between nodes over which communication at the link layer is facilitated. Interfaces therefore connect to links and multiple IPv6 subnets can be associated with a single link, to allow two nodes to communicate directly over a single link, even when they do not share a common IPv6 subnet (IPv6 prefix). OSPFv3 as a result operates on a per-link basis instead of per-IP-subnet as is found within IPv4. The term link therefore is used to replace the terms network and subnet which are understood within OSPFv2. OSPF interfaces are now understood to connect to a link instead of an IP subnet. This change affects the receiving of OSPF protocol packets, the contents of Hello packets, and the contents of network-LSAs.

The impact of links can be understood from OSPFv3 capability to now support multiple OSPF protocol instances on a single link. Where separate OSPF routing domains that wish to remain separate but operate over one or more physical network segments (links) that are common to the different domains. IPv4 required isolation of the domains through authentication which did not provide a practical solution to this design requirement.

The per-link operation also means the Hello packet no longer contains any address information, and instead it now includes an Interface ID that the originating router assigns to uniquely identify (among its own interfaces) its interface to the link.

OSPFv3 Authentication

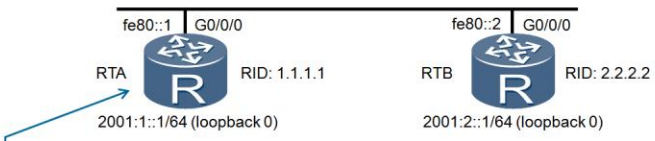


- OSPF authentication removed in OSPFv3, instead relying on the AH & ESP extension headers of IP for security.

Authentication in OSPFv3 is no longer supported, and as such the authentication type and authentication (value) fields from the OSPF packet header no longer exist. As of IPv6, changes to the IP header have allowed for the utilization of security protocols that were only present in IPv4 as part of the IPsec suite, since initial TCP/IP development in the late 1960's was never designed with security in mind, since security of TCP/IP at the time was not foreseen as a future requirement.

With the security improvements made to IPv6 and the utilization of IP extension headers in the protocol suite, OSPFv3 is capable of relying on the IP Authentication Header and the IP Encapsulating Security Payload to ensure integrity as well as authentication & confidentiality, during the exchange of OSPFv3 routing information.

Enabling OSPFv3




```
[RTA]ipv6
[RTA]ospfv3
[RTA-ospfv3-1]router-id 1.1.1.1
[RTA-GigabitEthernet0/0/0]ipv6 enable
[RTA-GigabitEthernet0/0/0]ipv6 address fe80::1 link-local
[RTA-GigabitEthernet0/0/0]ospfv3 1 area 0.0.0.0
[RTA-LoopBack0]ipv6 enable
[RTA-LoopBack0]ipv6 address 2001:1::1/64
[RTA-LoopBack0]ospfv3 1 area 0.0.0.0
```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Implementing OSPFv3 between peers requires, as with RIPng, that the router firstly be capable of supporting IPv6. Additionally the router must also enable the OSPFv3 protocol globally in the system view. Each interface should be assigned an IPv6 address. During the configuration of RIPng it was demonstrated how the interface can be automatically configured to assign a link local address. In this example an alternative and recommended method of link local address assignment is demonstrated. The link local IPv6 address is manually assigned and designated as a link local address using the *ipv6 <link local address> link-local* command. If the address associated with the physical interface is a global IPv6 unicast address, the interface will also automatically generate a link local address.

In order to generate an OSPFv3 route, the example demonstrates assigning global unicast addresses to the logical loopback interface of each router. The physical and logical interfaces both should be associated with the OSPFv3 process and be assigned a process ID (typically the same ID unless they are to operate as separate instances of OSPFv3) and also be assigned to an area, which in this case is confined to area 0.

As a reminder, OSPFv3 nodes rely on identification by neighboring routers through the use of the router ID, and therefore a unique router ID should be assigned for each router under the ospfv3 protocol view following the configuration of the ospfv3 command.

Configuration Validation

```
[RTA]display ospfv3
 Routing Process "OSPFv3 (1)" with ID 1.1.1.1
 Route Tag: 0
 Multi-VPN-Instance is not enabled
 SPF Intelligent Timer[millisecs] Max: 10000, Start: 500, Hold: 2000
 LSA Intelligent Timer[millisecs] Max: 5000, Start: 500, Hold: 1000
 LSA Arrival interval 1000 millisecs
 Default ASE parameters: Metric: 1 Tag: 1 Type: 2
 Number of AS-External LSA 0. AS-External LSA's Checksum Sum 0x0000
 Number of AS-Scoped Unknown LSA 0. AS-Scoped Unknown LSA's Checksum
Sum 0x0000
 Number of FULL neighbors 1
 Number of Exchange and Loading neighbors 0
......
```


Following the configuration of neighboring routers participating in OSPFv3, the *display ospfv3* command is used to verify the operation and parameters associated with OSPFv3. Each router will show a running OSPFv3 process and a unique router ID. If the adjacency between neighbors is established, the number of FULL (state) neighbors will show a value greater than zero.

Summary

- What is the port number that is used by RIPng for listening for route advertisements?
- What is used to uniquely identify each neighboring node running OSPFv3?

1. RIPng listens for route advertisements using UDP port 521.

2. A 32-bit router ID is used to uniquely distinguish each node running OSPFv3.

Thank you

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IPv6 Application Services
DHCPv6

HUAWEI TECHNOLOGIES CO., LTD.

Foreword

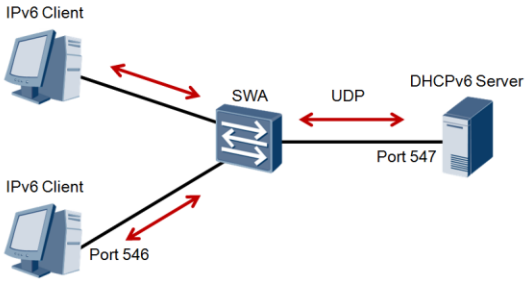
The IPv6 architecture has led to the redesign of many aspects of network operation. One such design change involves Neighbor Discovery, which in itself now defines a means for Stateless Address Autoconfiguration (SLAAC). DHCP for IPv6 (DHCPv6) includes a number of design changes that includes support for both SLAAC and stateful IPv6 addressing. DHCPv6 remains a client/server based application layer protocol, however includes a significant number of changes to align with the design aspects of IPv6. As such, DHCPv6 stateful and stateless implementations and characteristics are explained.

Objectives

Upon completion of this section, trainees will be able to:

- Describe the features of DHCPv6.
- Explain the stateful and stateless behavior of DHCPv6.
- Successfully configure DHCPv6 services.

DHCPv6



- Represents a stateful address auto configuration protocol.
- UDP based communication between client and server.

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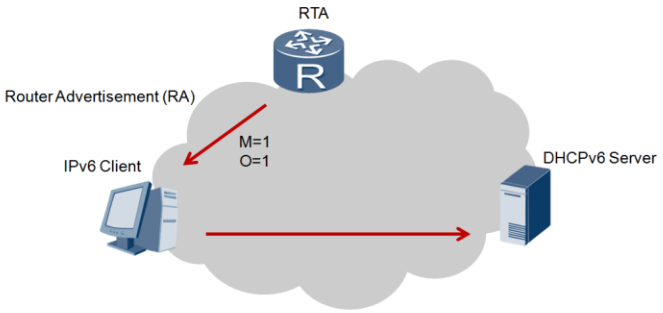
The Dynamic Host Configuration Protocol for IPv6 (DHCPv6) is a technology that dynamically manages and configures IPv6 addresses in a centralized manner. It is designed to assign IPv6 addresses and other network configuration parameters to hosts. DHCPv6 uses the client/server model. A client requests configurations such as the IPv6 address and DNS server address from the server, the server replies with requested configurations based on policies.

In stateless address autoconfiguration (SLAAC), routers do not record the IPv6 addresses of the hosts, therefore stateless address autoconfiguration has poor manageability. In addition, hosts configured with stateless address autoconfiguration cannot obtain other configuration parameters such as the DNS server address. ISPs do not provide instructions for automatic allocation of IPv6 prefixes for routers. Users therefore need to manually configure IPv6 addresses for devices during IPv6 network deployment.

As a stateful protocol for configuring IPv6 addresses automatically, DHCPv6 solves this problem. During stateful address configuration, the DHCPv6 server assigns a complete IPv6 address to a host and provides other configuration. Parameters such as the DNS server address and domain name. A relay agent may be used to forward DHCPv6 packets, however lies outside of the scope of this material The DHCPv6 server binds the IPv6 address to a client, improving overall network manageability.

Clients and servers exchange DHCP messages using UDP. The client uses a link-local address, determined through other mechanisms for transmitting and receiving DHCP messages. Clients listen for DHCP messages on UDP port 546, whilst servers (and relay agents) listen for DHCP messages on UDP port 547.

Stateful Addressing



- RA contains managed (M) and other (O) configuration flags.
- Stateful addressing (DHCPv6) used where flags are set to '1'

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Prior to the allocation of addresses, it should be clearly understood that an IPv6 node (client) is required to generate a link-local address and be successfully evaluated by the Duplicate Address Detection (DAD) process. Following this, a link router discovery process is involved, for which the IPv6 client node broadcasts a Router Solicitation (RS) message, and the link router responds with a Router Advertisement (RA) message after receiving the RS message.

Contained within the RA message are numerous fields containing configuration parameters for the local network. One field in particular referred to as the Autoconfig Flags field, is an 8 bit field that contains two specific bit values to determine the auto-configuration process for the local network. A "managed address configuration flag" (M) is a 1 bit value that is for defining whether stateful address configuration should be used, commonly applied in the presence of a DHCPv6 server on the local network. Where the value is set to 1, stateful addressing should be implemented, meaning the IPv6 client should obtain IPv6 addressing through stateful DHCPv6.

The other stateful configuration flag (O) represents the second flag bit value in the Autoconfig Flags field, and defines whether other network configuration parameters such as DNS and SNTP (for time management servers) should be determined through stateful DHCPv6. RFC2462 defines that where the M bit is true (a value of 1), the O bit must also be implicitly true, however in practice the M bit and the O bit may be defined interchangeably to support stateless addressing services in DHCPv6, in which an IPv6 address is not assigned but configuration parameters are.

It should also be noted that the managed address flag and other configuration flag is managed through VRP on the router, and is not set in the RA message by default. In order to set these flags, the commands *ipv6 nd autoconfig managed-address-flag* and *ipv6 nd autoconfig other-flag* should be configured on the gateway responsible for generating RA messages.

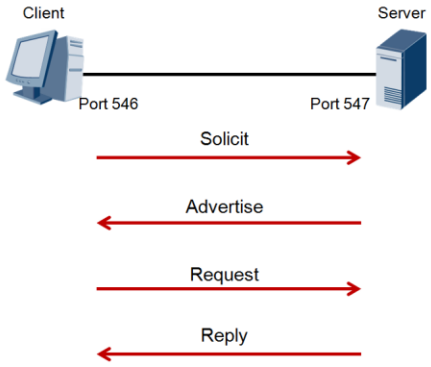
Enabling DHCPv6 Communication

- Link-local addresses are used as source address by clients, and DHCP servers reached via the multicast address FF02::1:2

Client nodes initiated on a network supporting stateful addressing may be serviced by one or more DHCPv6 servers. The IPv6 client uses a link-local address assigned to the interface for which it is requesting configuration information as the source address in the header of the IPv6 datagram.

The multicast address FF02::1:2 is a reserved multicast address that represents “All_DHCP_Relay_Agents_and_Servers”, and is used by a client to communicate with neighboring servers. All servers (and relay agents) are members of this multicast group. For any client sending a DHCP message to the All_DHCP_Relay_Agents_and_Servers address, it is expected that the client send the message through the interface for which configuration information is being requested, however exceptions may occur to this rule where two interfaces on the client are associated with the same link, for which it is possible for the alternative interface to be used. In either case the link local address of the forwarding interface must be used as the source address.

Assigning IPv6 Addressing



- Discovery of servers and assignment of IPv6 addresses & configuration parameter relies on a set of four messages.

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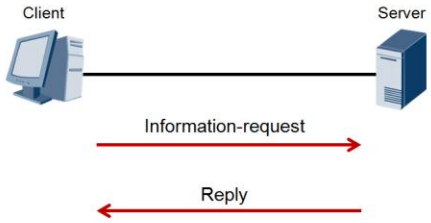
Obtaining stateful addressing and other parameters from a DHCPv6 server requires a series of messages be sent. A client initially sends a solicit message to locate servers, from which addressing and configuration parameters can be received.

Following the solicit message, a DHCPv6 server supporting the link will generate an advertise message in response to the solicit message, that indicates to the client, the IPv6 address of the server, providing the required DHCPv6 service. The client is then capable of using this IPv6 address to reference the DHCPv6 server and generate a request message. Where multiple servers respond to the solicit message, the client will need to decide which DHCPv6 server should be used, typically defined by a server preference value defined by the DHCPv6 administrator on the server, and carried in the advertise message. Additionally the server may carry options including a server unicast option which enables the client to use the IPv6 address of the DHCPv6 server to transmit further correspondence with this server as unicast messages.

The request message is transmitted to the selected DHCP server to request configuration parameters and one or multiple IPv6 addresses to be assigned. Finally the DHCPv6 server responds with a Reply message that contains the confirmed addresses and network configuration parameters.

Stateless Configuration Information

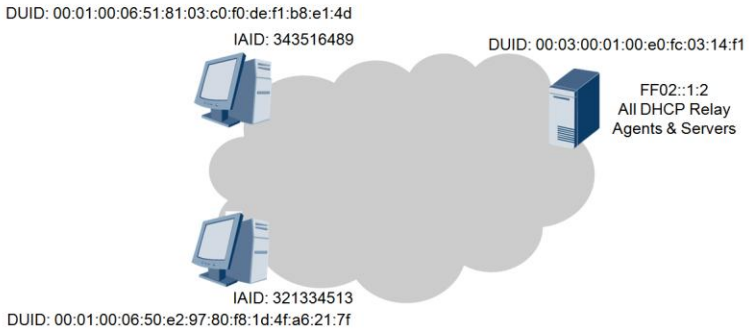


- Information-request used when IPv6 addressing not required.
- Reply used to deliver configuration parameters.

DHCP may also be employed to support stateless configuration in the event where a host is capable of retrieving IPv6 addressing information through stateless configuration means, and requires only specific configuration parameters from the DHCPv6 server. In such events Information-request messages are generated, and sent by clients to a server to request configuration parameters. The client is able to obtain configuration information such as server addresses and domain information, as a list of available configuration parameters, using only a single message and reply that is exchanged with a DHCP server.

The Information-Request message is sent to the “All_DHCP_Relay_Agents_and_Servers” multicast address following which servers respond with a Reply message containing the configuration information for the client. Since no dynamic state is being maintained (i.e. in the form of IPv6 address assignment) the allocation of configuration information is understood to be stateless.

DHCP Unique Identifier (DUID)



- Unique identifier of clients & servers in the DHCP community.
- Parameters bound to each DUID using Identity Associations (IA)

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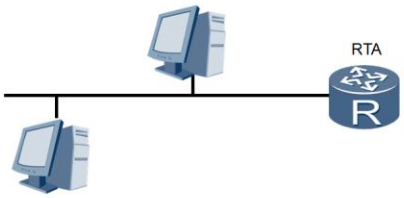
A DHCP Unique Identifier (DUID) is a value that is used to distinguish between each client and DHCP server, for which only one DUID is present in each case. Clients may have one or multiple interfaces for which each will be assigned an IPv6 address along with other configuration parameters and is referenced using an Identity Association Identifier (IAID). These are used together with DUID to allow DHCPv6 servers to reference a client and the interface address/configuration parameters that should be assigned.

In the case of each client, the DUID will be used to identify a specific DHCP server with which a client wishes to communicate. The length of the DUID value can vary from anywhere in the range of 96bits (12 bytes) to 160 bits (20 bytes), depending on the format that is used. Three such formats exist, using either the link-layer (DUID-LL) address, a combination of the link-layer address and enterprise number (DUID-EN), a vendor assigned value at the point of device manufacture, or a combination of the link-layer address and a timestamp value (DUID-LLT) generated at the point of DUID creation in seconds from midnight Jan 1st 2000 (GMT), modulo 2^{32}.

The initial 16 bit values (00:01) represent the format used, where “00:01” denotes the DUID-LLT format, “00:02” the DUID-EN format and “00:03” the DUID-LL format. In the case of the DUID-LL and DUID-LLT formats, the 16 bits immediately after represent the hardware address based on IANA hardware type parameter assignments, with 00:01 representing Ethernet (10Mb) and 00:06 defining IEEE 802 network standards. A time stamp follows in the DUID-LLT format and finally the link layer address value. For DUID-LL only the link layer address follows.

Setting the DHCP DUID

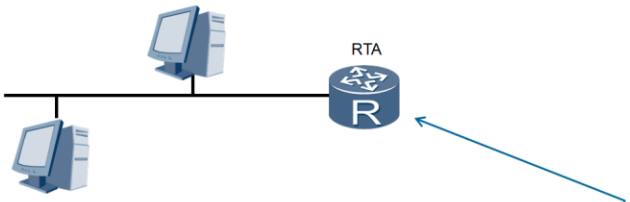



```
[RTA]dhcpv6 duid ll
Warning: The DHCP unique identifier should be globally-unique and
stable. Are you sure to change it? [Y/N]y
```

- Enables assignment of either the DUID-LL or DUID-LLT format.
- The DUID-LL format is assigned by default.

The DUID format can be assigned through the *dhcpv6 duid* command, for which either the DUID-LL or DUID-LLT format can be applied. The DUID-LL format is applied by default. For the DUID-LLT, the timestamp value will reference the time from the point at which the *dhcpv6 duid llt* command is applied. The *display dhcpv6 duid* command can be used to verify the current format based primarily on the length of the DUID value, as well as the DUID value itself.

IPv6 Address Pool



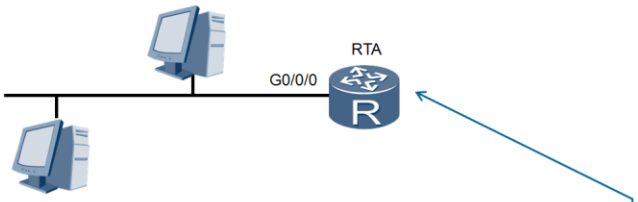

```
[RTA]dhcpv6 pool pool1
[RTA-dhcpv6-pool-pool1]address prefix 3000::/64
[RTA-dhcpv6-pool-pool1]excluded-address 3000::1
[RTA-dhcpv6-pool-pool1]dns-server 3001::1
[RTA-dhcpv6-pool-pool1]dns-domain-name huawei.com
```

- DHCPv6 parameters are assigned for each address pool.

The implementation of stateful addressing requires that an address pool be defined with a typical address prefix defined for the given range, as well as pool specific parameters. The example demonstrates how a pool is created with the defining of a pool and associated pool name, as well as the address prefix from which the range of host addresses will be allocated.

Excluded addresses refer to addresses that comprise of the pool range however should not be allocated through DHCP since they are commonly used for other applications such as the interface address of the DHCP server. Additional configuration parameters will also be specified for a given pool with examples such as server addresses and domain names being specified for parameter allocation to DHCPv6 clients.

Enable DHCPv6 Server




```
[RTA]ipv6
[RTA]dhcp enable
[RTA]interface GigabitEthernet 0/0/0
[RTA-GigabitEthernet0/0/0]ipv6 enable
[RTA-GigabitEthernet0/0/0]ipv6 address 3000::1/64
[RTA-GigabitEthernet0/0/0]dhcpv6 server pool1
```

- Address pool is associated with the DHCPv6 server interface.

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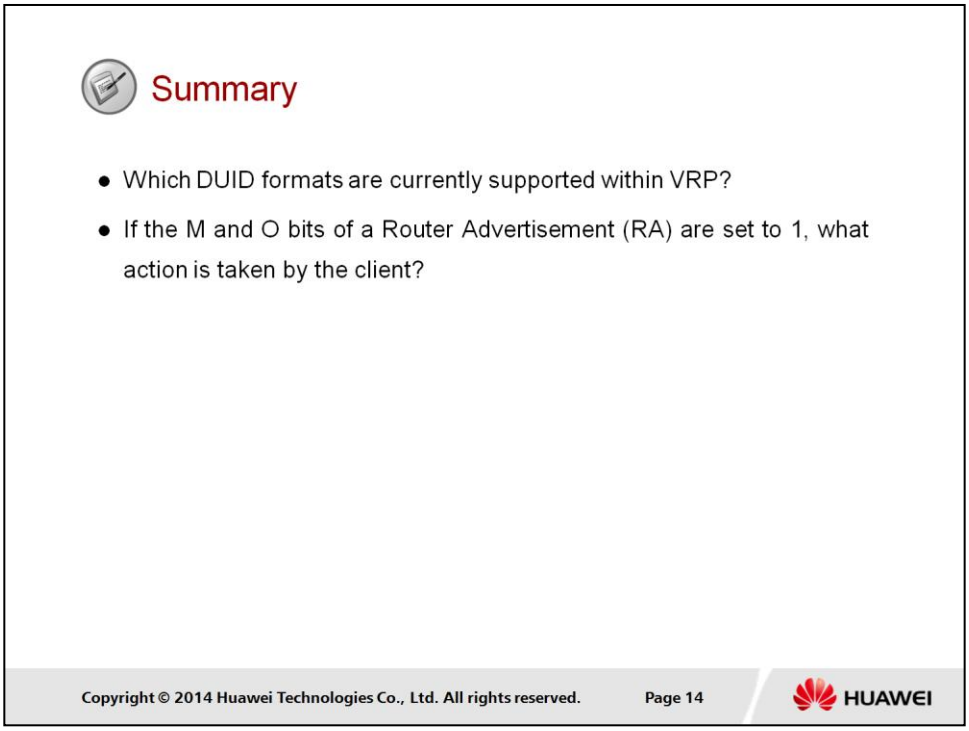
A created DHCPv6 pool is required to be associated with an interface through which it will service DHCP clients. An IPv6 address is assigned to the interface of the DHCPv6 server and the interface then associated with the address pool. In this case the excluded address value has been used to represent the interface address in order to ensure no attempts are made by the DHCPv6 server to assign the interface address to a DHCP client.

Displaying DHCPv6 Information

```
<RTA>display dhcpv6 pool
DHCPv6 pool: pool1
  Address prefix: 3000::/64
    Lifetime valid 172800 seconds, preferred 86400 seconds
    2 in use, 0 conflicts
   Excluded-address 3000::1
   Information refresh time: 86400
   DNS server address: 3001::1
   Domain name: huawei.com
   Conflict-address expire-time: 172800
   Active normal clients: 2
```

- Configured pools, pool based parameters, and client activity are referenced under the *display dhcp pool* command.

The resulting configuration of the DHCPv6 server can be clarified through the *display dhcpv6 pool* command, from which point the defined pool(s) can be identified and the address prefix associated with the pool determined. Additional information such as the lifetime can be viewed, for which the default lifetime of a leased address is 86400 seconds, or 1 day and can be reconfigured as necessary using the *information-refresh* command under the *dhcpv6 pool <pool-name>* view. Where active clients have leased addresses from the DHCP server, the related statistics can be found here.



1. The AR2200 series router is capable of supporting Link Layer (DUID-LL) and Link Layer with Time (DUID-LLT) formats.

2. When a router advertisement is received containing M and O bit values set to 1, the client will perform discovery of a DHCPv6 server for stateful address configuration. The configuration will include an IPv6 address and also other configuration information such as prefixes and addressing of servers providing services such as DNS.

Thank you

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