NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Computer Engineering

WAN WEB SERVICES

GRADUATION PROJECT

COM-400

Student: MOH'D MURAD AL-SMADI (20010943)

Supervisor: Assist. Prof. Dr. Firudin Muradov

Nicosia 2005

Acknowledgements

I would like to grant all the thanks and appreciation to my advisor Assist. Prof. Dr. Firudin Muradov, who through his wisdom and experience kindly guided me through these four years of studying to graduate as a computer engineer. I would also like to thank the computer engineering department with its entire staff for making my dream come true.I would also like to give my very special thanks and respect to my parents, for if it wasn't for them these four years would have been impossible to complete. It was their support and prayers that made me get this far.

And not to forget my dear friends, especially Sameer , Qays, Tawfeek, Samer the Lebanese, and his brother Nader, and last but not least my relative Khaled.

ABSTRACT

This Project introduces the various protocols and technologies used in wide-area network (WAN) environments. A WAN is a data communications network that covers a relatively broad geographic area and that often uses transmission facilities provided by common carriers, such as telephone companies. WAN technologies generally function at the lower three layers of the OSI reference model: the physical layer, the data link layer, and the network layer. A point-to-point link provides a single, pre-established WAN communications path from the customer premises through a carrier network, such as a telephone company, to a remote network Switched circuits allow data connections that can be initiated when needed and terminated when communication is complete. This works much like a normal telephone line works for voice communication. Integrated Services Digital Network (ISDN) is a good example of circuit switching. WANs use numerous types of devices that are specific to WAN environments. WAN switches, access servers, modems, CSU/DSUs, and ISDN terminal adapters. Other devices found in WAN environments that are used in WAN implementations include routers, ATM switches, and multiplexers.

In addition to that, this project describes the Web Services Architecture. It identifies the functional components and describes the relationships among those components to affect the desired properties of the overall architecture.

TABLE OF CONTENTS

LIST OF ABBREVIATION

WAN	Wide Area Network
OSI	Open System Interconnection
ISDN	Integrated Services Digital Network
CSU	Channel Service Unit
DSU	Digital Service Unit
ATM	Asynchronous Transfer Mode
TCP	Transmission Control Protocol
IP	Internet Protocol
SNA	Systems Network Architecture
DNS	Domain Name Service
DHCP	Dynamic Host Configuration Protocol
HSSI	High Speed Serial Interface

INTRODUCTION

This project is mainly made of four chapters. The first three talk about Wide Area Networks or WAN. These chapters introduce the various protocols and technologies used in wide-area network (WAN) environments. Topics stated in these chapters include point-to-point links, circuit switching, packet switching, virtual circuits, dialup services, and WAN devices. They also explain the classification, queuing, network provisioning, link fragmentation and interleaving, traffic shaping Call admission control of the WAN. In addition to that it introduces the devices used in wan connections, such as protocols like: Net bios, TCP/IP, physical network types like: leased lines, ISDN, Ethernet, ATM, radio, infrared, Microwave, satellite, and pure network devices: routers, bridges, encryption units and modems. The last chapter of the project discusses web services and their architecture.

The four chapters can be summarized as follows:

Chapter one describes a wide area network, and describes the protocols and technologies used in it.

Chapter two describes the infrastructure of the network, its organization, its control, and shaping in order to maintain a high efficiency.

Chapter three presents the hardware and software used in establishing a network. It also presents the procedures used in network security and management.

Chapter four describes a conceptual model and a context for understanding Web services and the relationships between the components of this model.

CHAPTER ONE

WAN TECHONOLGIES AND PROTOCOLS

1.1 Overview

This chapter introduces the various protocols and technologies used in wide-area network (WAN) environments. Topics summarized here include point-to-point links, circuit switching, packet switching, virtual circuits, dialup services, and WAN devices.

1.2 What Is a WAN?

A WAN is a data communications network that covers a relatively broad geographic area and that often uses transmission facilities provided by common carriers, such as telephone companies. WAN technologies generally function at the lower three layers of the OSI reference model: the physical layer, the data link layer, and the network layer. Figure 1.2 illustrates the relationship between the common WAN technologies and the OSI model.

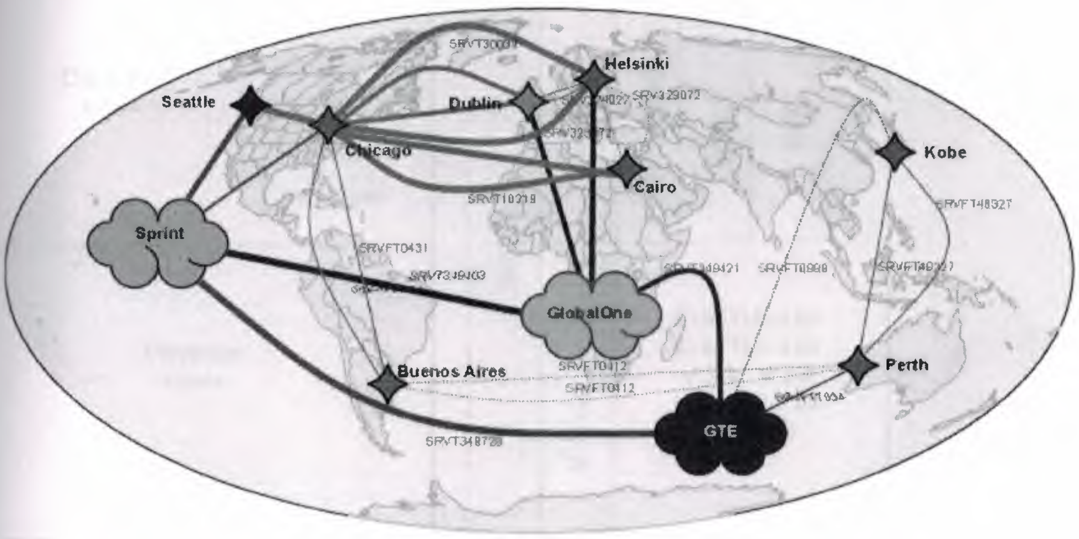


Figure 1.1 Shows Global Wide Area Network

1.3 Point-to-Point Links

A point-to-point link provides a single, pre-established WAN communications path from the customer premises through a carrier network, such as a telephone company, to a remote network. Point-to-point lines are usually leased from a carrier and thus are often called leased lines. For a point-to-point line, the carrier allocates pairs of wire and facility hardware to your line only. These circuits are generally priced based on bandwith required and distance between the two connected points. Point-to-point links.

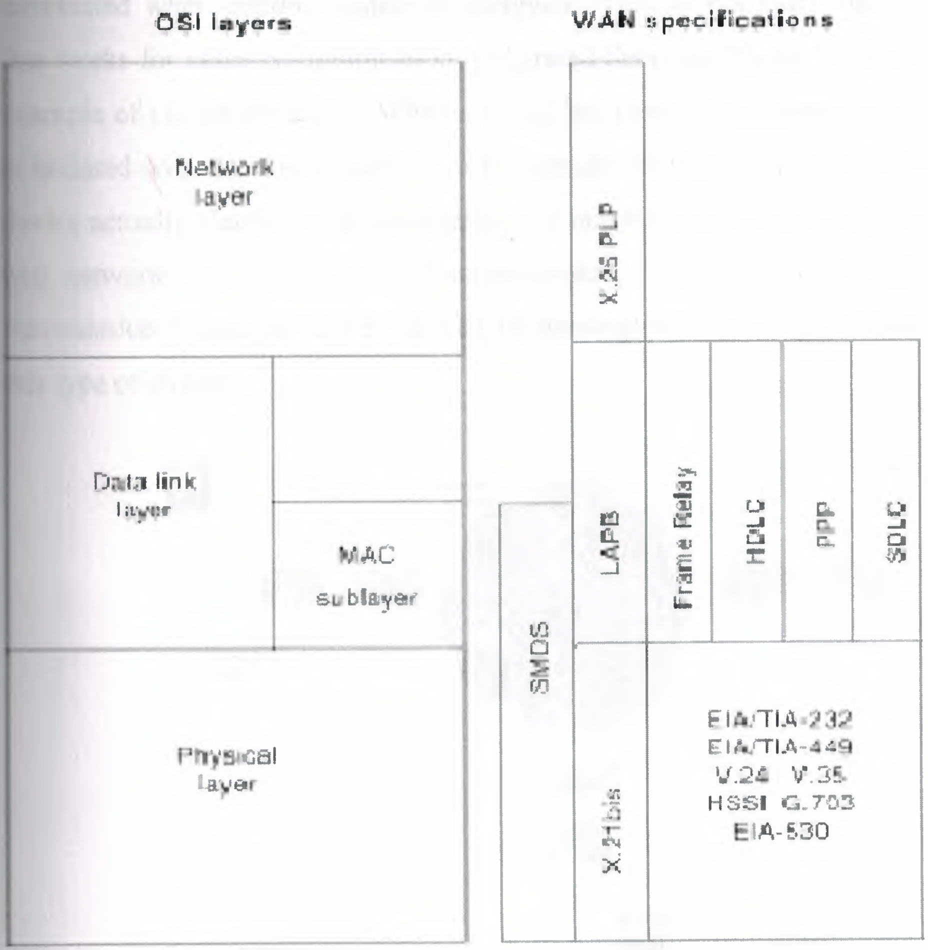


Figure 1.2 WAN Technologies Operate at the Lowest Levels of the OSI Model are generally more expensive than shared services such as Frame Relay. Figure 1.3 illustrates a typical point-to-point link through a WAN.

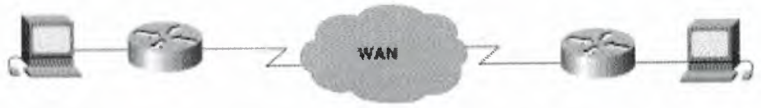


Figure 1.3 A Typical Point-to-Point Link Operates Through a WAN to a Remote Network

1.4 Circuit Switching

Switched circuits allow data connections that can be initiated when needed and terminated when communication is complete. This works much like a normal telephone line works for voice communication. Integrated Services Digital Network (ISDN) is a good example of circuit switching. When a router has data for a remote site, the switched circuit is initiated with the circuit number of the remote network. In the case of ISDN circuits, the device actually places a call to the telephone number of the remote ISDN circuit. When the two networks are connected and authenticated, they can transfer data. When the data transmission is complete, the call can be terminated. Figure 1.4 illustrates an example of this type of circuit.

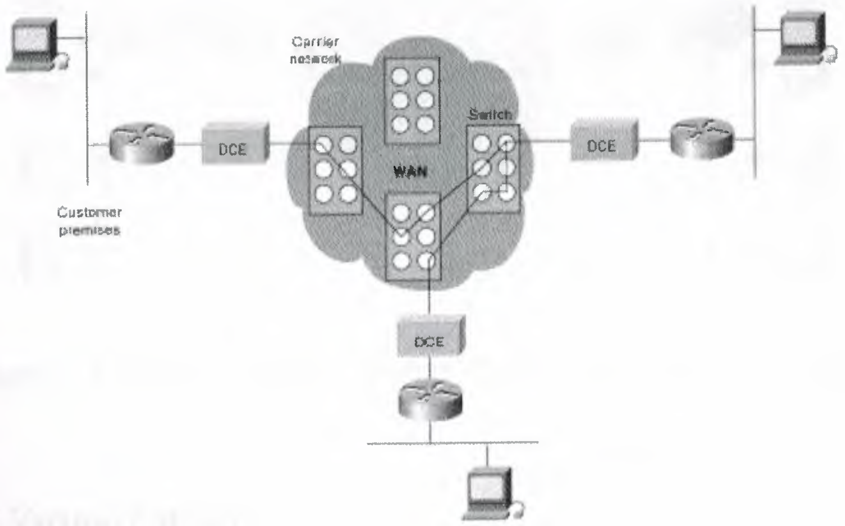


Figure 1.4 A Circuit-Switched WAN Undergoes a Process Similar to That Used for a Telephone Call

1.5 Packet Switching

Packet switching is a WAN technology in which users share common carrier resources. Because this allows the carrier to make more efficient use of its infrastructure, the cost to the customer is generally much better than with point-to-point lines. In a packet switching setup, networks have connections into the carrier's network, and many customers share the carrier's network. The carrier can then create virtual circuits between customers' sites by which packets of data are delivered from one to the other through the network. The section of the carrier's network that is shared is often referred to as a cloud.

Some examples of packet-switching networks include Asynchronous Transfer Mode (ATM), Frame Relay, Switched Multi-megabit Data Services (SMDS), and X.25. Figure 1.5 shows an example packet-switched circuit. The virtual connections between customer sites are often referred to as a virtual circuit.

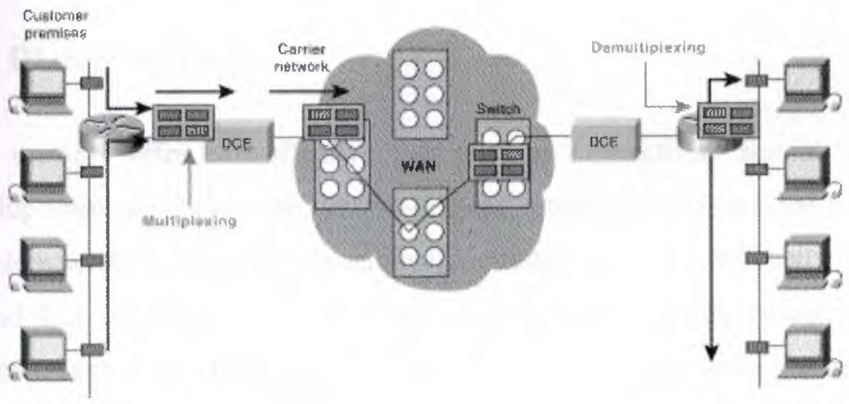


Figure 1.5 Packet Switching Transfers Packets Across a Carrier Network

1.6 WAN Virtual Circuits

A virtual circuit is a logical circuit created within a shared network between two network devices. Two types of virtual circuits exist: switched virtual circuits (SVCs) and permanent virtual circuits (PVCs).

SVCs are virtual circuits that are dynamically established on demand and terminated when transmission is complete. Communication over an SVC consists of three phases: circuit establishment, data transfer, and circuit termination. The establishment phase involves creating the virtual circuit between the source and destination devices. Data transfer involves transmitting data between the devices over the virtual circuit, and the circuit termination phase involves tearing down the virtual circuit between the source and destination devices. SVCs are used in situations in which data transmission between devices is sporadic, largely because SVCs increase bandwidth used due to the circuit establishment and termination phases, but they decrease the cost associated with constant virtual circuit availability.

PVC is a permanently established virtual circuit that consists of one mode: data transfer. PVCs are used in situations in which data transfer between devices is constant. PVCs decrease the bandwidth use associated with the establishment and termination of virtual circuits, but they increase costs due to constant virtual circuit availability. The service provider generally configures PVCs when an order is placed for service.

1.7 WAN Dialup Services

Dialup services offer cost-effective methods for connectivity across WANs. Two popular dialup implementations are dial-on-demand routing (DDR) and dial backup. DDR is a technique whereby a router can dynamically initiate a call on a switched circuit when it needs to send data. In a DDR setup, the router is configured to initiate the call when certain criteria are met, such as a particular type of network traffic needing to be transmitted. When the connection is made, traffic passes over the line. The router configuration specifies an idle timer that tells the router to drop the connection when the circuit has remained idle for a certain period.

Dial backup is another way of configuring DDR. However, in dial backup, the switched circuit is used to provide backup service for another type of circuit, such as point-to-point or packet switching. The router is configured so that when a failure is detected on the primary circuit, the dial backup line is initiated. The dial backup line then supports the

WAN connection until the primary circuit is restored. When this occurs, the dial backup connection is terminated.

1.8 WAN Devices

WANs use numerous types of devices that are specific to WAN environments. WAN switches, access servers, modems, CSU/DSUs, and ISDN terminal adapters are discussed in the following sections. Other devices found in WAN environments that are used in WAN implementations include routers, ATM switches, and multiplexers.

1.8.1 WAN Switch

A WAN switch is a multipart internetworking device used in carrier networks. These devices typically switch such traffic as Frame Relay, X.25, and SMDS, and operate at the data link layer of the OSI reference model. Figure 1.6 illustrates two routers at remote ends of a WAN that are connected by WAN switches.

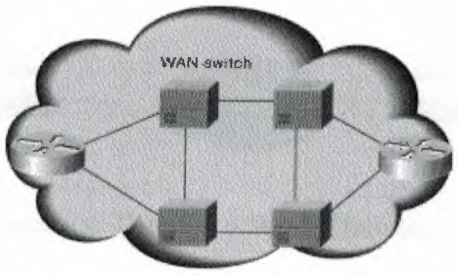


Figure 1.6 WAN Switches can connect Two Routers at Remote Ends of a WAN

1.8.2 Access Server

An access server acts as a concentration point for dial-in and dial-out connections. Figure 1.7 illustrates an access server concentrating dial-out connections into a WAN.

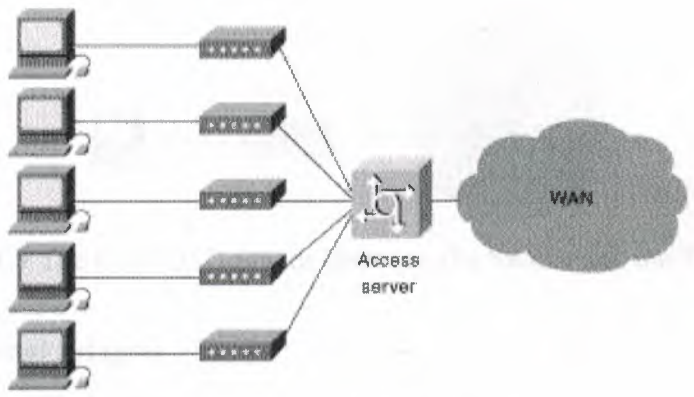


Figure 1.7 Access Server Concentrates Dial-Out Connections into a WAN

1.8.3 Modem

A modem is a device that interprets digital and analog signals, enabling data to be transmitted over voice-grade telephone lines. At the source, digital signals are converted to a form suitable for transmission over analog communication facilities. At the destination, these analog signals are returned to their digital form. Figure 1.8 illustrates a simple modem-to-modem connection through a WAN.

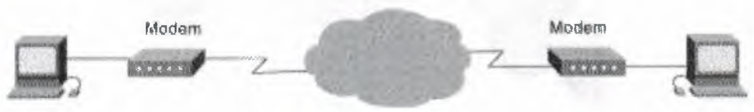


Figure 1.8 A Modem Connection Through a WAN Handles Analog and Digital Signals

1.8.4 CSU/DSU

A channel service unit/digital service unit (CSU/DSU) is a digital-interface device used to connect a router to a digital circuit like a T1. The CSU/DSU also provides signal timing for communication between these devices. Figure 1.9 illustrates the placement of the CSU/DSU in a WAN implementation.

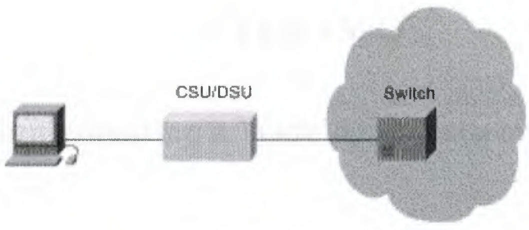


Figure 1.9 The CSU/DSU Stands Between the Switch and the Terminal

1.8.5 ISDN Terminal Adapter

An ISDN terminal adapter is a device used to connect ISDN Basic Rate Interface (BRI) connections to other interfaces, such as EIA/TIA-232 on a router. A terminal adapter is essentially an ISDN modem, although it is called a terminal adapter because it does not actually convert analog to digital signals. Figure 1.10 illustrates the placement of the terminal adapter in an ISDN environment.

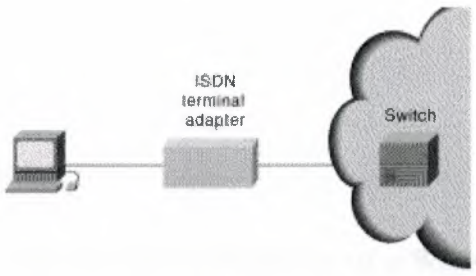


Figure 1.10 Terminal Adapter Connects the ISDN Terminal Adapter to Other Interfaces

CHAPTER TWO

Implementing a Wide Area Network

2.1 Overview

A lower total cost of ownership is one of the most compelling reasons for migrating to a converged data, voice, and video network. While a converged network can lower overall costs of the enterprise communications infrastructure, solid planning and design is still required for a successful deployment. Nowhere is this fact more evident than when running VoIP over a Wide Area Network (WAN).

As stated in "Overview" three basic tools must be used on every portion of the IP network to provide an environment that can ensure voice quality over the network:

- Classification
- Queuing
- Network provisioning

When the low bandwidths and slow link speeds of a WAN are introduced, you must also use several additional tools:

- Link Fragmentation and Interleaving (LFI)
- Traffic shaping
- Call admission control

All of these tools are described in the following sections.

2.2 Classification

Classification is the method by which certain traffic types are classified, or marked, as having unique handling requirements. These requirements might be a minimum required amount of bandwidth or a low tolerance for latency. This classification can be signaled to the network elements via a tag included in the IP Precedence or Differentiated Services

Code Point (DSCP), in Layer 2 schemes such as 802.1p, in the source and destination IP addresses, or in the implicit characteristics of the data itself, such as the traffic type using the Real-time Transport Protocol (RTP) and a defined port range.

In the recommended model, classification is done at both Layer 2 and Layer 3 on the IP phone. In this model, the phone is the "edge" of the managed network, and it sets the Layer 2 802.1p CoS value to 5 and the Layer 3 IP Precedence value to 5 or the DSCP value to EF.

2.3 Queuing

As was discussed in previous chapters, interface queuing is one of the most important mechanisms for ensuring voice quality within a data network. This is even more vital in the WAN because many traffic flows are contending for a very limited amount of network resources. Once traffic has been classified, the flow can be placed into an interface egress queue that meets its handling requirements. Voice over IP, because of its extremely low tolerance for packet loss and delay, should be placed into a Priority Queue (PQ). However, other traffic types may have specific bandwidth and delay characteristics as well. These requirements are addressed with the Low-Latency Queuing (LLQ) feature in IOS.

LLQ combines the use of a PQ with a class-based weighted fair queuing scheme. Classes are defined with classification admission schemes. Traffic flows have access to either the PQ, one of the class-based queues, or a default weighted fair queue. LLQ, the recommended queuing scheme for all low-speed links, allows up to 64 traffic classes with the ability to specify such parameters as priority queuing behavior for voice, a minimum bandwidth for Systems Network Architecture (SNA) data, and control protocols and weighted fair queuing for other traffic types.

When a Priority Queuing class is configured, the PQ has direct access to the transmit (TX) ring. This is, of course, unless interleaving is configured, in which case interleaving occurs prior to placing the PQ traffic onto the TX-ring. The maximum configured bandwidth in the PQs and class-based queues cannot exceed the minimum available amount of bandwidth on the WAN connection.

A practical example is a Frame Relay LLQ with a Committed Information Rate (CIR) of 128 kbps. If the PQ for VoIP is configured for 64 kbps and both the SNA and AVVID control protocol class-based queues are configured for 20 kbps and 10 kbps, respectively, the total configured queue bandwidth is 94 kbps. IOS defaults to a minimum CIR (mincir) value of CIR/2. The mincir value is the transmit value a Frame Relay router will "rate down" to when Backward Explicit Congestion Notifications (BECNs) are received. In this example, the mincir value is 64 kbps and is lower than the configured bandwidth of the combined queues. For LLQ to work in this example, a mincir value of 128 kbps should be configured.

2.3.1 Link Fragmentation and Interleaving

For low-speed WAN connections (in practice, those with a clocking speed of 768 kbps or below), it is necessary to provide a mechanism for Link Fragmentation and Interleaving (LFI). A data frame can be sent to the physical wire only at the serialization rate of the interface. This serialization rate is the size of the frame divided by the clocking speed of the interface. For example, a 1500-byte frame takes 214 ms to serialize on a 56-kbps circuit. If a delay-sensitive voice packet is behind a large data packet in the egress interface queue, the end-to-end delay budget of 150-200 ms could be exceeded. In addition, even relatively small frames can adversely affect overall voice quality by simply increasing the jitter to a value greater than the size of the adaptive jitter buffer at the receiver. Table 2.1 shows the serialization delay for various frame sizes and link speeds.

Table 2.1 Shows Serialization Delay

Link Speed	Frame Size (Bytes)					
	64	128	256	512	1024	1500
56 kbps	9 ms	18 ms	36 ms	72 ms	144 ms	214 ms
64 kbps	8 ms	16 ms	32 ms	64 ms	128 ms	187 ms
128 kbps	4 ms	8 ms	16 ms	32 ms	64 ms	93 ms
256 kbps	2 ms	4 ms	8 ms	16 ms	32 ms	46 ms
512 kbps	1 ms	2 ms	4 ms	8 ms	16 ms	23 ms
768 kbps	0.640 ms	1.28 ms	2.56 ms	5.12 ms	10.4 ms	15 ms

FI tools are used to fragment large data frames into regularly sized pieces and to interleave voice frames into the flow so that the end-to-end delay can be predicted accurately. This places bounds on jitter by preventing voice traffic from being delayed behind large data frames.

The two techniques used for this are FRF.12 for Frame Relay and Multi-link Point-to-Point Protocol (MLP) for point-to-point serial links. A 10-ms blocking delay is the recommended target to use for setting fragmentation size. To calculate the recommended fragment size, divide the recommended 10 ms of delay by one byte of traffic at the provisioned line clocking speed, as follows:

Fragment_Size = (Max_Allowed_Jitter * Link_Speed_in_kbps) / 8

For example:Fragment_Size = (10 ms * 56) / 8 = 70 bytes

Table 2.2 Shows the Recommended Fragment Size for Various Link Speeds.

Link Speed	Recommended Fragment Size
56 kbps	70 bytes
64 kbps	80 bytes
128 kbps	160 bytes
256 kbps	320 bytes
512 kbps	640 bytes
768 kbps	960 bytes

2.3.2 Traffic Shaping

In ATM and Frame-Relay networks, where the physical access speed varies between two endpoints, traffic shaping is used to prevent excessive delay from congested network interface buffers caused by these speed mismatches. Traffic shaping is a tool that meters the transmit rate of frames from a source router to a destination router. This metering is typically done at a value that is lower than the line or circuit rate of the transmitting interface. The metering is done at this rate to account for the circuit speed mismatches that are common in current multiple-access, non-broadcast networks.

Traffic leaving a high-speed interface such as a T1 line at a central site often terminates at a remote site that may have a much slower link speed (for example, 56 kbps). This is quite common and, in fact, has been one of the big selling points for Frame Relay. In Figure 2.3, the T1 interface on the router at the central site sends data out at a T1 rate even if the remote site has a clock rate of 56 kbps. This causes the frames to be buffered within the carrier Frame-Relay network, increasing variable delay. This same scenario can be applied in reverse. For example, the many remote sites, each with small WAN connections, when added together can oversubscribe the provisioned bandwidth or circuit speed at the central site. Traffic shaping is required for Frame-Relay networks for three reasons:

Over subscription of sites is part of the nature of Frame-Relay networks.

It is common for configurations to allow bursts that exceed the Committed Information Rate (CIR).

The default interval for Frame-Relay devices can add unnecessary delay.

The following sections describe some of the aspects of traffic shaping for Frame-Relay networks.

2.4 Network Provisioning

Properly provisioning the network bandwidth is a major component of designing a successful AVVID network. You can calculate the required bandwidth by adding the bandwidth requirements for each major application (for example, voice, video, and data). This sum then represents the minimum bandwidth requirement for any given link, and it should not exceed approximately 75% of the total available bandwidth for the link. This 75% rule assumes that some bandwidth is required for overhead traffic; such as routing and Layer 2 keep alive, as well as for additional applications such as e-mail and Hypertext Transfer Protocol (HTTP) traffic.

A VoIP packet consists of the payload, IP header, User Data gram Protocol (UDP) header, Real-time Transport Protocol (RTP) header, and Layer 2 Link header. At the default packetization rate of 20 ms, VoIP packets have a 160-byte payload for G.711 or a 20-byte payload for G.729. The IP header is 40 bytes, the UDP header is 8 bytes, and the RTP header is 12 bytes. The link header varies in size according to media.

The bandwidth consumed by VoIP streams is calculated by adding the packet payload and all headers (in bits), then multiplying by the packet rate per second (default of 50 packets per second). Table 2.3 details the bandwidth per VoIP flow at a default packet rate of 50 packets per second (pps). This does not include Layer 2 header overhead and does not take into account any possible compression schemes, such as compressed Real-time Transport Protocol (cRTP). You can use the Service Parameters menu in CallManager Administration to adjust the packet rate.

Table 2.3 Bandwidth Consumption for Voice Payload Only

CODEC	Sampling Rate	Voice Payload in Bytes	Packets per Second	Bandwidth per Conversation
G.711	20 ms	160	50	80 kbps
G.711	30 ms	240	33	53 kbps
G.729A	20 ms	20	50	24 kbps
G.729A	30 ms	30	33	16 kbps

A more accurate method for provisioning is to include the Layer 2 headers in the bandwidth calculations, as shown in Table 2.4.

Table 2.4 Bandwidth Consumption with Headers Included

CODEC	Ethernet 14 Bytes of Header	PPP 6 Bytes of Header	ATM 53-Byte Cells with a 48-Byte Payload	Frame-Relay 4 Bytes of Header
G.711 at 50 pps	85.6 kbps	82.4 kbps	106 kbps	81.6 kbps
G.711 at 33 pps	56.5 kbps	54.4 kbps	70 kbps	54 kbps
G.729A at 50 pps	29.6 kbps	26.4 kbps	42.4 kbps	25.6 kbps
G.729A at 33 pps	19.5 kbps	17.4 kbps	28 kbps	17 kbps

2.4.1 Call Admission Control

Call admission control is a mechanism for ensuring that voice flows do not exceed the maximum provisioned bandwidth allocated for voice conversations. After doing the calculations to provision the network with the required bandwidth to support voice, data, and possibly video applications, it is important to ensure that voice does not oversubscribe the portion of the bandwidth allocated to it. While most QoS mechanisms are used to protect voice from data, call admission control is used to protect voice from voice.

2.5 Point-to-Point WAN

Point-to-point WANs, while not as popular as in the past, are still one of the most common types of networks in use today. When designing a point-to-point WAN for an AVVID network, keep the following recommendations in mind:

IOS Release 12.1(3) T is the minimum recommended release for a point-to-point WAN.

Use Link Fragmentation and Interleaving (LFI) techniques on all WAN connections with speeds below 768 kbps.

Use Low-Latency Queuing (LLQ) with a priority queue for VoIP bearer streams and a class queue for VoIP control sessions.

Call admission control is required when the number of calls across the WAN can oversubscribe the allocated VoIP bandwidth.

2.5.1 LFI on Point-to-Point WANs

If the clocking speed of the connection is below 768 kbps, LFI must be used. Multi-link PPP (MLP) instead of PPP is required on all point-to-point links where LFI is needed. To enable LFI on point-to-point WANs, use the IOS command set for MLP.

2.5.2 cRTP on MLP Connections

Compressed RTP (cRTP) can have a dramatic impact on the amount of bandwidth each voice call uses. Prior to IOS Release 12.0(7) T, cRTP was process switched. In fact, fast switching for cRTP was not available on the Catalyst 2600 and 3600 until a bug fix was implemented in IOS Release 12.0(7) T. In addition, some of the newer versions of IOS (specifically, Release 12.1(2.x) T) still use process switching for cRTP. Always read the release notes before attempting to use any specific feature.

2.5.3 LLQ for VoIP over MLP

Low-Latency Queuing (LLQ) is required to support voice over the WAN. When configuring LLQ for MLP-enabled interfaces, put the service-policy output in the multi-link interface configuration. In the following example, two classes are defined: one for the VoIP media stream and one for the control traffic. Access to these classes, and therefore the queues they service, is done through access lists that match either Layer 3 ToS classification or source and destination IP addresses and ports. The access lists look slightly different for the control traffic at the central site because a Catalyst 6000 has already classified VoIP Control sessions with a DSCP value of 26 (AF31, which is backward compatible with IP Precedence 3).

All VoIP media traffic is placed into the Priority Queue (PQ), which is given 100 kbps of bandwidth. All Skinny Protocol control traffic is placed into a class-based queue and is given 10 kbps of bandwidth. All other traffic is queued using Weighted Fair Queuing.

2.6 Frame-Relay WAN

Frame-Relay networks are the most popular WANs in use today because of the low cost associated with them. However, because Frame Relay is a non-broadcast technology that uses over subscription to achieve costs savings, it is not always an easy platform on which to implement AVVID solutions. While this section outlines the basic requirements for successfully deploying AVVID solutions across a Frame-Relay WAN, extensive explanations of Frame Relay committed information rate (CIR), committed burst rate (Bc), excess burst rate (Be), and interval configurations are examples of frame relay WAN.

When designing a Frame-Relay WAN for an AVVID network, keep the following recommendations in mind:IOS Release 12.1(2) T is the minimum recommended release for a Frame-Relay WAN. You must use traffic shaping with Frame-Relay WANs. Use Link Fragmentation and Interleaving (LFI) techniques on all virtual circuits with speeds below 768 kbps. Use Low-Latency Queuing (LLQ) with a Priority Queue (PQ) for VoIP bearer streams and a class-based queue for VoIP control sessions.

Call admission control is required when the number of calls across the WAN can oversubscribe the allocated VoIP bandwidth.

2.6.1 FRF.12 for LFI on Frame-Relay WANs

To enable Link Fragmentation and Interleaving (LFI) on Frame-Relay WANs, you must also use traffic shaping. Unlike MLP, the actual fragment size must be configured when using LFI on Frame Relay. In Frame-Relay networks, the fragmentation size is based on the Permanent Virtual Circuit (PVC), not the actual serialization rate (clocking speed) of the interface.

This method is used because the Frame-Relay traffic shaping policy allows only the specified bit rate in the Committed Information Rate (CIR) to enter the interface transmit buffer.

In other words, the rate of the PVC CIR is the clocking rate to reference when estimating fragmentation requirements in a frame-relay environment.

2.6.2 LLQ for VoIP over Frame Relay

Low-Latency Queuing (LLQ) is required to support voice over the WAN. When configuring LLQ for Frame-Relay interfaces, put the service-policy output in the map-class frame-relay configuration section. In the following example, two classes are defined: one for the VoIP media stream and one for the control traffic. Access to these classes, and therefore the queues they service, is done through access lists that match either Layer 3 ToS classification or source and destination IP addresses and ports. The access lists look slightly different for the control traffic at the central site because a Catalyst 6000 has already classified VoIP Control sessions with a DSCP value of 26.

All VoIP media traffic is placed into the Priority Queue (PQ), which is given 100 kbps of bandwidth. All Skinny Protocol control traffic is placed into a class-based queue and given 10 kbps of bandwidth. All other traffic is queued using Weighted Fair Queuing.

2.7 ATM WAN

Asynchronous Transfer Mode (ATM) is becoming a more common medium for WANs because many service providers have adopted this technology.

One of the difficulties with using ATM in WANs is that it was designed for high speeds, not low speeds. Many enterprises are attempting to deploy AVVID solutions over low-speed ATM connections. This generally results in complications because many of the IOS QoS tools are not currently supported on ATM interfaces, and many of the interface defaults are automatically configured for high-speed ATM circuits.

This is evident in the default sizing of ATM TX-ring buffers. For example, by default, the 7200 router OC-3 interface (the PA-A3) sets the TX-ring buffer to 8192 bytes. This is a correct setting for an OC-3, but, for a 256-kbps Permanent Virtual Circuit (PVC) configured on the interface, very large TX-ring buffer delays can occur. Because of this, the TX-ring has to be configured to a much lower value on a sub-interface level. When designing an ATM WAN for an AVVID network, keep the following recommendations in mind:

IOS Release 12.1(5) T for MLP over ATM is the minimum recommended release for an ATM WAN.

For all ATM connections below DS-3 speeds, you must adjust the TX-ring buffer size.

It is preferable to use two Permanent Virtual Circuits (PVCs) if the PVC speed is less than 768 kbps.

If using single PVC that is less than 768 kbps, use MLP over ATM for LFI.

If using single PVC, use LLQ with a Priority Queue (PQ) for VoIP bearer streams and a class-based queue for VoIP control sessions.

Call admission control is required when the number of calls across the WAN can oversubscribe the allocated VoIP bandwidth.

2.8 Frame-Relay-to-ATM Internetworking WAN

Many enterprises are deploying AVVID networks that use Frame Relay at the remote sites and ATM at the central location. The conversion is accomplished through ATM-to-Frame-Relay Service Internetworking (FRF.8) in the carrier network.

When designing a Frame-Relay-to-ATM Internetworking WAN for an AVVID network, keep the following recommendations in mind:

IOS Release 12.1(5) T for MLP over ATM and MLP over Frame Relay is the minimum recommended release for this configuration.

FRF.8 Transparent Mode is the only support method for MLP over ATM and Frame-Relay Service Internetworking.

For all ATM connections below DS-3 speeds, you must adjust the TX-ring buffer size.

Use two Permanent Virtual Circuits (PVCs) if the ATM and Frame-Relay PVC speed is less than 768 kbps.

If using single PVC that is less than 768 kbps, use MLP over ATM and Frame Relay for LFI.

If using single PVC, use LLQ with a Priority Queue (PQ) for VoIP bearer streams and a class-based queue for VoIP control sessions.

Call admission control is required when the number of calls across the WAN can oversubscribe the allocated VoIP bandwidth.

CHAPTER THREE

WAN DEVICES

3.1 Overview

Network security is vital. Many applications (IBM 3270 telnet emulation, Telnet, ftp...) send unencrypted passwords across the network. Although a network cannot be completely secured, the weakest links should be protected. It is not realistic to expect the Network to be ever 100% secure. There are two principal tendencies in network security today:

New applications being developed are often designed so that they can transfer data securely across insecure networks. i.e. some type of authentication / encryption is built-in.

IP level encryption (for TCP/IP networks) offers a secure channel between two machines, even over insecure networks. One example is SKIP

Network security could easily be enhanced if Vendors replaced relics such as ftp, telnet and rlogin with more secure alternatives such as ssh, if NIS+ and/or Kerberos clients were bundled with all major OSs and a secure email system such as pgp were fully integrated into vendors email clients. But history shows that this is unlikely to happen... Centralized network management is important for maintaining network security. The Network (meaning both LAN and WAN) is analyzed here in terms of:

Protocols: Net bios, TCP/IP, SNA, IPX, DECnet... Physical network types: leased lines, ISDN, X25, FDDI, Ethernet, ATM, radio, infra red, Microwave, GSM, satellite. Pure Network devices: routers, bridges, encryption units and modems. Firewalls are discussed in the next chapter.

3.2 Network Model (OSI)

The Open Systems Interconnect model is the standard for describing the transmission of data across networks. The seven-layer model is particularly useful in comparing different architectures. The following diagram should help to understand the relationships between OSI, TCP/IP and communications layers used by LAN Manager.

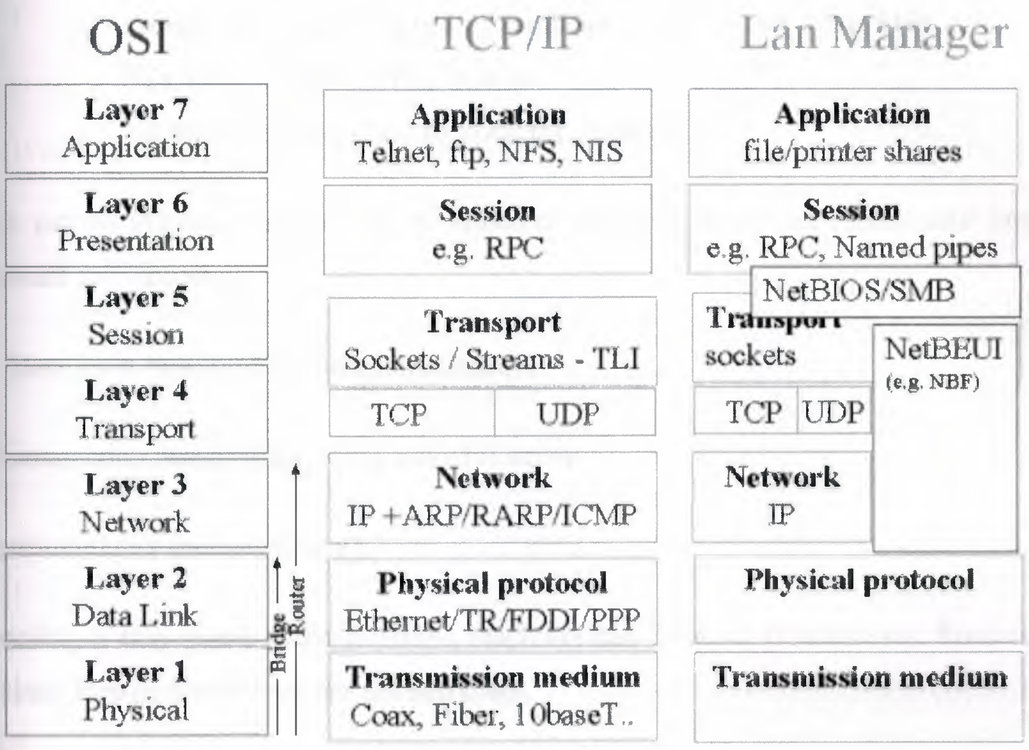


Figure 3.1 Shows the Seven OSI Layer Representation

3.3 Network Protocols

3.3.1 LAN Manager / Microsoft Network / NT Domains

NetBEUI: Use only on local subnets. WINS (Windows Internet Naming Service) allows Net bios name to IP address resolution via a highly automated dynamic database. It reduces the need for LMHOSTS files. RAS (Remote Access Service).

3.3.2 TCP/IP

- Weaknesses
- TCP/IP was not designed for high security:
    - Protection through the use of privileged ports (0-1000) has little value since PCs have become TCP/IP clients.
    - No traffic priority (easy to flood the network).

Traffic can be injected; packets can be stolen or hijacked, so ensure routers and firewall implement anti-spoofing.

UDP (data gram based) offers no authentication.

TCP (connection based) offers weak authentication.

No confidentiality (no encryption).

IP spoofing is easy (weak authentication), machines can lie about IP addresses. Routers can be tricked. Header checksums are not sufficient.

Checksums are easy to cheat (weak algorithm).

However, TCP/IP is reliable, robust and the de-facto standard.

DNS (Domain Name Service)

The DNS, which is used on the internal network, should not be visible to the outside world (Internet). Firewalls, which provide DNS information to the Internet, should only resolve firewall addresses/names (i.e. for email, an MX record which points to the firewall itself) and not provide any information about hosts on the internal network.

The internal DNS server can be set up to send unresolved queries to the external DNS server, which will then search the Internet.

Internal clients should point to the internal DNS server(s).

Clients with very few, designated connections do not need to use DNS.

DNS servers should be configured as class .

Use replica (secondary) servers to increase availability.

Up the latest version of the Public Domain BIND for the Internet exposed DNS servers, the public versions evolves more quickly and bug are fixed more rapidly than most vendors.

DHCP (Dynamic Host Configuration Protocol)

DHCP is very practical, especially for Laptops and in environments where reorganizations are constant. However, dynamic DHCP makes it difficult to uniquely identify machines, so for class networks, avoid the use of dynamic IP addressing. Static DHCP may be useful for centralizing the management of IP addresses.

An IP address should uniquely identify a machine (to prevent host spoofing and allow use of IP address access control i.e. inetd tcp_wrappers on UNIX machines). If DHCP is to be used (for large laptop populations for example), class servers should have static IP address and not be configured via DHCP.

Ethernet MAC addresses can also be used to uniquely identify a host's traffic, if the MAC addresses are recorded and a database kept up to date and relevant network monitoring software exists.

3.4 Physical network types

If confidentiality is a major concern, use fiber optics, they are very difficult to interrupt or sniff.

3.4.1 Ethernet

Use hubs instead of Thin Ethernet (Star formation). Use switches instead of hubs for better performance and security (all packets are not sent to all nodes).

Avoid "unused" lived connections.

Do not daisy chain.

Disconnect unused sockets.

Networks could be physically secured by using conduit.

3.4.2 Leased lines

Copper leased lines should be hardware or software encrypted.

FDDI

Because FDDI is a fiber optic ring, it is impossible to "listen" by detection of magnetic fields and if someone tries to connect to the ring, they need specialist equipment and the ring would be disturbed - it should not go unnoticed.

ATM

ATM (Asynchronous transfer mode) is a complex suite of protocols with many interesting features, such as bandwidth allocation, virtual networks, and high speed... They are useful primarily by telecom providers. The complexity of ATM makes it difficult for hackers to crack, but also difficult to configure correctly.

HSSI

HSSI (High Speed Serial Interface) is an interface technology that was developed to fill the needs for a high-speed data communication solution over WAN links. It uses differential emitter-coupled logic (ECL), which provides high-speed data transfer with low noise level. HSSI makes bandwidth resources easy to allocate, making T3 and other broadband services available and affordable. HSSI requires the presence of only two control signals, making it highly reliable because there are fewer circuits that can fail. HSSI performs four loop back tests for reliability.

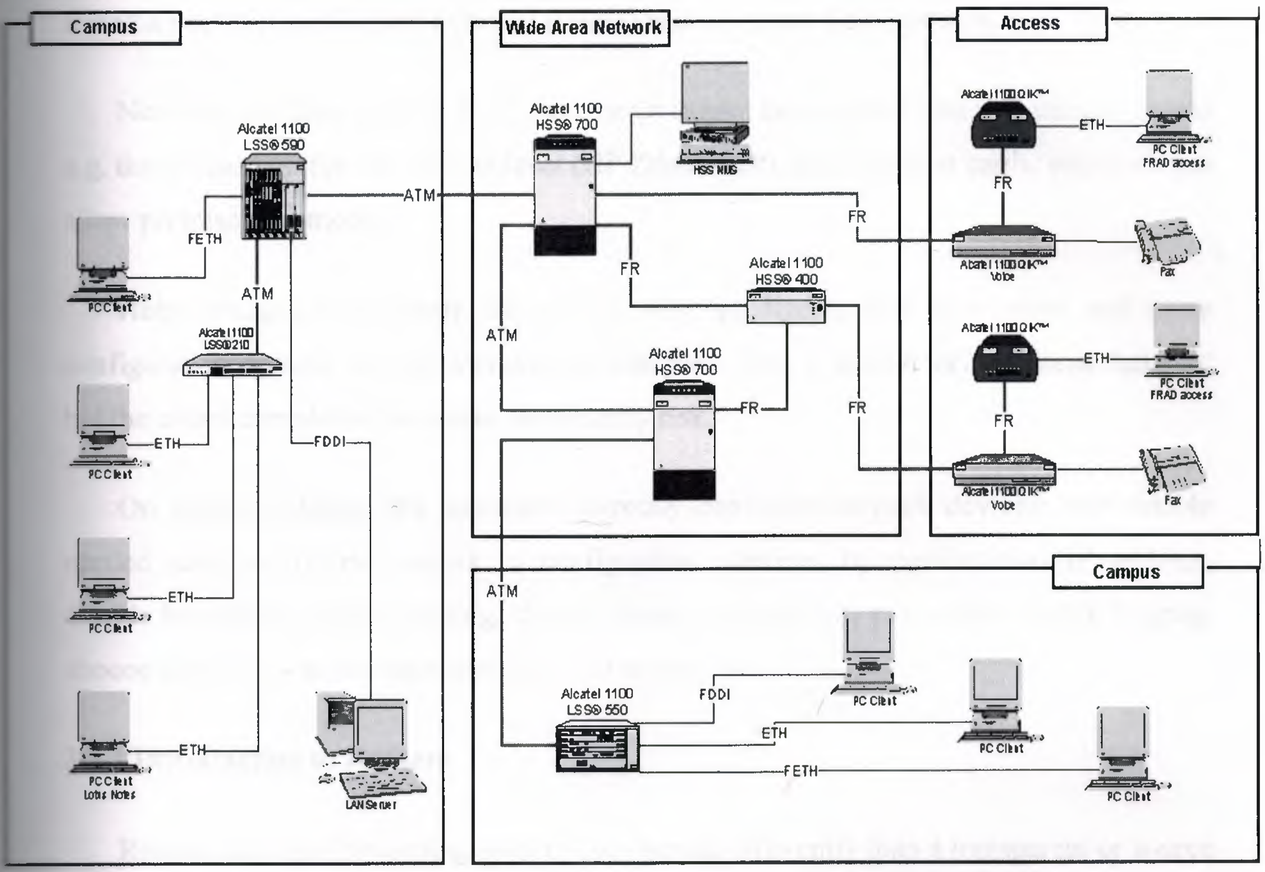


Figure 3.2 Shows a Physical Component of WAN

3.5 Network Devices

Most attacks come from the inside, so: No "sniffer" or "network analyzer" software is to be allowed on any PC unless the Network manager, the Security manager and the user, has authorized it is fully aware of his responsibilities and the PC is logged on a list of dangerous machines. The status of these machines should be reviewed yearly.

On systems (such as SunOS, Solaris) which include such software as standard, should eitherDelete the utility or Change permissions on the utility so that it can only be used by root. Of course the user must NOT have access to the root account in this case.

Class systems should not be allowed on the same subnet as .

Install a packet filter/firewall between internal networks and class systems.

Network interface cards in PCs: some cards cannot be switched into promiscuous mode e.g. those based on the TROPIC chipset (HP Ether twist). Buy Ethernet cards, which do not allow promiscuous mode.

Hubs, bridges and routers are getting very intelligent; they have more and more configuration options and are increasingly complex. This is useful for additional features, but the added complexity increases the security risk.

On critical subnets, it's important correctly configure network devices: only enable needed services, restrict access to configuration services by port/interface/IP address, disable broadcasts, source routing, choose strong (non default) passwords, enable logging, choose carefully who has user/enable/admin access, etc.

3.5.1 Introduction to Routers

Routers are data forwarding devices but operate differently than a transparent or source Route Bridge. They separate networks into regions like each region is assigned a unique network number. These network numbers are unique for each network they are assigned to and packet forwarding is based on these network IDs. Routers route packets based on a protocol as well as a network ID as most routers today are Multiprotocol in that one box can forward different protocol packets. Routers, like bridges, can be used locally or remotely.

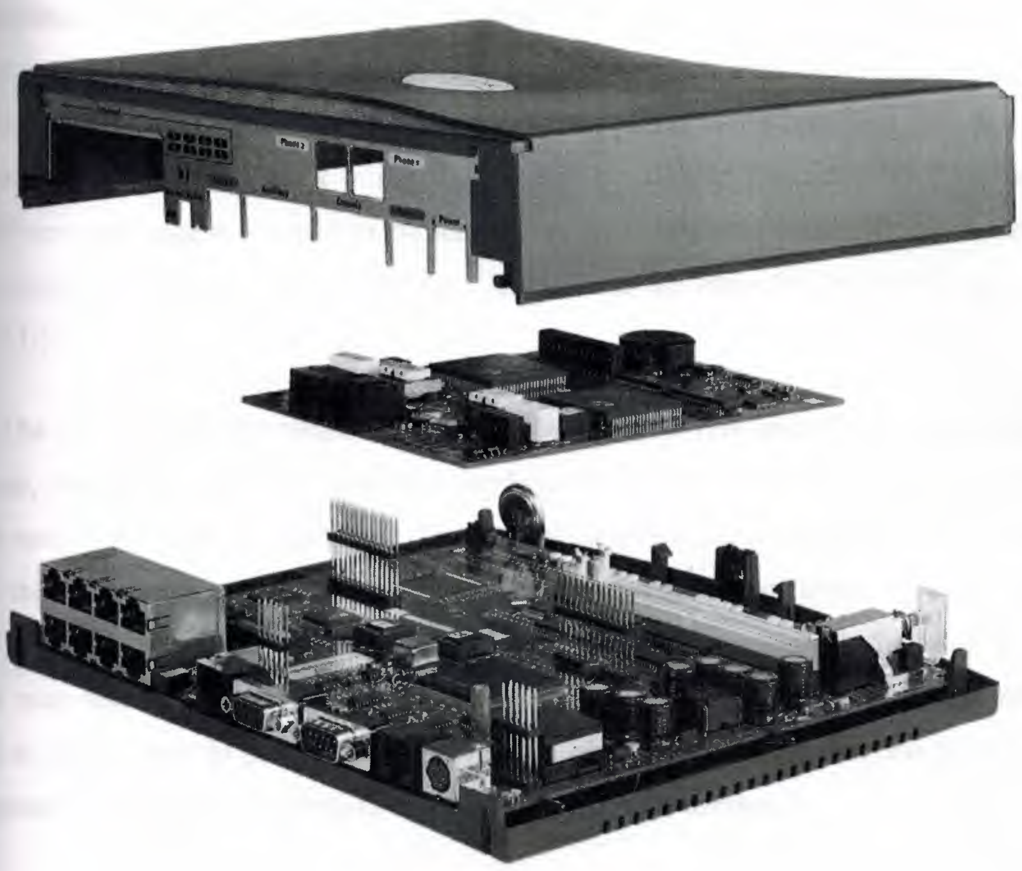


Fig 3.3 Show a Router Diagram

A router is an Intermediate System (IS), which operates at the network layer of the OSI reference model. Routers may be used to connect two or more IP networks, or an IP network to an Internet connection. A router consists of a computer with at least two-network interface cards supporting the IP protocol. The router receives packets from each interface via a network interface and forwards the received packets to an appropriate output network interface. Received packets have all link layer protocol headers removed, and transmitted packets have a new link protocol header added prior to transmission.

The router uses the information held in the network layer header (i.e. IP header) to decide whether to forward each received packet, and which network interface to use to send the packet. Most packets are forwarded based on the packet's IP destination address, along with routing information held within the router in a routing table. Before a packet is forwarded, the processor checks the Maximum Transfer Unit (MTU) of the specified interface. The router into two or more smaller packets must fragment packets larger than the interface's MTU. If a packet is received which has the Don't Fragment (DF) bit set in the packet header, the packet is not fragmented, but instead discarded. In this case, an ICMP error message is returned to the sender (i.e. to the original packet's IP source address) informing it of the interface's MTU size. This forms the basis for Path MTU discovery (PMTU).

The routing and filter tables resemble similar tables in link layer bridges and switches. Except, that instead of specifying link hardware addresses (MAC addresses), the router table specify network (IP addresses). The routing table lists known IP destination addresses with the appropriate network interface to be used to reach that destination. A default entry may be specified to be used for all addresses not explicitly defined in the table. A filter table may also be used to ensure that unwanted packets are discarded. The filter may be used to deny access to particular protocols or to prevent unauthorized access from remote computers by discarding packets to specified destination addresses.

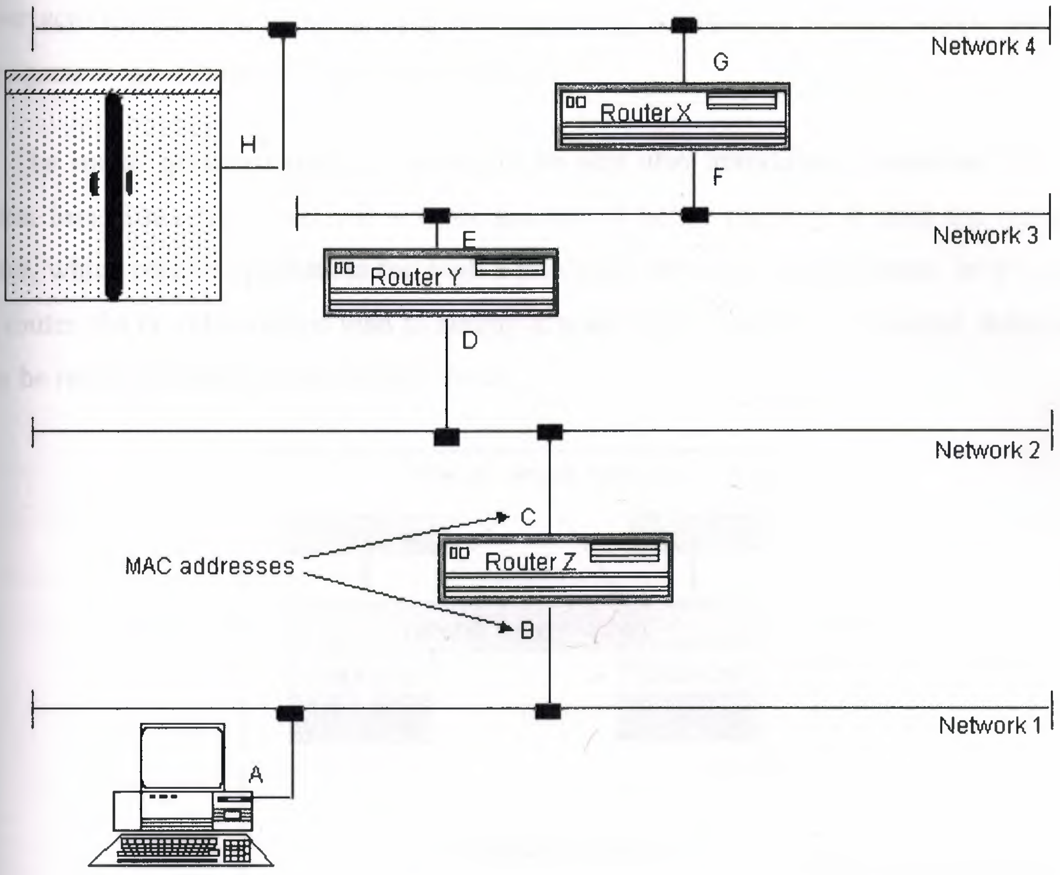


Figure 3.4 Shows a Routing of a Router

A router forwards packets from one IP network to another IP network. Like other systems, it determines the IP network from the logical AND of an IP address with the associated sub network address mask. One exception to this rule is when a router receives an IP packet to a network broadcast address. In this case, the router discards the packet. Forwarding broadcast packet can lead to severe storms of packets, and if uncontrolled could lead to network overload. A router introduces delay (latency) as it processes the packets it receives. The total delay observed is the sum of many components including:

Time taken to process the frame by the data link protocol

Time taken to select the correct output link (i.e. filtering and routing)

Queuing delay at the output link (when the link is busy)

Other activities which consume processor resources (computing routing tables, network management, generation of logging information)

The router queue of packets waiting to be sent also introduces a potential cause of packet loss. Since the router has a finite amount of buffer memory to hold the queue, a router, which receives packets at too high a rate, may experience a full queue. In this case, the router ahs no other option than to simply discard excess packets. If required, these may later be retransmitted by a transport protocol.

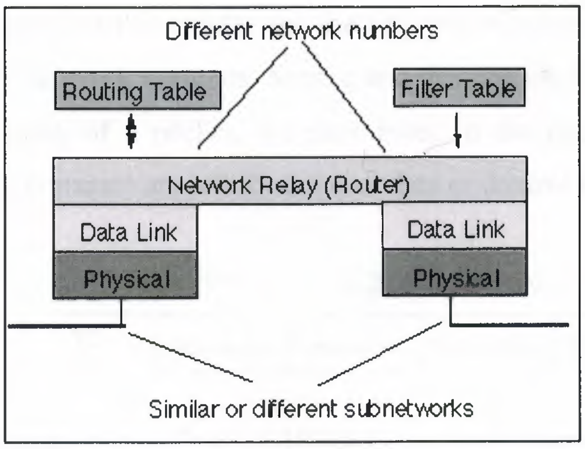


Figure 3.5 Shows Architecture of a router

Routers are often used to connect together networks, which use different types of links (for instance an HDLC link connecting a WAN to a local Ethernet LAN). The optimum (and maximum) packet lengths (i.e. the Maximum Transfer Unit (MTU)) are different for different types of network. A router may therefore use IP to provide segmentation of packets into a suitable size for transmission on a network. Associated protocols perform network error reporting (ICMP), communication between routers (to determine appropriate routes to each destination) and remote monitoring of the router operation.

3.5.1.1 Routing

Most network protocols were designed with network-layer routing. Routers base forwarding decisions on an embedded network number in the network layer header of the packet. They include network numbers that can be thought of as area codes in the phone system as we must use the area code to call different areas. Any number of end stations may be assigned to one network number like routers do not keep track of individual end stations' addresses. Network numbers group network stations into one or more network numbers. Routers combine networks and form Internets.

3.5.1.2 Information in Packet

Each OSI layer in the implementation of hardware and software of a WAN controller will be placed in the packet. Network layer information is placed in the data field of packet, which is placed in this header for the network number, and this layer header contains more than just network numbers. Source and destination MAC address fields are reserved for the beginning of a packet. Whether bytes in the packet the hardware and software headers do not consume are left for the user data or control information.

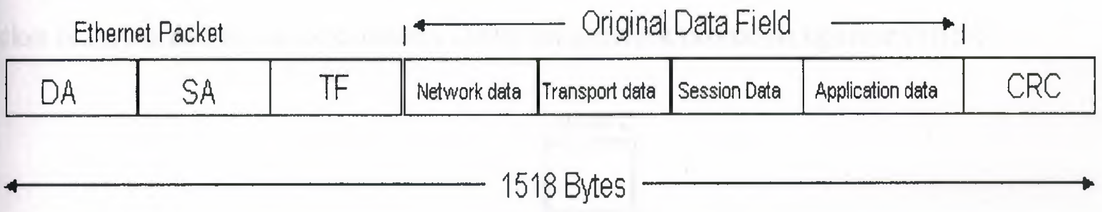


Figure 3.6 Shows the Information in a Packet

3.5.1.3 Router Operation

Routers forward packets based not on the MAC address of the packet but on the network number inside the packet. Each network separated by a router is assigned a unique network number End stations know only of the network number of the network to which they are attached. Before an end station transmits a packet, it compares the network number of the destination to the network number and if the network numbers are the same, the packet is simply transmitted on the cable, addressed to the destination station, as the destination station is local. If the network numbers do not match, the end station must find a router that it can send the packet to so that it can be transmitted to the original end. The requesting station submits a special type of packet to the network requesting information from the routers. The requesting station acquires the router's MAC address by some means specific to the protocol.

3.5.1.4 Directly Attached Networks

A router receives the request and if it can find the network number, it sends a response back to the requesting station. Node A picks the path that has the lowest cost to the final destination. There is only one router response in this example. Node A sends the packet to router Z. The source MAC address is A and the destination MAC address is B (the router's MAC address. The destination network number is located on the other side of the router. The router directly to the end station forwards the packet. The packet is addressed with source address as the routers address, source address C. The destination address is the destination end station, destination station D. If the destination is not on the other side of the router, the router has the next router's address in its routing table and the packet is forwarded to the next router. Different network protocols operate differently.

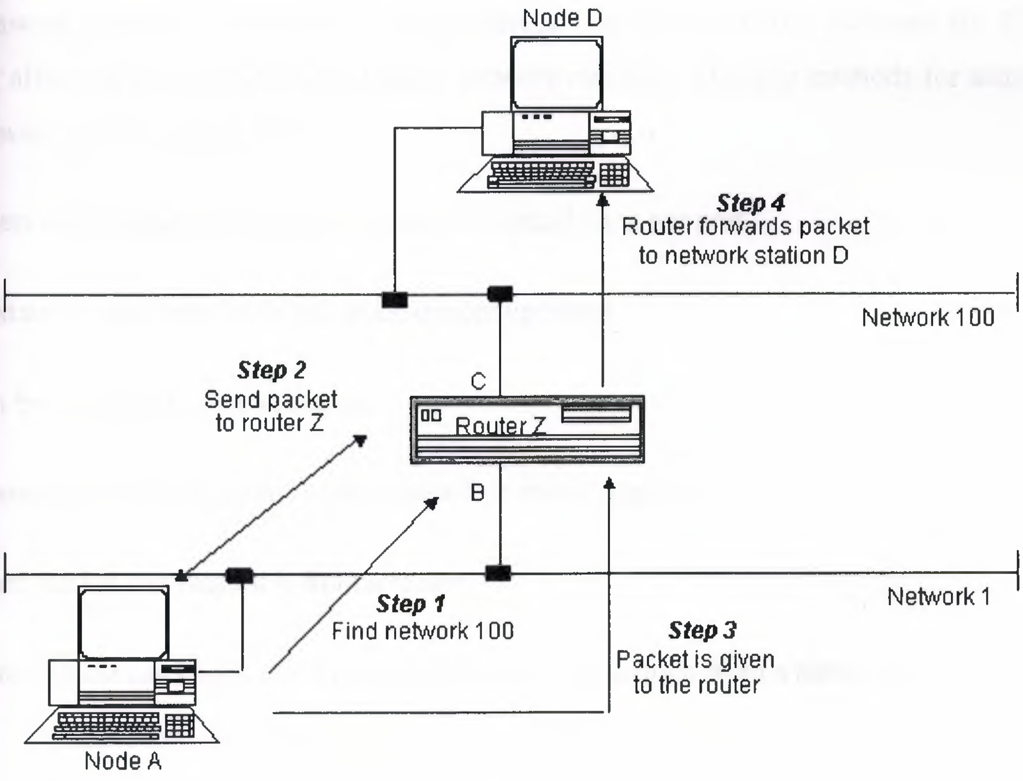


Figure 3.7 Shows a Directly Attached Network to WAN

3.5.1.5 Non-Directly Attached Networks

If the destination network is not directly attached to the router, the router will forward the packet to another router in the forwarding path of the destination network. Router-to-router communication is directly MAC addressed. All routers in the path will perform the same decisions as the previous router. The last router in the path to the destination will forward the packet directly to the destination. Important to note that the data link MAC headers will constantly change while the packet is being forwarded. Very little information in the network header will change the network layer header in the packet will contain the originator's full address and final destination address of the packet. The full address of a network station is the combination of the network ID and its MAC address. This uniquely identifies any station on the Internet.

3.5.1.6 Network Numbers

With the addition of routers, there are now two types of addresses on the network one is network numbers, and other is MAC address. The XNS network numbers are 32 bits long, allowing for 4,294,967,294 unique network numbers. Multiple methods for acquiring a network number are as follows:

Routers are assigned their network numbers, usually one per port.

End stations can listen to the network (router updates).

It can be assigned to an end station.

End stations can build passive tables based on router updates.

An end station can request it from a router.

An end station can acquire a remote stations network address from a name server.

3.5.1.7 Routing Information Protocol (RIP)

This is known as a routing table update protocol as most commonly found router update protocol is called Routing Information Protocol (RIP). Developed by Xerox and gained widespread acceptance by the proliferation of TCP/IP's implementation of it in UNIX. Other protocols adopted RIP as their standard routing update protocol. Different protocol implementations of RIP cannot update each other this is known as a distance vector protocol and vector is the network number and the distance is how far away (hops) the »network is one hop is considered one router traversed. Devised for very stable, small-to-medium size networks (less than a few hundred nodes).

3.5.1.8 Multiprotocol Routers

LANs currently operate with many different types of protocols.

Apple Computers can use AppleTalk.

UNIX workstations use TCP/IP.

Client/Server applications could use Novell NetWare.

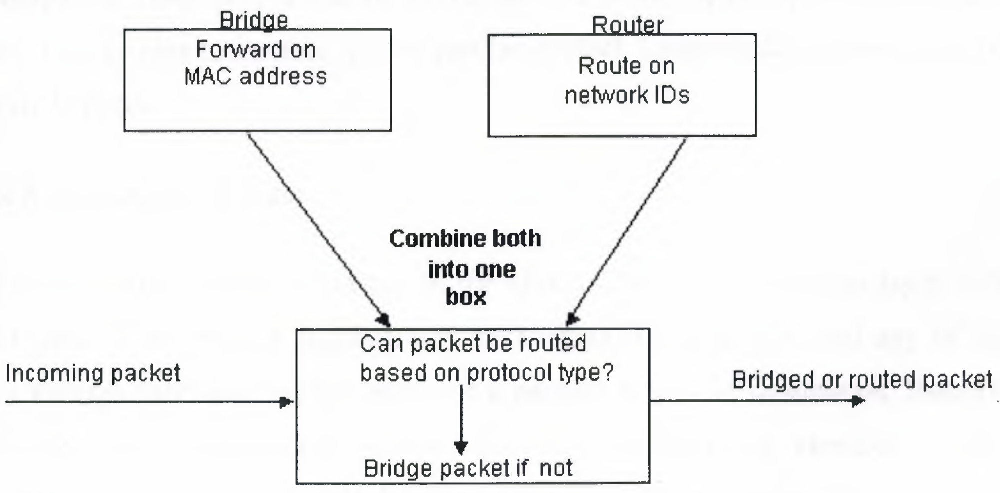


Figure 3.8 Shows a Block Diagram of Multiprotocol Router

Routes not only based on the network IDs but also are able to pass the packet to the correct protocol processor by examining the Type of packet.

3.5.2 Hubs

A special type of network device called the hub can be found in many home and small business networks. Though they've existed for many years, the popularity of hubs has exploded recently, especially among people relatively new to networking. Do you own a hub, or are you considering purchasing one? This article explains the purpose of hubs and some of the technology behind them.

3.5.2.1 General Characteristics of Hubs

A hub is a small rectangular box, often constructed mainly of plastic that receives its power from an ordinary wall outlet. A hub joins multiple computers (or other network devices) together to form a single network segment. On this network segment, all computers can communicate directly with each other. Ethernet hubs are by far the most common type, but hubs for other types of networks (such as USB) also exist.

A hub includes a series of ports that each accepts a network cable. Small hubs network four computers. They contain four or sometimes five ports (the fifth port being reserved for "uplink" connections to another hub or similar device). Larger hubs contain eight, 12, 16, and even 24 ports.

3.5.2.2 Key Features of Hubs

Hubs classify as Layer 1 devices in the OSI model. At the physical layer, hubs can support little in the way of sophisticated networking. Hubs do not read any of the data passing through them and are not aware of a packet's source or destination. Essentially, a hub simply receives incoming packets, possibly amplifies the electrical signal, and broadcasts these packets out to all devices on the network (including the one that sent the packet!). Hubs remain a very popular device for small networks because of their low cost. A good five-port Ethernet hub can be purchased for less then $50 USD.

Technically speaking, three different types of hubs exist:

1. Passive
2. Active
3. Intelligent

Passive hubs do not amplify the electrical signal of incoming packets before broadcasting them out to the network. Active hubs, on the other hand, will perform this function -- a function that is also present in a different type of dedicated network device called a repeater. Some people use the terms concentrator when referring to a passive hub and multiport repeater when referring to an active hub. Intelligent hubs add extra features to an active hub that are of particular importance to businesses. An intelligent hub typically is stackable (built in such a way that multiple units can be placed one on top of the other to conserve space). It also typically includes remote management support via SNMP support.

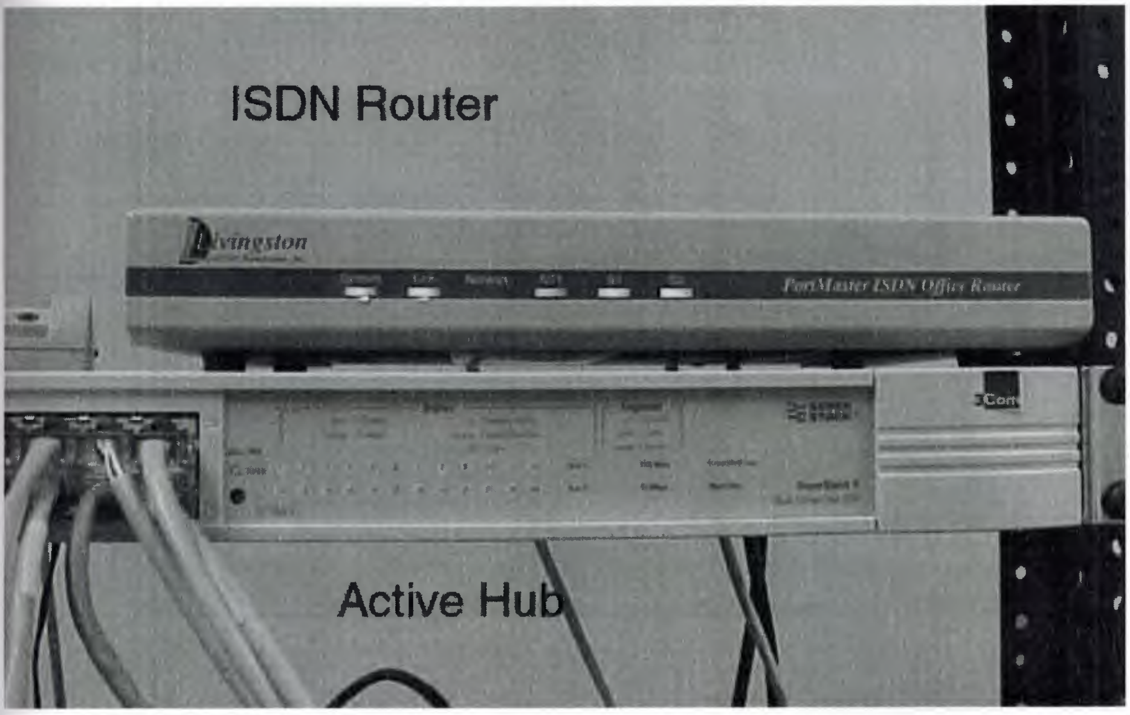


Figure 3.9 Shows an Active Hub Used with ISDN Router

3.5.3 Bridges

Useful for breaking up subnets into small segments, making it easier to localize errors.Restricts traffic local to machines to that segment, by sensing what Ethernet addresses are where. This improves both network performance and privacy (makes sniffing more difficult).

Newer bridges also have built in http servers, if possible restrict access to certain IP address/interfaces, and avoid using this service from public or potentially hostile networks.

3.5.4 Modems

A modem is used to connect a computer to the Internet. It begins with an overview of some of the basic signals the RS-232 serial interface uses to connect an external modem to a computer. The importance of these signals for proper operation of the modem will be discussed in terms of both modem and software configuration. This is known as Network Interface Card (NIC)

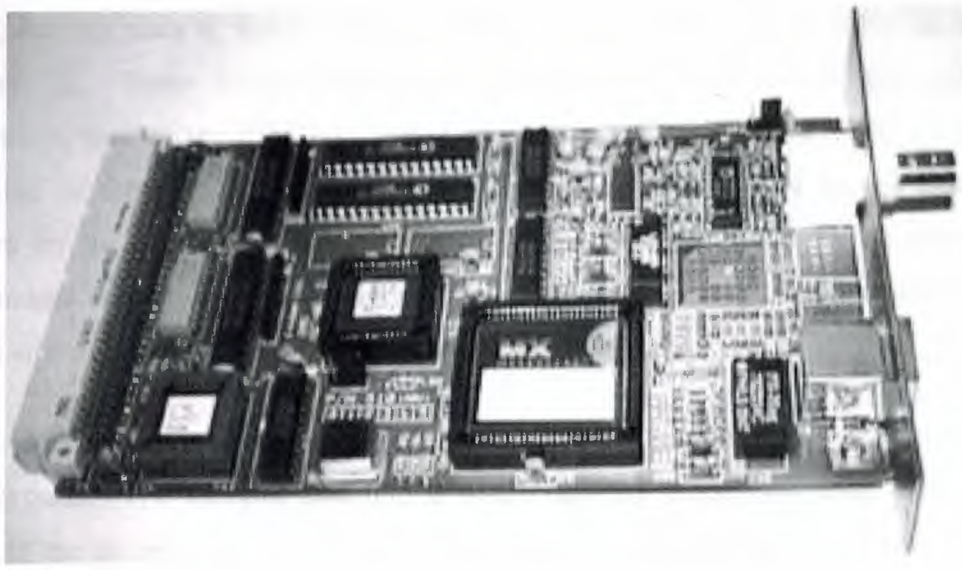


Figure 3.10 Shows a Network Interface Card

3.5.4.1 The Modem Plug (RS-232 Interface overview)

The EIA (Electronic Industries Association) RS-232 standard specifies signals for serial interfaces used to connect computers and modems. For technical precision, the terms Data Terminal Equipment (DTE) and Data Communication Equipment (DCE) are used to distinguish between the computer and the modem, respectively. This is useful because serial interfaces are used for many things besides computers and modems such as dumb terminals, plotters, scanners, printers, etc. These terms are important because they are used to define the interface signals. A different type of serial cable is needed to connect a modem to a computer (DTE to DCE connections use a modem cable) than is used to, say, connect one computer to another (DTE to DTE connections use a null-modem cable). Such PC programs such as Lap-Link, or the MS-DOS INTERLNK command use null modem cables.

The standard is based on a 25-pin connector, of which ten connections are commonly used. The names of the signals and the pin designations on a standard DB25 pin connector are: protective (frame) ground 1, transmit data 2, receive data 3, request to send 4, clear to send 5, data set ready 6, signal ground 7, carrier detect 8, data terminal ready 20, and ring indicator 22. Many manufacturers have designed serial connectors that use fewer connections, such as the IBM AT DB9 connector, or the Macintosh DIN 8. To simplify discussion of these signals this document will generally only refer to pin designation numbers for the standard 25-pin connector (DB25). Modem cables for computers with non-standard connectors are usually available, which provide a DB25 connector at the modem end with a subset of the 10 connections mentioned above.

Three of these connections are absolutely essential: transmit data, receive data, and signal ground. The transmit data line is where data are transmitted from the computer (DTE) to the modem (DCE). The receive data line is where data are received from the modem (DCE) by the computer (DTE). Signal ground is the reference against which all other signals apply voltage. Think of a battery and a light bulb: it is not possible for current to flow without two wires. Signal ground is the second wire for all the other signals.

3.5.4.2 Error Correction and Data Compression

Almost more confusing than the actual protocols and modem commands is the terminology used to describe error correction (also called error control). Error correction is similar to file transfer protocols such as Kermit, X, Y, or Z modem. File transfer protocols break files up into chunks called packets. Error correction does the same thing except the blocks of data are called frames and are generally smaller than those typically used by modern file transfer protocols. In all cases additional information such as a checksum is added to the packet (frame) to verify that the data was undamaged in transit. If the data does not match the checksum the entire packet or frame must be resent. This technique trades off some speed for reliability. Like sliding-windows protocol severalframes may be sent before an acknowledgment is required. The maximum data block size and the number of frames allowed before an acknowledgment is required are parameters negotiated by the modems when they connect.

3.5.4.3 Direct, Normal, and Reliable Connections

Many modems will use these terms to distinguish between several types of modem configurations. A direct connection is the old-fashioned sort with no error correction or data compression. In a direct connection the DTE rate (computer serial speed) and the link rate (modem connection speed) must match. A normal connection uses flow control for speed buffering so the DTE and link rates may differ. A reliable connection uses flow control and will often hang up if error correction and data compression cannot be established. An auto-reliable connection is like a reliable one except the modem will fall back to normal or direct mode automatically rather than hang up.

3.5.5 Integrated Services Digital Network (ISDN)

Integrated Services Digital Network (ISDN) is comprised of digital telephony and data transport services offered by regional telephone carriers. ISDN involves the digitalization of the telephone network, which permits voice, data, text, graphics, music, video, and other source material to be transmitted over existing telephone. The emergence of ISDN represents an effort to standardize subscriber services, user/network interfaces, and network and Internet work capabilities. ISDN applications include high-speed image applications (such as Group IV facsimile), additional telephone lines in homes to serve the telecommuting industry, high-speed file transfer, and video conferencing. Voice service is also an application for ISDN. This chapter summarizes the underlying technologies and services associated with ISDN.

3.5.5.1 ISDN Components

ISDN components include terminals, terminal adapters (TAs), network-termination devices, line-termination equipment, and exchange-termination equipment. ISDN terminals come in two types. Specialized ISDN terminals are referred to as terminal equipment type 1 (TE1). Non-ISDN terminals, such as DTE, that predates the ISDN standards are referred to as terminal equipment type 2 (TE2). TE1s connect to the ISDN network through a four-wire, twisted-pair digital link. TE2s connect to the ISDN network through a TA. The ISDN TA can be either a standalone device or a board inside the TE2. If the TE2 is implemented as a standalone device, it connects to the TA via a standard physical-layer interface. Examples include EIA/TIA-232-C (formerly RS-232-C), V.24, and V.35. Beyond the TE1 and TE2 devices, the next connection point in the ISDN network is the network termination type 1 (NT1) or network termination type 2 (NT2) device. These are network-termination devices that connect the four-wire subscriber wiring to the conventional two-wire local loop. In North America, the NT1 is a customer premises equipment (CPE) device. In most other parts of the world, the NT1 is part of the network provided by the carrier. The NT2 is a more complicated device that typically is found in digital private branch exchanges (PBXs) and that performs Layer 2 and 3 protocol functions and concentration services. An NT1/2 device also exists as a single device that combines the functions of an NT1 and an NT2. ISDN specifies a number of reference points that define logical interfaces between functional groupings; such as TAs and NT1s. ISDN reference points include the following:

• R—The reference point between non-ISDN equipment and a TA.

• S—The reference point between user terminals and the NT2.

• T—The reference point between NT1 and NT2 devices.

The reference point between NT1 devices and line-termination equipment in the carrier network. The U reference point is relevant only in North America, where the carrier network does not provide the NT1 function. Figure 12-1 illustrates a sample ISDN configuration and shows three devices attached to an ISDN switch at the central office.

Two of these devices are ISDN-compatible, so they can be attached through an S reference point to NT2 devices. The third device (a standard, non-ISDN telephone) attaches through the reference point to a TA. Any of these devices also could attach to an NT1/2 device, which would replace both the NT1 and the NT2. In addition, although they are not shown, similar user stations are attached to the far right ISDN switch.

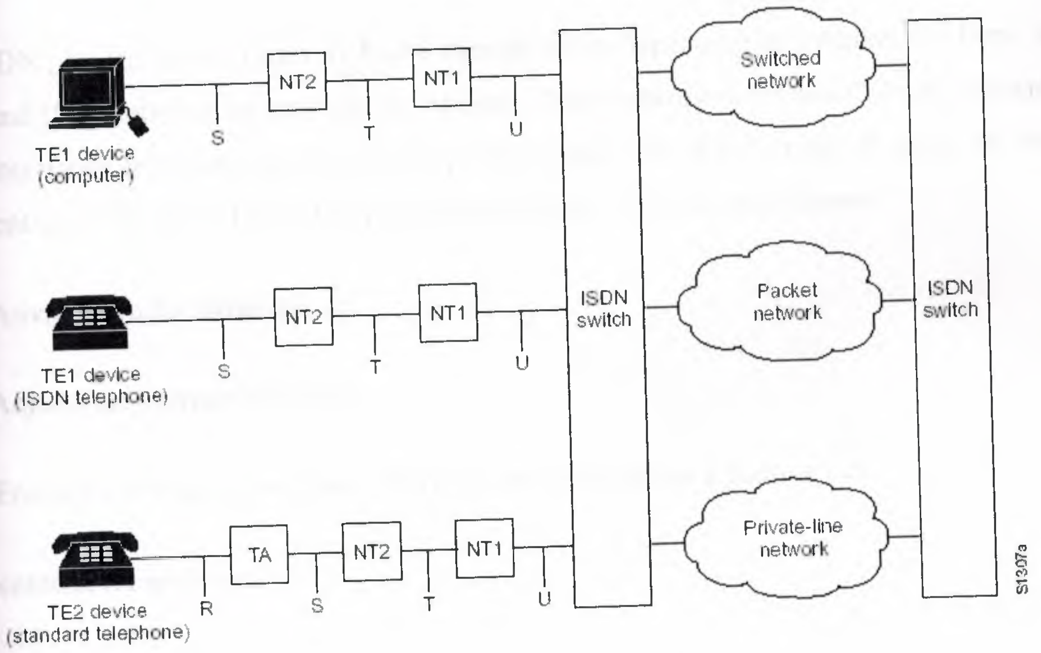


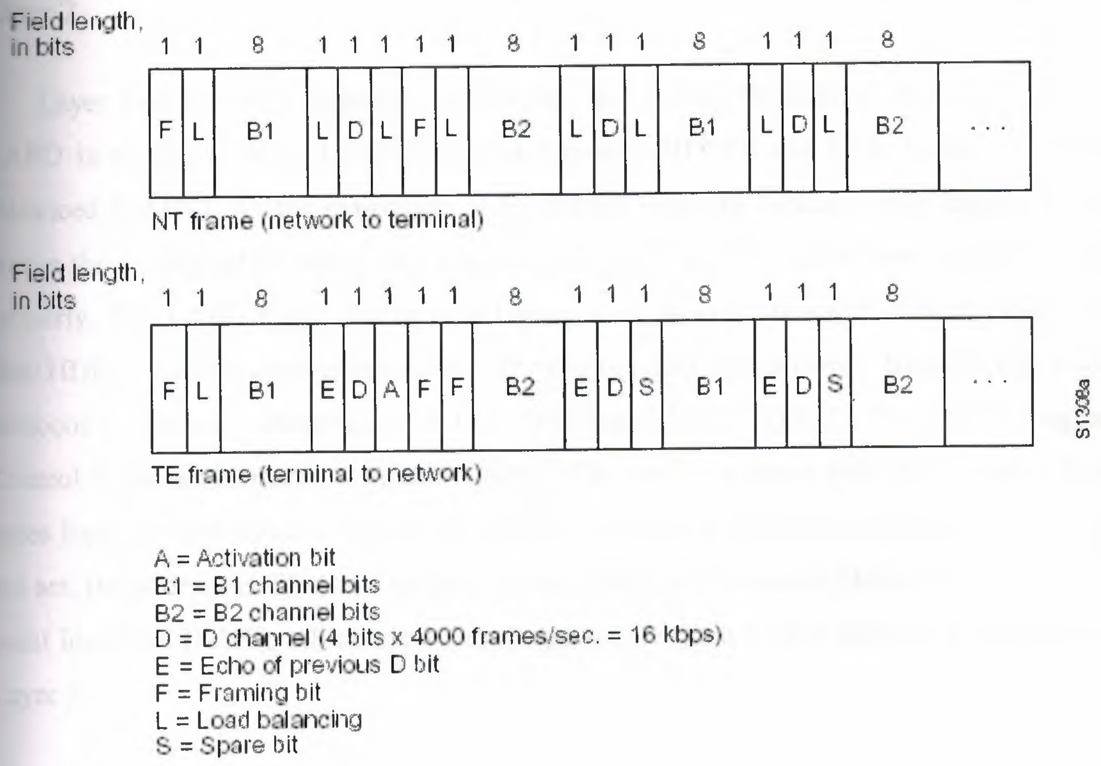
Figure 3.11 Shows a Sample ISDN configuration is illustrated.

The ISDN Basic Rate Interface (BRI) service offers two B channels and one D channel (2B+D). BRI B-channel service operates at 64 kbps and is meant to carry user data; BRI D-channel service operates at 16 kbps and is meant to carry control and signaling information, although it can support user data transmission under certain circumstances. The D channel signaling protocol comprises Layers 1 through 3 of the OSI reference model. BRI also provides for framing control and other overhead, bringing its total bit rate to 192 kbps. The BRI physical-layer specification is International Telecommunication Union Telecommunication Standardization Sector (ITU-T) (formerly the Consultative Committee for International Telegraph and Telephone [CCITT]) I.430. ISDN Primary Rate Interface (PRI) service offers 23 B channels and one D channel in North America and Japan, yielding a total bit rate of 1.544 Mbps (the PRI D channel runs at 64 Kbps). ISDN PRI in Europe, Australia, and other parts of the world provides 30 B channels plus one 64-Kbps D channel and a total interface rate of 2.048 Mbps. The PRI physical-layer specification is

Layer 1

ISDN physical-layer (Layer 1) frame formats differ depending on whether the frame is outbound (from terminal to network) or inbound (from network to terminal). Both physical-layer interfaces are shown in Figure 12-2). The frames are 48 bits long, of which 36 bits represent data. The bits of an ISDN physical-layer frame are used as follows:

- F—Provides synchronization
- L—Adjusts the average bit value
- E—Ensures contention resolution when several terminals on a passive bus contend for a channel
- A—Activates devices
- S—Unassigned
- B1, B2, and D—Handles user data



Field length, in bits
1 1 8 1 1 1 1 1 8 1 1 1 8 1 1 1 8
F L B1 L D L F L B2 L D L B1 L D L B2 . . .
NT frame (network to terminal)
Field length, in bits
1 1 8 1 1 1 1 1 8 1 1 1 8 1 1 1 8
F L B1 E D A F F B2 E D S B1 E D S B2 . . .
TE frame (terminal to network)
S1308a
A = Activation bit
B1 = B1 channel bits
B2 = B2 channel bits
D = D channel (4 bits x 4000 frames/sec. = 16 kbps)
E = Echo of previous D bit
F = Framing bit
L = Load balancing
S = Spare bit

Figure 3.12 Shows ISDN Physical-layer frame formats

Multiple ISDN user devices can be physically attached to one circuit. In this configuration, collisions can result if two terminals transmit simultaneously. ISDN therefore provides features to determine link contention. When an NT receives a D bit from the TE, it echoes back the bit in the next E-bit position. The TE expects the next E bit to be the same as its last transmitted D bit. Terminals cannot transmit into the D channel unless they first detect a specific number of ones (indicating "no signal") corresponding to a pre-established priority. If the TE detects a bit in the echo (E) channel that is different from its D bits, it must stop transmitting immediately. This simple technique ensures that only one terminal can transmit its D message at one time. After successful D- message transmission, the terminal has its priority reduced by requiring it to detect more continuous ones before transmitting. Terminals cannot raise their priority until all other devices on the same line have had an opportunity to send a D message. Telephone connections have higher priority than all other services, and signaling information has a higher priority than non-signaling information.

Layer 2

Layer 2 of the ISDN signaling protocol is Link Access Procedure, D channel (LAPD). LAPD is similar to High-Level Data Link Control (HDLC) and Link Access Procedure, Balanced (LAPB). As the expansion of the LAPD acronym indicates, this layer it is used across the D channel to ensure that control and signaling information flows and is received properly. The LAPD frame format (see Figure 12-3) is very similar to that of HDLC and, like HDLC, LAPD uses supervisory, information, and unnumbered frames. The LAPD protocol is formally specified in ITU-T Q.920 and ITU-T Q.921. The LAPD Flag and Control fields are identical to those of HDLC. The LAPD Address field can be either 1 or 2 bytes long. If the extended address bit of the first byte is set, the address is 1 byte; if it is not set, the address is 2 bytes. The first Address-field byte contains identifier service access point identifier (SAPI), which identifies the portal at which LAPD services are provided to Layer 3.

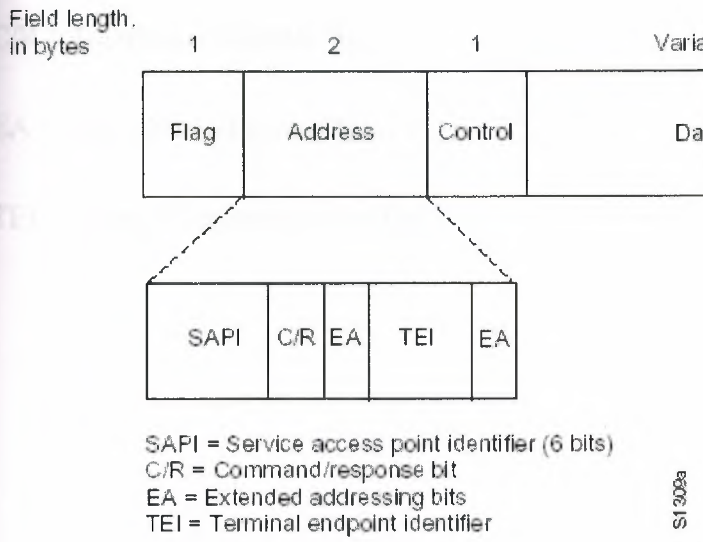

Field length, in bytes
1
2
1
Variable
1
1
Flag
Address
Control
Data
FCS
Flag
SAPI
C/R
EA
TEI
EA
SAPI = Service access point identifier (6 bits)
C/R = Command/response bit
EA = Extended addressing bits
TEI = Terminal endpoint identifier
S1308a

Figure 3.13 Shows LAPD frame format is similar to HDLC and LAPB.

The C/R bit indicates whether the frame contains a command or a response. The terminal end-point identifier (TEI) field identifies either a single terminal or multiple terminals. A TEI of all ones indicates a broadcast.

Layer 3

Two Layer 3 specifications are used for ISDN signaling: ITU-T (formerly CCITT) I.450 (also known as ITU-T Q.930) and ITU-T I.451 (also known as ITU-T Q.931). Together, these protocols support user-to-user, circuit-switched, and packet-switched connections. A variety of call-establishment, call-termination, information, and miscellaneous messages are specified, including SETUP, CONNECT, RELEASE, USER INFORMATION, CANCEL, STATUS, and DISCONNECT. This Address Flag Control Data FCS Flag Field length, in bytes variable messages are functionally similar to those provided by the X.25 Figure 3.14, from ITU-T I.451, shows the typical stages of an ISDN circuit-switched call.

TEI EA C/R SAPI

SAPI = Service access point identifier (6 bits)

C/R = Command/response bit

EA = Extended addressing bits

TEI = Terminal endpoint identifier

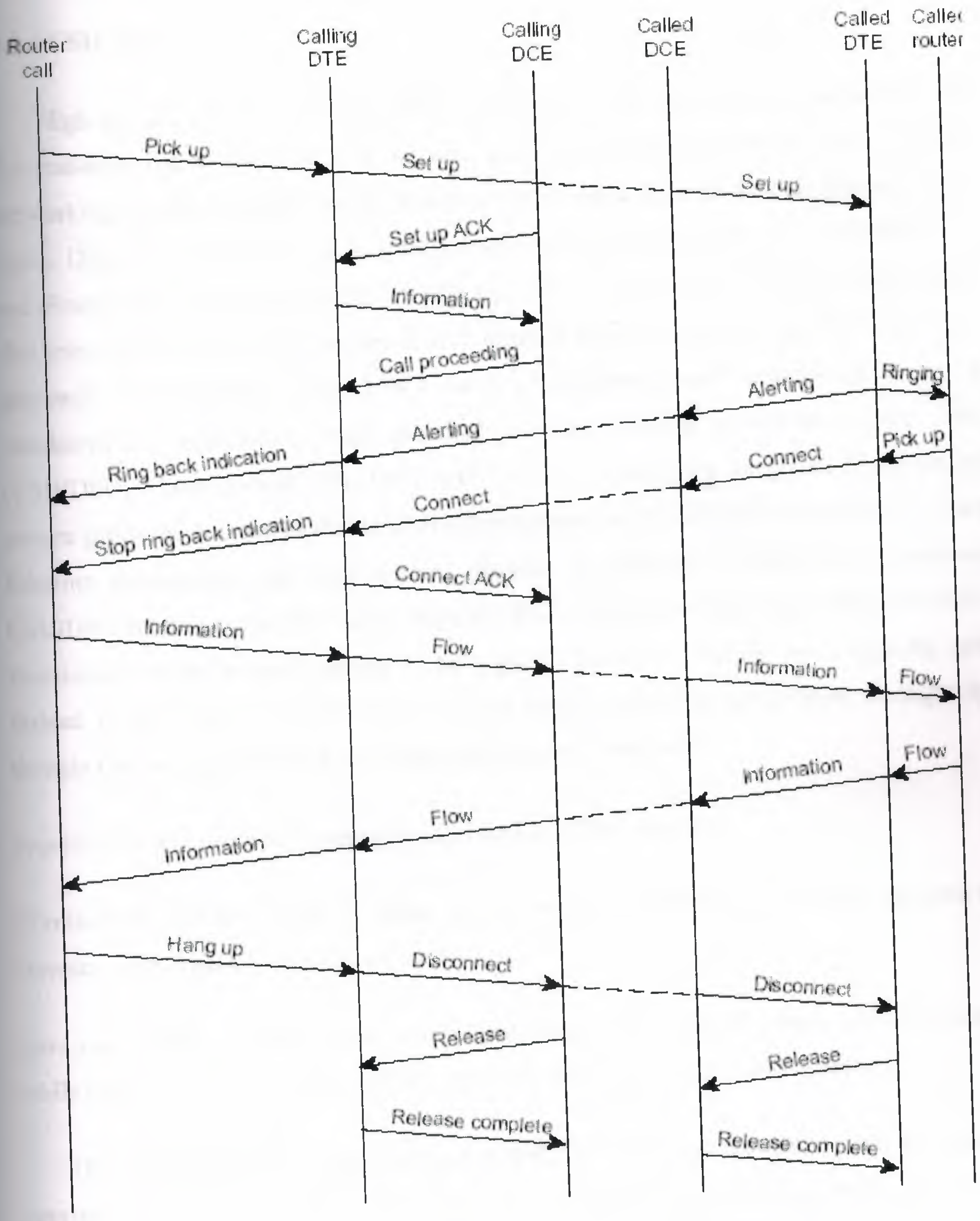


Figure 3.14 Shows an illustration of Circuit Switch Call.

3.5.6 CSU/DSU

High-speed, LAN-attached applications continue to rise, generating an increasing need for cost-effective WAN access for intranet and Internet access implementation. Routed networking is today the most widely implemented network solution for organizations of all types. Digital circuits operating at speeds from 56Kbps (DDS service) to 1.544Mbps (T1 and Fractional T1 services) to T3 (45 Mbps or 28 T1's) provide the WAN infrastructure that interconnects the routers located at each location served by the network. The traditional approach to terminating DDS, T1/FT1 and T3 circuits at each location is to use a standalone or high-density rack mounted Channel Service Unit/Data Service Unit (CSU/DSU). "Line-by-line" CSU/DSUs and CSU/DSUs providing integrated T1 access are mature products, and are available with enhancements such as SNMP management, direct Ethernet connections, and dial restoral features. In addition to traditional standalone CSU/DSU solutions, routers with an integral CSU/DSU are available. Integrated CSU/DSU functionality initially might appear to be a good choice, i.e., having one integrated unit instead of two functional units may provide certain reliability advantages. It might be thought that having the CSU/DSU integrated into the router will:

Provide a lower cost than comparable separate CSU/DSU devices

Eliminate a potential point of failure in the network, namely, the cabling required to connect an external CSU/DSU to a router

Save rack space at a central site, and reduce two boxes to one at remote sites however, *while these benefits appear good, there are other factors that require consideration.*

This management briefing will discuss that, depending on the application; integrated approaches do not necessarily save money or eliminate points of failure. In addition, this briefing will outline valuable features available only in non-integrated CSU/DSUs.

3.5.6.1 Comparing Basic Capabilities

Figure 3.15 shows a basic T1 network access arrangement using traditional non-integrated CSU/DSUs at both the remote and central sites.

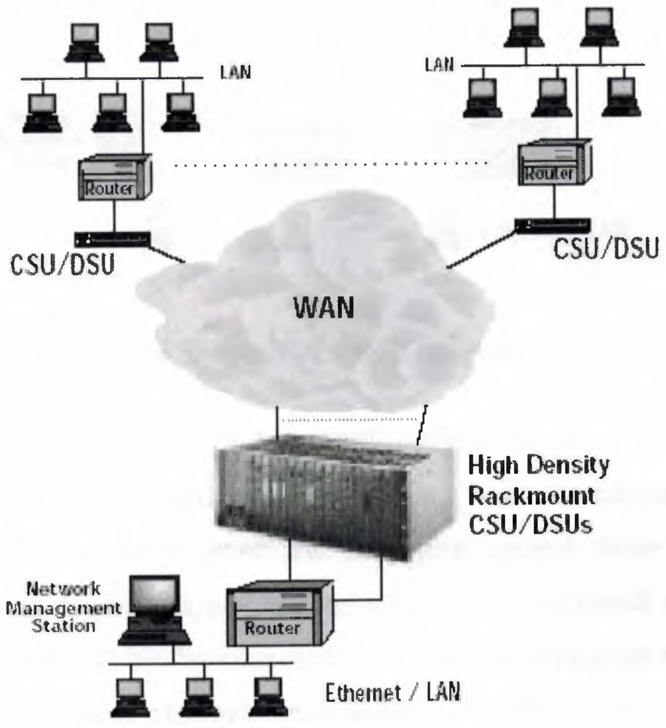


Figure 3.15 Shows a Basic T1 Network Access

The network depicted in Figure 3.14 can be viewed as either being traditional point-to-point DDS/T1 networking or as frame relay. Figure 3.16 shows the same T1 access objective achieved with integral CSU/DSUs. At first glance, it seems that the router with integral CSU/DSU approach is simpler to install and should be more cost effective. However, another look at both approaches shows that this may not be the case. Cost Savings Proponents of router-integrated T1 CSU/DSUs argue that the internal units are less costly to purchase than separate, external CSU/DSUs.

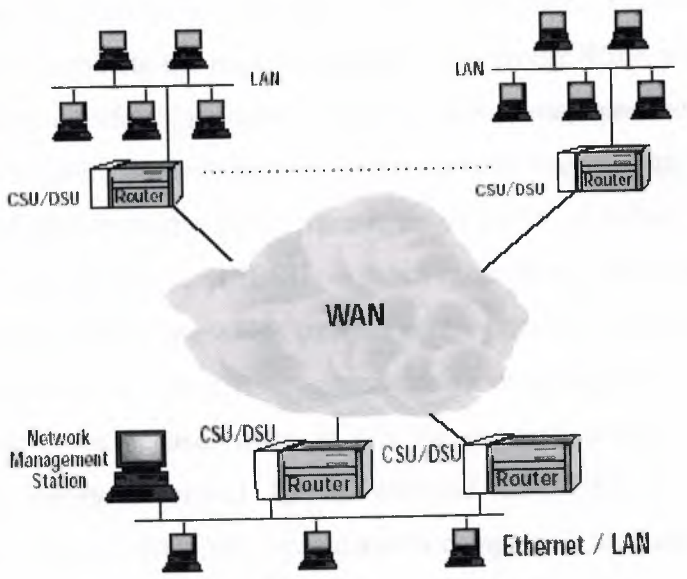


Figure3.16 Shows WAN with Integrated Routers

Typically, however, depending on feature content, the list prices of an internal unit and a standalone managed external unit are very similar. When the capabilities of the router integrated CSU/DSU are investigated and compared against those of the standalone CSU/DSU, additional diagnostics and testing features will be found with the standalone CSU/DSU having better troubleshooting capabilities for the same price or lower. Therefore, if cost is the primary issue, external non-managed CSU/DSUs may be the lowest cost option. In many cases integral T1 DSU router ports are simply DSX type device. This means that an external Telco provided demarcation device such as a CSU or CSU/Smart Jack must be installed. Such a device introduces an additional fault point in the network and requires customer provided AC power. If a standalone CSU/DSU device is deployed, the Telco provided product and associated costs are eliminated, allowing the user to directly connect to the T1 circuit. External units offer more complete diagnostics and remote management features, providing long term operating cost savings by reducing the need to dispatch technicians to remote sites. External CSU/DSUs offer significant line cost savings by the use of efficient multiplexing. Examples of CSU/DSU features that provide the opportunity of increased network savings are multi-port CSU/DSUs that may be used to support inter-office PBX networking and secure and non-secure routed data paths where examples of these applications are discussed later in this paper. Points of Failure because integral CSU/DSUs eliminate the need for a cable between the WAN port of the router and the CSU/DSU (DTE interface), a potential point of failure may have been eliminated. This may be true if cables were prone to failure, which typically they are not. However, the non-integrated solution also provides relief from a single point of failure. Should a problem occur in a router with integral CSU/DSU — much more likely than a cable failure — on-site troubleshooting to determine which internal component has failed will be necessary. If the results of the testing are in any way inconclusive or ambiguous, replacing the entire router may appear to be needed, when in fact the problem actually may be a network service problem, easily identified by an external CSU/DSU. If diagnostic testing capabilities of an integral CSU/DSU were deemed comparable to those of a nonintegrated CSU/DSU then the integral CSU/DSU solution would provide a superior solution. However, this is not the case by design. Many non-integrated CSU/DSUs offer superior fault isolation through comprehensive line and BERT diagnostic testing. This briefing concludes that troubleshooting the rare cable failure and its repair, is much easier and far less disruptive to the network operation than troubleshooting and replacing of a router, or the integral CSU installed in the router. Space Saving For central site rack mounting of large numbers of WAN links, the initial size of the router(s) with integral CSU/DSUs takes up much more real estate than that of a high density CSU/DSU shelf. For example, two CSU/DSUs using GDC's Spectra- Comm 2000 shelf require only 1.75" (44.45 mm) of rack height, and up to 16 CSU/DSU units can be housed in the SpectraComm 5000 shelf, which is only 7" high (180 mm).

Power Savings of power is not usually a benefit put forth by the proponents of integral CSU/DSUs. Why? Routers are designed for environmentally controlled computer rooms. Routers typically exhaust a considerable amount of heat consuming a high amount of BTUs. When a CSU/DSU is placed inside a router it becomes part of the power consumption equation. Routers are typically AC powered with backup power (if supplied) provided via generator. Commercial power interruption of a router with integral CSU/DSU affects the WAN connection as well as the integral LAN. Redundant power supply modules may not be an option of many low-to-medium end routers. Lack of commercial power is a major point of failure to a router with integral CSU/DSU. Many standalone and all rack mount CSU/DSUs manufactured by GDC offer dual power options (AC and DC). Redundant power supply modules are available on all SpectraComm and Universal Access System products. All GDC CSU/DSUs, standalone as well as rack mount, use six watts or less of power. GDC CSU/DSU shelves do not use fans and due to the very low power budget design dissipate heat. Air-conditioned environments are not needed. NEBS (Network Equipment Building Standards) NEBS compliancy is a requirement when sharing Telco Central Office space, but many aspects of NEBS are beneficial to premise installations. Very few routers with integral CSU/DSUs can pass the stringent NEBS tests, and therefore, are not allowed to be installed in the Central Office. Applicable NEBS benefits include fire safety, electrical hazard and shock protection, lightning protection and power line isolation. Costly repairs and network disasters can be greatly reduced by the use of an external CSU/DSU. For example, if an integral DSU were utilized, a lightning strike of power surge on the network would travel directly into the router and conceivably pass to the LAN, which may be connected to PCs and other LAN devices. As a result, all attached users and equipment are put at risk. However, by using GDC's CSU/DSUs, which protect against hazardous line transients including power lines and transmission lines, the risk is eliminated.

3.5.6.2 Value Added

Most standalone CSU/DSUs offer additional capabilities typically not provided by integral CSU/DSU offerings. These include:

1. DSL Services
2. Multiport Capability
3. Drop-and-Insert Capability
4. Upgradeable
5. Portable
6. Demarcation of Service Point
7. Variable Line Equalization / Build outs
8. Automatic Service Rate Selection
9. Service Line Isolation / Protection

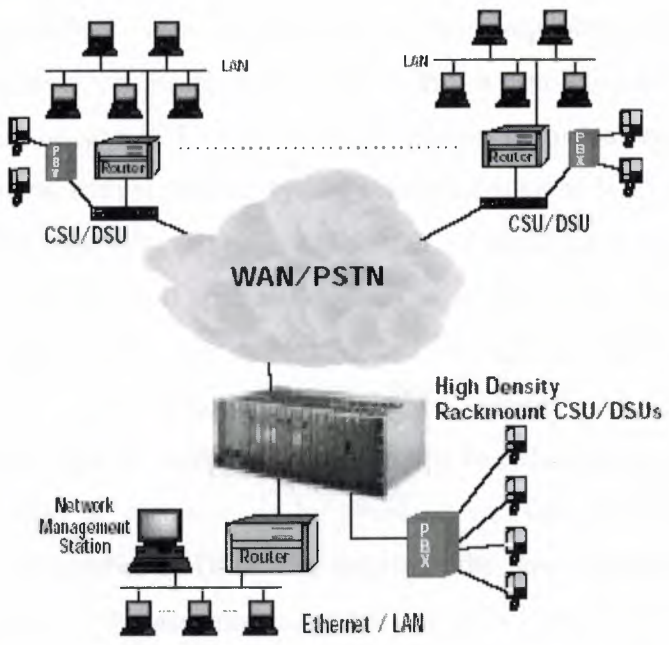


Figure 3.17 Shows a PBX and Router Sharing Single

T1 Access with "Drop-and-Insert" CSU/DSU Depending upon the application, these capabilities can be critical to the resiliency, manageability, and cost effectiveness of a network; and any one of them can make a strong case for a non-integrated as opposed to a router-integrated approach. Unlike integrated T1 CSU/DSUs, non-integrated T1 CSU/DSUs support multiple ports and/or drop-and insert capabilities. The advantage of this is far greater applications flexibility — assuming incremental T1 channel capacity is available. For example, as shown in Figure 3.18, users can easily add via drop-and-insert an additional application, such as voice from a PBX, saving the cost of a separate new T1 circuit. DSL Services The ILEC's competitors, known as the CLECs, are emerging and offering comparable T1 replacement services such as DSL. These services provide an external NTU device, which connects conventional WAN traffic to DSL. An integral CSU/DSU within a router prevents customers from leveraging this future cost savings, which is predicted to dominate service markets for years to come. Multiport Capability allows individual DS0 channels (56/64Kbps) of a T1 to be segmented to support a legacy application. This can be an effective way of eliminating the cost of an analog leased line between corporate headquarters and a regional facility. The ability to support multiple applications over a simple T1 without adding multiplexing equipment allows maximum use of the T1 line and saves on multiple line costs. Only a non-integrated solution has this capability. Many non-integrated T1 access devices support up to four separate data terminal equipment (DTE) ports with standard physical interfaces such as V.35, EIA- 530/422, and EIA/TIA-232-E. This capability can be in addition to the drop-and-insert capability and can be used to support an additional application, such as a PBX, via a DSX-1 interface port. The DSX-1 port also allows the standalone unit to act as a CSU, thus supporting applications where CSU-only functions are required. Figure 3.17 shows a dual router application – again a single T1 access circuit is shared to reduce network costs. Drop-and-Insert Capability allows a T1 circuit to be groomed into two or more "channels" each comprising a selected number of DS0s. For example, the data network could be assigned 512Kbps (8 DS0s) and a PBX assigned the remaining 1024 kbps (16 DS0s) for voice. This mapping or DS0s would eliminate the need for two separate circuits; one for data and one for voice. If two circuits were required to meet the total bandwidth requirement, network diversity could be implemented for the data network (or the voice network), without having to purchase additional circuits. Drop-and-insert can also be used to split a T1 circuit between two routers, each being assigned a fractional T1 circuit speed, for example, 1,024Kbps (16 DS0s) and 512Kbps (8 DS0s) respectively. This accommodates situations where secure server access has to be provided for Internet access, but the firewall is not required (or desired) on the organization's intranet. Upgradeable Unlike an integrated CSU/DSU that is limited to its basic functionality, a non-integrated CSU/DSU can easily be upgraded to support drop-and- Access with "Drop-and Insert" CSU/DSU insert and/or multiport features.

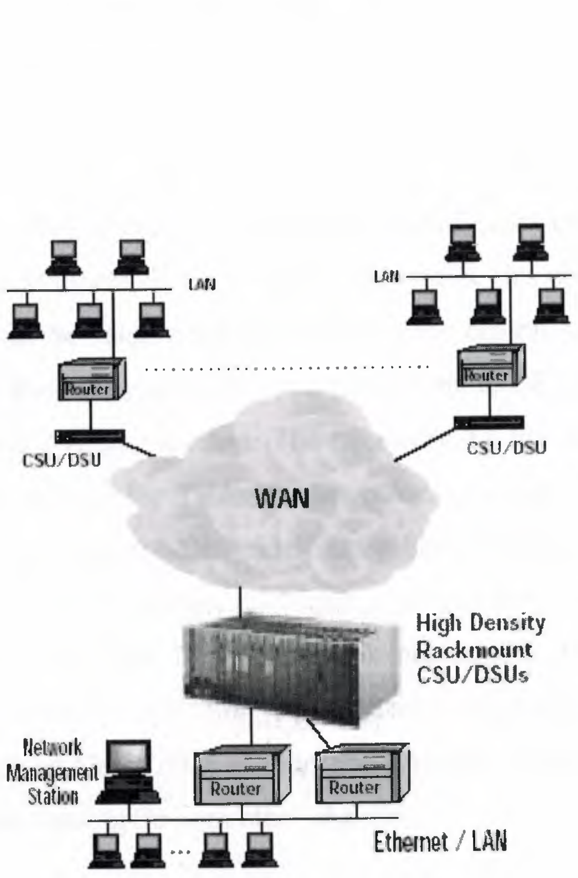


Figure 3.18 Shows Dual Routers Sharing Single T1

In this way, non-integrated access greatly increases the flexibility to accommodate network change and growth and match the best router and best access features to the application. Portable a non-integrated CSU/DSU, whether directly or indirectly LAN connected, can be easily relocated. A non-integrated unit can also be used with any manufacturer's router and also within non-routed applications in the same T1 network.

3.5.6.3 Diagnostic Testing

Fault Insulation and Troubleshooting With an integral CSU/DSU, fault isolation troubleshooting can be difficult. Should the router at the central site fail, the network administrator cannot immediately isolate the problem as to an integral CSU/DSU failure, a T1 line failure, or a network failure. If the router at the remote site fails the network manager will probably have to dispatch a technician to test the router or at the very least contact the Telco to check the T1 circuit. In contrast, as illustrated in Figure 5, a non-integrated solution can include a LAN-connected, out-of-band management path to the CSU/DSU at the central site and an in-band management path at the remote site. Consequently, if the central site router fails, the condition of the central site CSU/DSU and router — and the router DTE connection and corresponding leads can be determined via a LAN-attached Network Manager. If the remote router fails, the condition of the remote router and CSU/DSU can be determined directly from the central site. If the circuit fails, management communications can be maintained to the remote CSU/DSU via the switched network using a collocated analog modem. The necessary T1 line diagnostic tests can be run without the need to contact the Telco, further reducing the cost of ownership for the standalone solution. Comprehensive Diagnostic Loop back Testing As figure 6 shows, in fractional T1 and multiport applications, loop-back testing at the channel level is essential for isolating problems within the T1 24 DS0 channel bundle. However, most router-integrated CSU/DSUs support only full T1 payload loop backs, while Out-of-Band Management non-integrated CSU/DSUs support non-intrusive channel loop back tests that do not interfere with data passing through other channels.

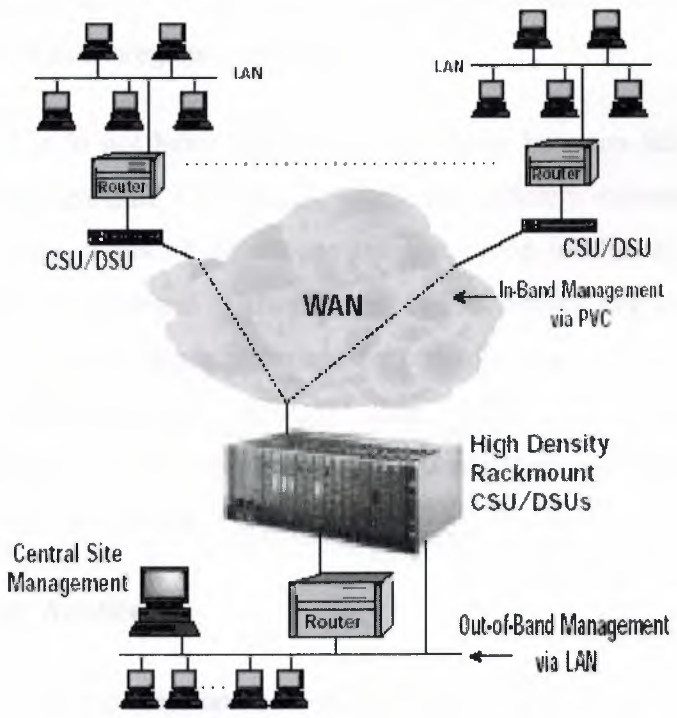

LAN
LAN
Router
Router
CSU/DSU
CSU/DSU
WAN
In-Band Management via PVC
High Density Rackmount CSU/DSUs
Central Site Management
Router
Out-of-Band Management via LAN

Figure 3.19 Shows Centralized, In-Band Management

Line Monitoring Break-in line monitoring and testing are standard T1 CSU/DSU features that allow a technician to break into the T1 path to monitor the condition of the circuit and corresponding T1 channels, as well as to trouble shoot by sending specific test transmit/ receive signals. Break-in line monitoring and testing is done using external test equipment without disturbing the data flow via a convenient front panel connector on the CSU/DSU. Most integrated CSU/DSUs do not have this feature. When they do, the break-in connector is inconveniently located at the back of the router lost among all the cables.

3.5.6.4 Single Point of Failure

Router vendors argue that the integrated approach allows easier installation and integrating the CSU/DSU in the router eliminates two sources of possible failure:

Either the separate CSU/DSU itself or the associated cabling. Consider that the CSU/DSU is still an active component of the network and should failure occur as stated earlier, the network disruption in servicing an integrated router is much greater than that created by servicing a non-integrated CSU/DSU.

Integrated CSU/DSUs do not have comparable meantime- between-failure (MTBF) ratios to that of the telecom-standard CSU/DSUs, which are typically expressed in hundreds of years. The most likely points of failure are the local loop or the router itself, with its complicated software and integral hardware components. Strong diagnostic capabilities as described in the previous paragraphs cannot be considered an option; they are a "must have" item. If a router with an CSU/DSU fails Figure 3.20, the integral CSU/DSU functionality will be lost — or at best significantly diminished — potentially crippling any ability to troubleshoot the network.

3.5.6.5 Frame Relay Application

A major portion of installed data networks consist of routed frame relay. Frame relay networks offer many obvious benefits, including an economic advantage over multiple point-to-point networks. With frame relay, optimum network design requires good knowledge of the traffic volumes actually being carried. If a frame relay network is over-designed, much of the economic advantage will be lost. If the network is under-specified the network response times during busy periods will become unacceptable, resulting in loss of productivity, not to mention complaints from users. In addition, due to the bursty nature of LAN-to-LAN traffic, it may be difficult without actual monitoring of the traffic, to know whether poor response times are the result of congestion in the carriers network or the result of under-sized (i.e. under specified) frame relay circuits, or the result of server response times. The solution to these potential problems is the Frame Relay Probe or "Frame-Aware" CSU/DSU, which can provide real-time network traffic information and network status information. Frame Relay analysis capabilities found within routers is not enough.

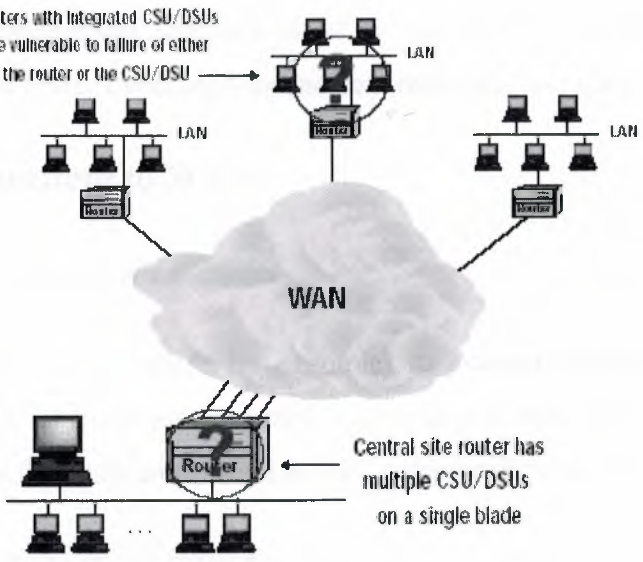

Routers with Integrated CSU/DSUs are vulnerable to failure of either the router or the CSU/DSU
LAN
LAN
LAN
Router
Router
Router
WAN
Router
Central site router has multiple CSU/DSUs on a single blade

Figure 3.20 Sows Single Point of Failure Risk

Frame Probe For example, GDC's Frame Relay Probe provides both the probe and the CSU/DSU functionalities in one unit providing valuable information on:

1. Network Availability
2. PVC Availability

3. Network Delay
4. PVC Throughput
5. End-to-End Frame Loss
6. Forward and Backward Explicit Congestion
7. Notifications (FECNs and BECNs)
8. Discard Eligibility (DE) Frames
9. Local Management Interface (LMI) Statistics
10. (Timeouts and No Responses)
11. Bandwidth Utilization
12. Committed Information Rate (CIR) Utilization.

Data can be retrieved from each innovx unit via the web and can be stored in a PC network management station. Using either Innovx Frame Manager software or industry available network management software such as Concord's Network Health; weekly, monthly, quarterly and yearly trend analysis and data reporting is readily available.

3.6 External connections to WANs

3.6.1 Permission for external connections

For external access (via modem for example) to internal systems or from internal systems to the outside (Internet for example), a user should have the written permission. The user should prove that such an external access is absolutely necessary.

These external connections can be classed as incoming and outgoing:

3.6.2 Example Incoming connections

Dialup access for company partners.

Dialup access for IT staff and directors.

Access from universities (co-ordination on research projects).

Internet Email.

Enterprise WWW Server.

EDI

3.6.3 Example Outgoing Connections

Access to Vendor Bulletin boards (for getting information, drivers).

Customer connections: providing special services to clients (examples?).

Internet Email.

Normal Internet access: Netscape via proxy server.

Special Internet Access: WWW, Archie, ftp, news, telnet, gopher, wais.

EDI (see above).

3.6.4 Simple Internet or Bulletin board access

If Internet access is required for information browsing (e.g. ftp or Web) on a sensitive zone, one solution is to use a simple PC with modem but with absolutely no (internal) network connection. It is important that these connections be registered with, and audited regularly by centralized security staff.

3.6.5 Insecure subnets

Where many external connections are required in one building, one possibility is to group together the external connections on an "Insecure Subnet" which has direct outside access, but which is separated from the internal network via a Firewall. This minimizes cost (only one firewall) and maximizes flexibility, but great care must be taken in the daily usage on these machines on the "Insecure Subnet", as they must be considered as dangerous, penetrated hosts.

3.6.6 Network Management / Monitoring

Networks are becoming more important, data speeds and volumes are increasing and networks are becoming more and more heterogeneous. Professional Network monitoring can help to analyze and predict problems (and increase availability). Such monitors can also be used to increase security by two methods:

a) "Strange" network behavior could be an intrusion, so a monitor should be able to note "strange" (i.e. not "normal") network behavior.
b) If security policy specifies that certain services are not to be used by certain hosts at specified times, network monitor software could be used to check this. e.g. if the security policy for a network specifies that ftp is not to be used between 00:00 and 06:00, then any ftp traffic on the network at this time should be monitored an reported as a security alert. This kind of monitoring is especially useful for local high security networks.The Solaris 1 utility etherfind or the Solaris 2 utility snoop or the VMS utility ethermon could be used to monitor the network for unusual behavior, but only from qualified, trusted personnel! Utilities such as Satan can be used to identify devices on an IP network, as well as report on TCP/IP security problems. Such utilities should be removed from all other machines.

CHAPTER FOUR

Web Services Architecture

4.1 Purpose of the Web Service Architecture

Web services provide a standard means of interoperating between different software applications, running on a variety of platforms and/or frameworks. This document (WSA) is intended to provide a common definition of a Web service, and define its place within a larger Web services framework to guide the community. The WSA provides a conceptual model and a context for understanding Web services and the relationships between the components of this model.

The architecture does not attempt to specify how Web services are implemented, and imposes no restriction on how Web services might be combined. The WSA describes both the minimal characteristics that are common to all Web services, and a number of characteristics that are needed by many, but not all, Web services.

The Web services architecture is interoperability architecture: it identifies those global elements of the global Web services network that are required in order to ensure interoperability between Web services.

4.2 Document Organization

This document has two main sections: a core concepts section (2 Concepts and Relationships) and a stakeholder's perspectives section (3 Stakeholder's Perspectives).

Two Concepts and Relationships provide the bulk of the conceptual model on which conformance constraints could be based. For example, the resource concept states that resources have identifiers (in fact they have URIs). Using this assertion as a basis, we can assess conformance to the architecture of a particular resource by looking for its identifier. If, in a given instance of this architecture, a resource has no identifier, then it is not a valid instance of the architecture.

While the concepts and relationships represent an enumeration of the architecture, the stakeholders' perspectives approaches from a different viewpoint: how the architecture meets the goals and requirements. In this section we elucidate the more global properties of the architecture and demonstrate how the concepts actually achieve important objectives.

A primary goal of the Stakeholder's Perspectives section is to provide a top-down view of the architecture from various perspectives. For example, in the 3.6 Web Services Security section we show how the security of Web services is addressed within the architecture. The aim here is to demonstrate that Web services can be made secure and indicate which key concepts and features of the architecture achieve that goal.

The key stakeholder's perspectives supported in this document reflect the major goals of the architecture itself: interopability, extensibility, security, Web integration, implementation and manageability.

4.3 What is a Web service?

For the purpose of this Working Group and this architecture, and without prejudice toward other definitions, we will use the following definition:[Definition: A Web service is a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the Web service in a manner prescribed by its description using SOAP messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards.]

4.3.1 Agents and Services

A Web service is an abstract notion that must be implemented by a concrete agent. (See Figure 1-1) The agent is the concrete piece of software or hardware that sends and receives messages, while the service is the resource characterized by the abstract set of functionality that is provided. To illustrate this distinction, you might implement a particular Web service using one agent one day (perhaps written in one programming language), and a different agent the next day (perhaps written in a different programming language) with the same functionality. Although the agent may have changed, the Web service remains the same.

4.3.2 Requesters and Providers

The purpose of a Web service is to provide some functionality on behalf of its owner -- a person or organization, such as a business or an individual. The provider entity is the person or organization that provides an appropriate agent to implement a particular service. (See Figure 1-1: Basic Architectural Roles.)

A requester entity is a person or organization that wishes to make use of a provider entity's Web service. It will use a requester agent to exchange messages with the provider entity's provider agent.

(In most cases, the requester agent is the one to initiate this message exchange, though not always. Nonetheless, for consistency we still use the term "requester agent" for the agent that interacts with the provider agent, even in cases when the provider agent actually initiates the exchange.)

4.3.3 Service Description

The mechanics of the message exchange are documented in a Web service description (WSD). (See Figure 1-1) The WSD is a machine-processable specification of the Web service's interface, written in WSDL. It defines the message formats, data types, transport protocols, and transport serialization formats that should be used between the requester agent and the provider agent. It also specifies one or more network locations at which a provider agent can be invoked, and may provide some information about the message exchange pattern that is expected. In essence, the service description represents an agreement governing the mechanics of interacting with that service.

4.3.4 Semantics

The semantics of a Web service is the shared expectation about the behavior of the service, in particular in response to messages that are sent to it. In effect, this is the "contract" between the requester entity and the provider entity regarding the purpose and consequences of the interaction. Although this contract represents the overall agreement between the requester entity and the provider entity on how and why their respective agents will interact, it is not necessarily written or explicitly negotiated. It may be explicit or implicit, oral or written, machine processable or human oriented, and it may be a legal agreement or an informal (non-legal) agreement. (Once again this is a slight simplification that will be explained further in 3.3 Using Web Services.)

While the service description represents a contract governing the mechanics of interacting with a particular service, the semantics represents a contract governing the meaning and purpose of that interaction. The dividing line between these two is not necessarily rigid. As more semantically rich languages are used to describe the mechanics of the interaction, more of the essential information may migrate from the informal semantics to the service description. As this migration occurs, more of the work required to achieve successful interaction can be automated.

4.3.5 Overview of Engaging a Web Service

There are many ways that a requester entity might engage and use a Web service. In general, the following broad steps are required, as illustrated in Figure 1-1: (1) the requester and provider entities become known to each other (or at least one becomes know to the other); (2) the requester and provider entities somehow agree on the service description and semantics that will govern the interaction between the requester and provider agents; (3) the service description and semantics are realized by the requester and provider agents; and (4) the requester and provider agents exchange messages, thus performing some task on behalf of the requester and provider entities. (I.e., the exchange of messages with the provider agent represents the concrete manifestation of interacting with the provider entity's Web service.) These steps are explained in more detail in 3.4 Web Service Discovery. Some of these steps may be automated, others may be performed manually.

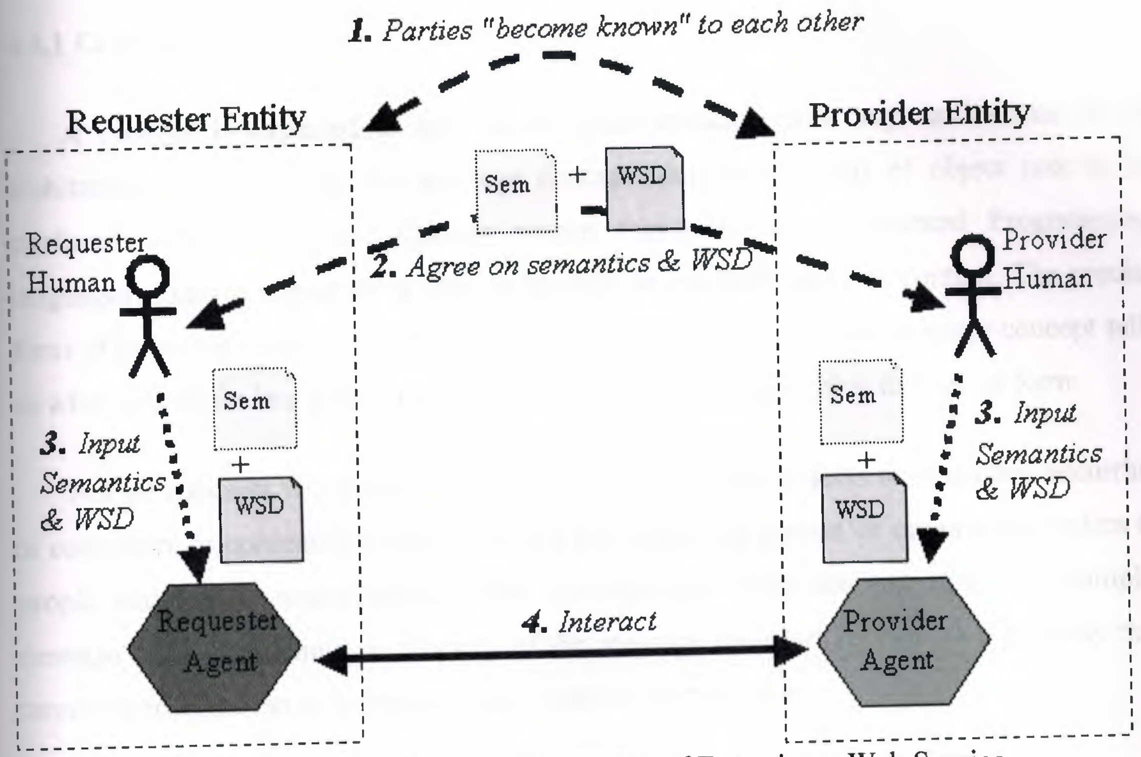


Figure 1-1. The General Process of Engaging a Web Service

4.4 Concepts and Relationships

The formal core of the architecture is this enumeration of the concepts and relationships that are central to Web services' interoperability.

The architecture is described in terms of a few simple elements: concepts, relationships and models. Concepts are often noun-like in that they identify things or properties that we expect to see in realizations of the architecture, similarly relationships are normally linguistically verbs.As with any large-scale effort, it is often necessary to structure the architecture itself. We do this with the larger-scale meta-concept of model. A model is a coherent portion of the architecture that focuses on a particular theme or aspect of the architecture.

4.4.1 Concepts

A concept is expected to have some correspondence with any realizations of the architecture. For example, the message concept identifies a class of object (not to be confused with Objects and Classes as are found in Object Oriented Programming languages) that we expect to be able to identify in any Web services context. The precise form of a message may be different in different realizations, but the message concept tells us what to look for in a given concrete system rather than prescribing its precise form.

Not all concepts will have a realization in terms of data objects or structures occurring in computers or communications devices; for example the person or organization refers to people and human organizations. Other concepts are more abstract still; for example, message reliability denotes a property of the message transport service — a property that cannot be touched but nonetheless is important to Web services.

Each concept is presented in a regular, stylized way consisting of a short definition, an enumeration of the relationships with other concepts, and a slightly longer explanatory description. For example, the concept of agent includes as relating concepts the fact that an agent is a computational resource, has an identifier and an owner. The description part of the agent explains in more detail why agents are important to the archicture.

4.4.2 Relationships

Relationships denote associations between concepts. Grammatically, relationships are verbs; or more accurately, predicates. A statement of a relationship typically takes the form: concept predicate concept. For example, in agent, we state that:

An agent is a computational resource This statement makes an assertion, in this case about the nature of agents. Many such statements are descriptive, others are definitive: A message has a message sender such a statement makes an assertion about valid instances of the architecture: we expect to be able to identify the message sender in any realization of the architecture. Conversely, any system for which we cannot identify the sender of a message is not conformant to the architecture. Even if a service is used anonymously, the sender has an identifier but it is not possible to associate this identifier with an actual person or organization.

4.4.3 Concept Maps

Many of the concepts in the architecture are illustrated with concept maps. A concept map is an informal, graphical way to illustrate key concepts and relationships. For example the diagram:

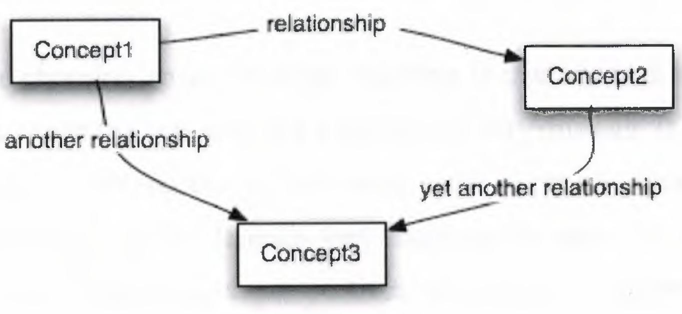


Figure 2.1 Concept Map

Shows three concepts which are related in various ways. Each box represents a concept, and each arrow (or labeled arc) represents a relationship. The merit of a concept map is that it allows rapid navigation of the key concepts and illustrates how they relate to each other. It should be stressed however that these diagrams are primarily navigational aids; the written text is the definitive source.

4.4.4 Model

A model is a coherent subset of the architecture that typically revolves around a particular aspect of the overall architecture. Although different models share concepts, it is usually from different points of view; the major role of a model is to explain and encapsulate a significant theme within the overall Web services architecture.

For example, the Message Oriented Model focuses and explains Web services strictly from a message passing perspective. In particular, it does not attempt to relate messages to services provided. The Service Oriented Model, however, lays on top of and extends the Message Oriented Model in order to explain the fundamental concepts involved in service - in effect to explain the purpose of the messages in the Message Oriented Model.

Each model is described separately below, in terms of the concepts and relationships inherent to the model. The ordering of the concepts in each model section is alphabetical; this should not be understood to imply any relative importance. For a more focused viewpoint the reader is directed to the Stakeholder's perspectives section which examines the architecture from the perspective of key stakeholders of the architecture.

The reason for choosing an alphabetical ordering is that there is a large amount of cross-referencing between the concepts. As a result, it is very difficult, if not misleading, to choose a non-alphabetic ordering that reflects some sense of priority between the concepts. Furthermore, the optimal ordering depends very much on the point of view of the reader. Hence, we devote the Stakeholders perspectives section to a number of prioriterized readings of the architecture.

4.4.5 Conformance

Unlike language specifications, or protocol specifications, conformance to an architecture is necessarily a somewhat imprecise art. However, the presence of a concept in this enumeration is a strong hint that, in any realization of the architecture, there should be a corresponding feature in the implementation. Furthermore, if a relationship is identified here, then there should be corresponding relationships in any realized architecture. The consequence of non-conformance is likely to be reduced interoperability: The absence of such a concrete feature may not prevent interoperability, but it is likely to make such interoperability more difficult.

A primary function of the Architecture's enumeration in terms of models, concepts and relationships is to give guidance about conformance to the architecture. For example, the architecture notes that a message has a message sender; any realization of this architecture that does not permit a message to be associated with its sender is not in conformance with the architecture. For example, SMTP could be used to transmit messages. However, since SMTP (at present) allows forgery of the sender's identity, SMTP by itself is not sufficient to discharge this responsibility.

4.4.6 The Architectural Models

This architecture has four models, illustrated in Figure 2-2. Each model in Figure 2-2 is labeled with what may be viewed as the key concept of that model.

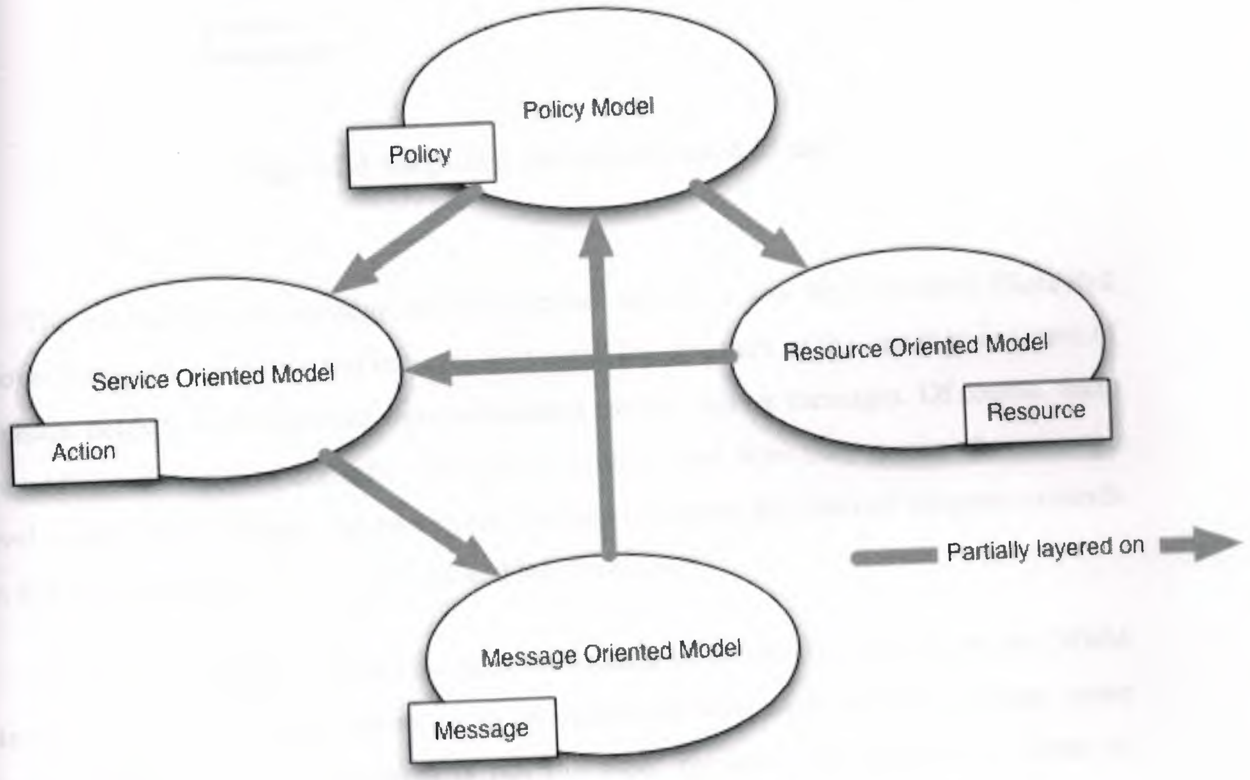


Figure 2.2 Meta Model of the Architecture

The four models are:

The Message Oriented Model focuses on messages, message structure, message transport and so on — without particular reference as to the reasons for the messages, nor to their significance.

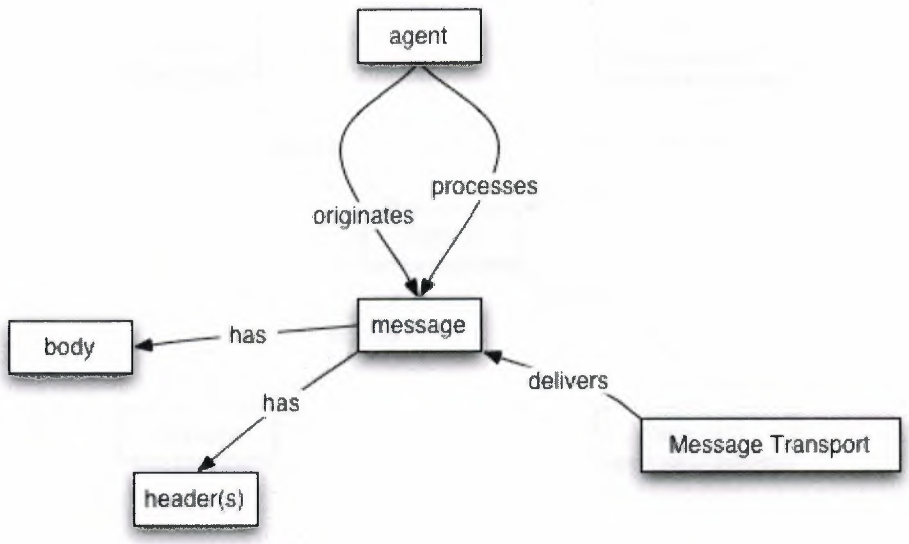


Figure 2.3 Simplified Message Oriented Model

The essence of the message model revolves around a few key concepts illustrated above: the agent that sends and receives messages, the structure of the message in terms of message headers and bodies and the mechanisms used to deliver messages. Of course, there are additional details to consider: the role of policies and how they govern the message level model. The abridged diagram shows the key concepts; the detailed diagram expands on this to include many more concepts and relationships.

The Service Oriented Model focuses on aspects of service, action and so on. While clearly, in any distributed system, services cannot be adequately realized without some means of messaging, the converse is not the case: messages do not need to relate to services.

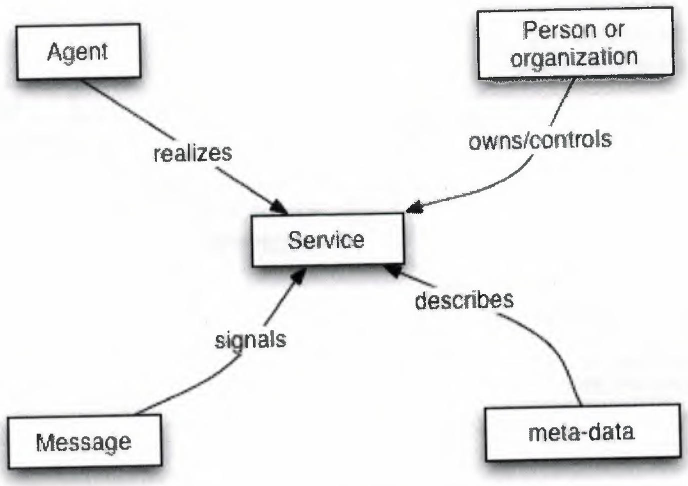


Figure 2.4 Simplified Service Oriented Model

The Service Oriented Model is the most complex of all the models in the architecture. However, it too revolves around a few key ideas. A service is realized by an agent and used by another agent. Services are mediated by means of the messages exchanged between requester agents and provider agents.

A very important aspect of services is their relationship to the real world: services are mostly deployed to offer functionality in the real world. We model this by elaborating on the concept of a service's owner — which, whether it is a person or an organization, has a real world responsibility for the service.

Finally, the Service Oriented Model makes use of meta-data, which, as described in 3.1 Service Oriented Architecture, is a key property of Service Oriented Architectures. This meta-data is used to document many aspects of services: from the details of the interface and transport binding to the semantics of the service and what policy restrictions there may be on the service. Providing rich descriptions is key to successful deployment and use of services across the Internet.

The Resource Oriented Model focuses on resources that exist and have owners.

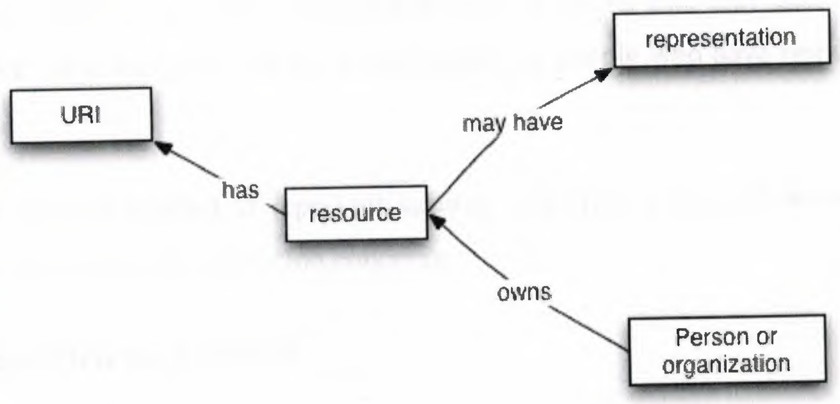


Figure 2.5 Simplified Resource Oriented Model

The resource model is adopted from the Web Architecture concept of resource. We expand on this to incorporate the relationships between resources and owners.

The Policy Model focuses on constraints on the behavior of agents and services. We generalize this to resources since policies can apply equally to documents (such as descriptions of services) as well as active computational resources.

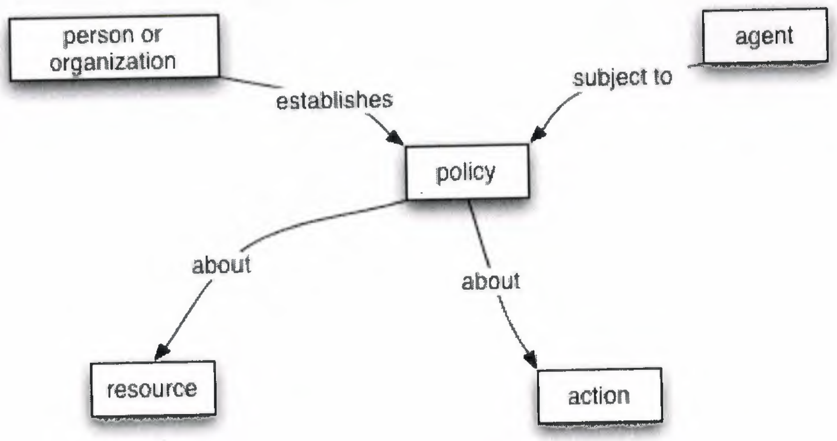


Figure 2.6 Simplified Policy Model

Policies are about resources. They are applied to agents that may attempt to access those resources, and are put in place, or established, by people who have responsibility for the resource.

Policies may be enacted to represent security concerns, quality of service concerns, management concerns and application concerns.

4.5 Message Oriented Model

4.5.1 Message Oriented Model Introduction

The Message Oriented Model focuses on those aspects of the architecture that relate to messages and the processing of them. Specifically, in this model, we are not concerned with any semantic significance of the content of a message or its relationship to other messages.

However, the MOM does focus on the structure of messages, on the relationship between message senders and receivers and how messages are transmitted.

The MOM is illustrated in the Figure 2-7:

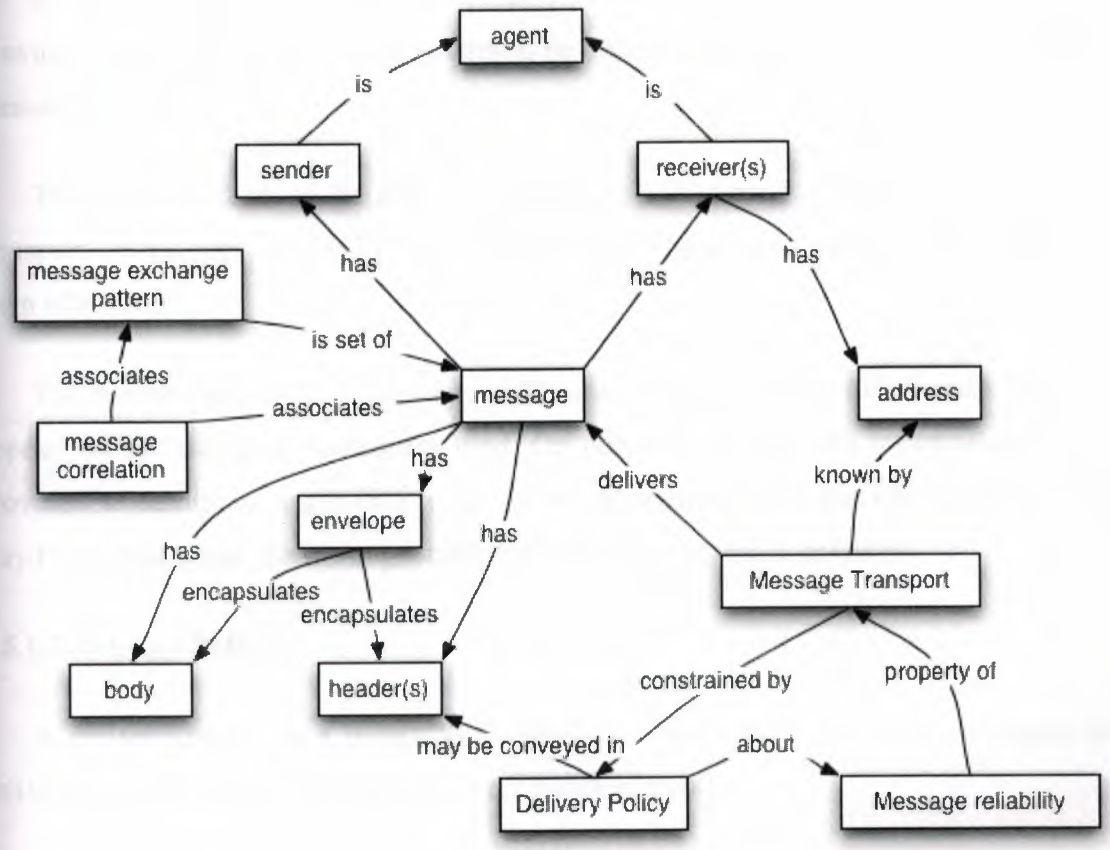


Figure 2.7 Message Oriented Model

4.5.1.1 Address

An address is that information required by a message transport mechanism in order to deliver a message appropriately.An address is information used to describe how and where to deliver messages.

An address may be a URI. An address is typically transport mechanism specific. An address may be contained in the message envelope.

In order for message transport mechanisms to function, it is normally necessary to provide information that allows messages to be delivered. This is called the address of the message receiver.

Typically, the form of the address information will depend of the particular message transport. In the case of an HTTP message transport, the address information will take the form of a URL.

The precise method that a message sender uses to convey address information will also depend on the transport mechanism used. On occasion, the address information may be provided as additional arguments to the invoking procedure. Or the address information may be located within the message itself; typically in the message envelope.

4.5.1.2 Delivery Policy

A delivery policy is a policy that constrains the methods by which messages are delivered by the message transport.Delivery policy is a policy.

Delivery policy constrains message transport .Delivery policy may be expressed in a policy description language .Delivery policy may express the quality of service associated with delivering a message by a message transport mechanism .

Delivery policies are those policies that relate to the delivery of messages.Typically, a delivery policy applies to the combination of a particular message and a particular message transport mechanism. The policies that apply, however, may originate from descriptions in the message itself, or be intrinsic to the transport mechanism, or both.Examples of delivery policies include quality of service assurances — such as reliable versus best effort message delivery — and security assurances — such as encrypted versus unencrypted message transport. Another kind of delivery policy could take the form of assertions about recording an audit of how the message was delivered.

4.5.1.3 Message

A message is the basic unit of data sent from one Web services agent to another in the context of Web services.

A message is a unit of data sent from one agent to another

A message may be part of a message sequence .

A message may be described using a service description language

A message has a message sender .A message has one or more message recipients

A message may have an identifier A message has a message body.

A message has zero or more message headers.

A message has a message envelope .

A message is delivered by a message transport system.

A message may have a delivery policy associated with it .

A message represents the data structure passed from its sender to its recipients. The structure of a message is defined in a service description.

The main parts of a message are its envelope, a set of zero or more headers, and the message body. The envelope serves to encapsulate the component parts of the message and it serves as a well-known location for message transport services to locate necessary addressing information. The header holds ancillary information about the message and facilitates modular processing. The body of the message contains the message content or URIs to the actual data resource.

A message can be as simple as an HTTP GET request, in which the HTTP headers are the headers and the parameters encoded in the URL are the content. Note that extended Web services functionality in this architecture is not supported in HTTP headers.

A message can also simply be a plain XML document. However, such messages do not support extended Web services functionality defined in this architecture.

A message can be a SOAP XML, in which the SOAP headers are the headers. Extended Web services functionality are supported in SOAP headers.

4.5.1.4 Message Body

A message body is the structure that represents the primary application-specific content that the message sender intends to deliver to the message recipient.A message body is contained by the message envelope. A message body is the application-specific content intended for the message recipient.

The message body provides a mechanism for transmitting information to the recipient of the message. The form of the message body, and other constraints on the body, may be expressed as part of the service description.In many cases, the precise interpretation of the message body will depend on the message headers that are in the message.

4.5.1.5 Message Correlation

Message correlation is the association of a message with a context. Message correlation ensures that a requester agent can match the reply with the request, especially when multiple replies may be possible.Message Correlation is a means of associating a message within a specific conversational context. Message correlation may be realized by including message identifiers to enable messages to be identified. Message correlation allows a message to be associated with a particular purpose or context. In a conversation, it is important to be able to determine that an actual message that has been received is the expected message. Often this is implicit when conversations are relayed over stream-oriented message transports; but not all transports allow correlation to be established so implicitly.

For situations where correlation must be handled explicitly, one technique is to associate a message identifier with messages. The message identifier is an identifier that allows a received message to be correlated with the originating request. The sender may also add an identifier for a service, not necessarily the originating sender, who will be the recipient of the message (see asynchronous messaging).

Correlation may also be realized by the underlying protocol. For example, HTTP/1.1 allows one to correlate a request with its response.

4.5.1.6 Message Envelope

A message envelope is the structure that encapsulates the component parts of a message: the message body and the message headers.A message envelope may contain address information about the intended recipients of its associated message A message envelope contains the message body. A message envelope contains the message headers.

4.5.1.7 Message Exchange Pattern (MEP)

A Message Exchange Pattern (MEP) is a template, devoid of application semantics, that describes a generic pattern for the exchange of messages between agents. It describes relationships (e.g., temporal, causal, sequential, etc.) of multiple messages exchanged in conformance with the pattern, as well as the normal and abnormal termination of any message exchange conforming to the pattern.A message exchange pattern describes a generic pattern for the exchange of messages between agents. A message exchange pattern should have a unique identifier. A message exchange pattern may realize message correlation .A message exchange pattern may describe a service invocation distributed applications in a Web services architecture communicate via message exchanges. These message exchanges are logically factored into patterns that may be composed at different levels to form larger patterns. A Message Exchange Pattern (MEP) is a template, devoid of application semantics, that describes a generic pattern for the exchange of (one-way) messages between agents. The patterns can be described by state machines that define the flow of the messages, including the handling of faults that may arise, and the correlation of messages.

4.5.1.8 Message Header

A message header is the part of the message that contains information about a specific aspect of the message. A message header is contained in a message envelope .A message header may be a specific well known types .A message header may identify .A service role, which denotes the kind of processing expected for the header. A message header may be processed independently of the message body

Message headers represent information about messages that is independently standardized (such as WS-Security) — and may have separate semantics -- from the message body. For example, there may be standard forms of message header that describe authentication of messages. The form of such headers is defined for all messages; although, of course, a given authentication header will be specific to the particular message.

The primary function of headers is to facilitate the modular processing of the message, although they can also be used to support routing and related aspects of message processing. The header part of a message can include information pertinent to extended Web services functionality, such as security, transaction context, orchestration information, message routing information, or management information.

Message headers may be processed independently of the message body, each message header may have an identifying service role that indicates the kind of processing that should be performed on messages with that header. Each message may have several headers, each potentially identifying a different service role.

Although many headers will relate to infrastructure facilities, such as security, routing, load balancing and so on; it is also possible that headers will be application specific. For example, a purchase order processing Web service may be structured into layers; corresponding to different functions within the organization. These stakeholders may process headers of different messages in standardized ways: the customer information may be captured in one standardized header, the stock items by a different standardized header and so on.

4.5.1.9 Message Receiver

A message receiver is an agent that receives a message. A message receiver is a agent .A message receiver is the recipient of a message The message receiver is an agent that is intended to receive a message from the message sender.

Messages may be passed through intermediaries that process aspects of the message, typically by examining the message headers. The message recipient may or may not be aware of processing by such intermediaries.

Often a specific message receiver, the ultimate recipient, is identified as the final recipient of a message. The ultimate recipient will be responsible for completing the processing of the message.

4.5.1.10 Message Reliability

Message reliability is the degree of certainty that a message will be delivered and that sender and receiver will both have the same understanding of the delivery status.Message reliability is a property of message delivery. Message reliability may be realized by a combination of message acknowledgement and correlation. Message reliability may be realized by a transport mechanism .The goal of reliable messaging is to both reduce the error frequency for messaging and to provide sufficient information about the status of a message delivery. Such information enables a participating agent to make a compensating decision when errors or less than desired results occur. High level correlation such as "two-phase commit" is needed if more than two agents are involved. Note that in a distributed system, it is theoretically not possible to guarantee correct notification of delivery; however, in practice, simple techniques can greatly increase the overall confidence in the message delivery.

It is important to note that a guarantee of the delivery of messages alone may not improve the overall reliability of a Web service due to the need for end-to-end reliability. (See "End-to-End Arguments in System Design".) It may, however, reduce the overall cost of a Web service.

Message reliability may be realized with a combination of message receipt acknowledgement and correlation. In the event that a message has not been properly received and acted upon, the sender may attempt a resend, or some other compensating action at the application level.

4.5.1.11 Message Sender

A message sender is the agent that transmits a message.A message sender is an agent .A message sender is the originator of a message

A message sender is an agent that transmits a message to another agent. Although every message has a sender, the identity of the sender may not be available to others in the case of anonymous interactions.

Messages may also be passed through intermediaries that process aspects of the message; typically by examining the message headers. The sending agent may or may not be aware of such intermediaries.

4.5.1.12 Message Sequence

A message sequence is a sequence of related messages.A message sequence is a sequence of related messages .A message sequence may realize a documented message exchange pattern A requester agent and a provider agent exchange a number of messages during an interaction. The ordered set of messages exchanged is a message sequence.This sequence may be realizing a well-defined MEP, usually identified by a URI.

4.5.1.13 Message Transport

A Message Transport is a mechanism that may be used by agents to deliver messages.A message transport is a mechanism that delivers messages. A message transport has zero or more capabilities .A message transport is constrained by various delivery policies .A message transport must know sufficient address information in order to deliver a message. The message transport is the actual mechanism used to deliver messages. Examples of message transport include HTTP over TCP, SMTP, message oriented middleware, and so on.The responsibility of the message transport is to deliver a message from a sender to one or more recipient, i.e. transport a SOAP Infoset from one agent to another, possibly with some implied semantics (e.g. HTTP methods semantics).Message transports may provide different features (e.g. message integrity, quality of service guaranties, etc.).For a message transport to function, the sending agent must provide the address of the recipient.

4.5.2 The Service Oriented Model

The Service Oriented Model (SOM) focuses on those aspects of the architecture that relate to service and action.The primary purpose of the SOM is to explicate the relationships between an agent and the services it provides and requests. The SOM builds on the MOM, but its focus is on action rather than message.The concepts and relationships in the SOM are illustrated in Figure 2-8:

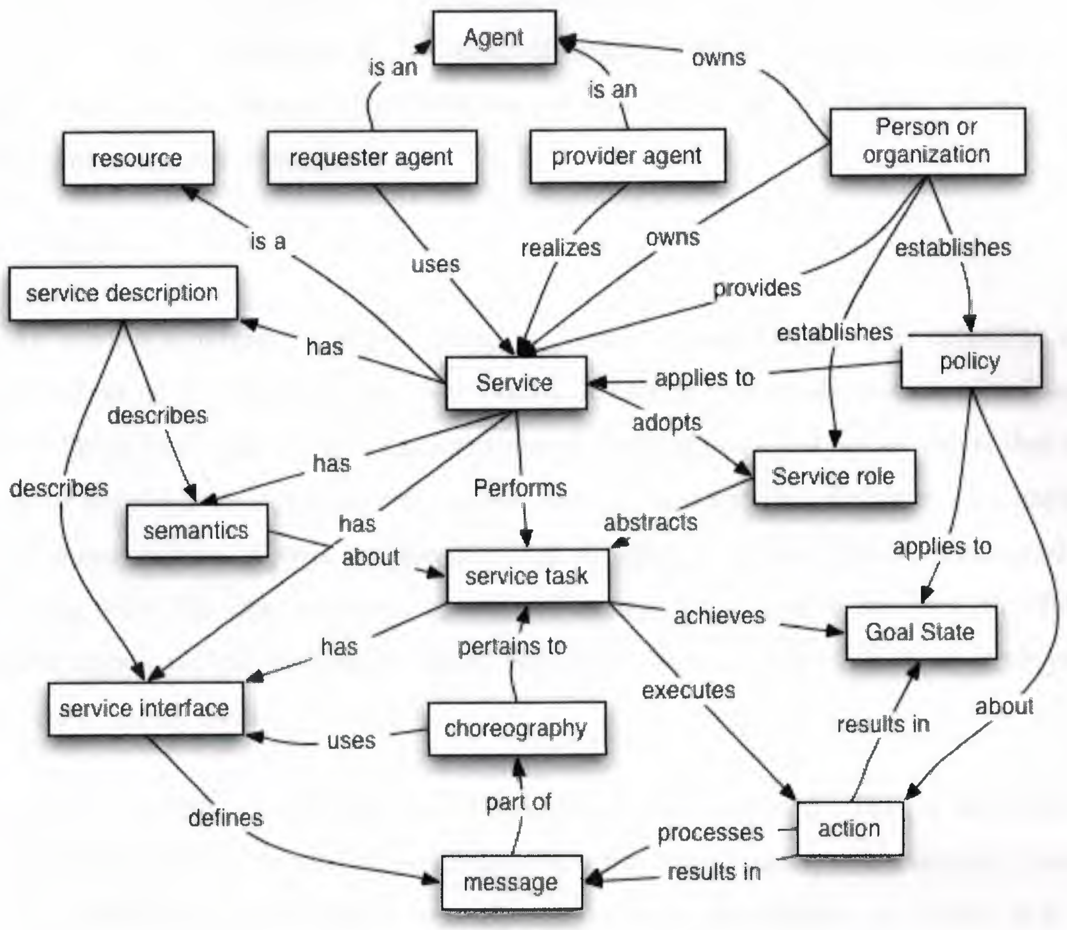


Figure 2.8 Service Oriented Model

4.5.2.1 Action

An action, for the purposes of this architecture, is any action that may be performed by an agent, possibly as a result of receiving a message, or which results in sending a message or another observable state change. An action may result in a desired goal state. An action may be the sending of a message .An action may be the processing of a received message. At the core of the concept of service is the notion of one party performing action(s) at the behest of another party. From the perspective of requester and provider agents, an action is typically performed by executing some fragment of a program.

In the WSA, the actions performed by requester and provider agents are largely out of scope, except in so far as they are the result of messages being sent or received. In effect, the programs that are executed by agents are not in scope of the architecture, however the resulting messages are in scope.

4.5.2.2 Agent

An agent is a program acting on behalf of person or organization. (This definition is a specialization of the definition in [Web Arch]. It corresponds to the notion of software agent in [Web Arch].)An agent is a computational resource .An agent has an owner that is a person or organization .An agent may realize zero or more services .An agent may request zero or more services .Agents are programs that engage in actions on behalf of someone or something else. For our purposes, agents realize and request Web services. In effect, software agents are the running programs that drive Web services — both to implement them and to access them.

Software agents are also proxies for the entities that own them. This is important as many services involve the use of resources which also have owners with a definite interest in their disposition. For example, services may involve the transfer of money and the incurring of legal obligations as a result.We specifically avoid any attempt to govern the implementation of agents; we are only concerned with ensuring interopability between systems.

4.5.2.3 Choreography

A choreography defines the sequence and conditions under which multiple cooperating independent agents exchange messages in order to perform a task to achieve a goal state.A choreography uses one or more service interfaces . A choreography defines the pattern of possible interactions between a set of agents . A choreography may be expressed in a choreography description language .A choreography pertains to a given task .A choreography defines the relationship between exchanged messages and tasks of a service. A choreography is a model of the sequence of operations, states, and conditions that control the interactions involved in the participating services. The interaction prescribed by a choreography results in the completion of some useful function. Examples include the placement of an order, information about its delivery and eventual payment, or putting the system into a well-defined error state.

A choreography can be distinguished from an orchestration. An orchestration defines the sequence and conditions in which one Web service invokes other Web services in order to realize some useful function.

A choreography may be described using a choreography description language. A choreography description language permits the description of how Web services can be composed, how service roles and associations in Web services can be established, and how the state, if any, of composed services is to be managed.

4.5.2.4 Capability

A capability is a named piece of functionality (or feature) that is declared as supported or requested by an agent. .A capability has a identifier which is a URI .

A capability has a description of its semantics .A capability can be advertised by an agent that supports it .A capability can be required by agent that wishes to use it .A capability may be referenced by a service description .Agents participating in an exchange may implement a wide variety of features. For example, there may be different ways to achieve the reliable delivery of a message, or there may be several mechanisms available to support security. A Web service may advertise that it supports a particular capability, and an agent requiring that capability might select the service on that basis. Or a Web service may indicate that it requires a particular capability of any requester agent that uses it, and a requester agent may select it or avoid it on that basis. There may also be a negotiation -- either manual or automatic -- about which capabilities to select. The concept of capability encompasses SOAP features, but is broader.

4.5.2.5 Goal State

A goal state is a state of some service or resource that is desireable from some person or organization's point of view. A goal state is a state of the real world, which includes the state of relevant resources .A goal state is desired by some person or organization which has an interest in defining it. A goal state may be characterized informally, or formally with a formal expression. .

Goal states are associated with tasks. Tasks are the unit of action associated with services that have a measurable meaning. Typically measured from the perspective of the owner of a service, a goal state is characterized by a predicate that is true of that state — for example; a book selling service may have as its goal state that a book has been purchased by a legitimate customer.

It is difficult to be formal about vague properties such as desirable, however, it is also clear that services are deployed and used with an intention. An e-commerce service is oriented towards buying and selling, a stock ticker service is oriented towards giving timely information. A goal state is simply a way of being able to declare success when a task has completed successfully.

4.5.2.6 Provider Agent

A provider agent is an agent that is capable of and empowered to perform the actions associated with a service on behalf of its owner — the provider entity.A provider agent is a Web service software agent .A provider agent realizes one or more services. A provider agent performs, or causes to perform the actions associated with a task. A provider agent acts on behalf of a provider entity .The provider agent is the software agent that realizes a Web service by performing tasks on behalf of its owner — the provider entity.A given service may be offered by more than one agent, especially in the case of composite services, and a given provider agent may realize more than one Web service.

4.5.2.7 Provider Entity

The provider entity is the person or organization that is providing a Web service.A provider entity is a person or organization .A provider entity offers a Web service .

A provider entity owns a provider agent .The provider entity is the person or organization that is offering a Web service. The provider agent acts on behalf of the provider entity that owns it.

4.5.2.8 Requester Agent

A requester agent is a software agent that wishes to interact with a provider agent in order to request that a task be performed on behalf of its owner — the entity. A requester agent is an agent .A requester agent uses a service. A requester agent acts on behalf of a requester entity .The requester agent is the software agent that requires a certain function to be performed on behalf of its owner — the requester entity. From an architectural perspective, this is the agent that is looking for and invoking or initiating an interaction with a provider agent.

4.5.2.9 Requester Entity

The requester entity is the person or organization that wishes to use a provider entity's Web service. A requester entity is a person or organization .A requester entity owns a requester agent .The requester entity is the person or organization that wishes to make use of a Web service. The requester entity is the counterpart to the provider entity.

4.5.2.10 Service

A service is an abstract resource that represents a capability of performing tasks that represents a coherent functionality from the point of view of provider entities and requester entities. To be used, a service must be realized by a concrete provider agent.

A service is a resource .A service performs one or more tasks .A service has a service description .A service has a service interface. A service has service semantics. A service has an identifier. A service has a service semantics .A service has one or more service roles in relation to the service's owner .A service may have one or more policies applied to it.A service is owned by a person or organization. A service is provided by a person or organization. A service is realized by a provider agent. A service is used by a requester agent.

A service is an abstract resource that represents a person or organization in some collection of related tasks as having specific service roles. The service may be realized by one or more provider agents that act on behalf of the person or organization — the provider entity. The critical distinction of a Web service, compared to other Web resources, is that Web services do not necessarily have a representation; however, they are associated with actions.

4.5.2.11 Service Description

A service description is a set of documents that describe the interface to and semantics of a service.A service description is a machine-processable description of a service .A service description is a machine-processable description of the service's interface. A service description contains a machine-processable description of the messages that are exchanged by the service. A service description may include a description of the service's semantics .A service description is expressed in a service description language A service description contains the details of the interface and, potentially, the expected behavior of the service. This includes its data types, operations, transport protocol information, and address. It could also include categorization and other metadata to facilitate discovery and utilization. The complete description may be realized as a set of XML description documents.

There are many potential uses of service descriptions: they may be used to facilitate the construction and deployment of services, they may be used by people to locate appropriate services, and they may be used by requester agents to automatically discover appropriate provider agents in those case where requester agents are able to make suitable choices.

4.5.2.12 Service Interface

A service interface is the abstract boundary that a service exposes. It defines the types of messages and the message exchange patterns that are involved in interacting with the service, together with any conditions implied by those messages.A service interface defines the messages relevant to the service .A service interface defines the different types of messages that a service sends and receives, along with the message exchange patterns that may be used.

4.5.2.13 Service Intermediary

A service intermediary is a Web service whose main role is to transform messages in a value-added way. (From a messaging point of view, an intermediary processes messages en route from one agent to another.) Specifically, we say that a service intermediary is a service whose outgoing messages are equivalent to its incoming messages in some application-defined sense. A service intermediary is a service. A service intermediary adopts a specific service role. A service intermediary preserves the semantics of messages it receives and sends.A service intermediary is a specific kind of service which typically acts as a kind of filter on messages it handles. Normally, intermediaries do not consume messages but rather forward them to other services. Of course, intermediaries do often modify messages but, it is of the essence that from some application specific perspective they do not modify the meaning of the message.

Of course, if a message is altered in any way, then from some perspectives it is no longer the same message. However, just as a paper document is altered whenever anyone writes a comment on the document, and yet it is still the same document, so an intermediary modifies the messages that it receives, forwarding the same message with some changes.

Coupled with the concept of service intermediary is the service role is adopts. Typically, this involves one or more of the messages' headers rather than the bodies of messages. The specification of the header is coupled with the permissable semantics of the intermediary should make it clear to what extent the messages forwarded by an itnermediary are the same message and what modifications are permitted.

There are a number of situations where additional processing of messages is required. For example, messages that are exchanged between agents within an enterprise may not need encryption; however, if a message has to leave the enterprise then good security may suggest that it be encrypted. Rather than burden every software agent with the means of encrypting and decrypting messages, this functionality can be realized by means of an intermediary. The main responsiblity of the software agents then becomes ensuring that the messages are routed appropriately and have the right headers targetted at the appropriate intermediaries.

4.5.2.14 Service Role

A service role is an abstract set of tasks which is identified to be relevant by a person or organization offering a service. Service roles are also associated with particular aspects of messages exchanged with a service.A service role is a set of service tasks .A service role may be defined in terms of particular properties of messages. A service role may be established by a service owner. A service role is an intermediate abstraction between service and task. A given message that is received by a service may involve processing associated with several service roles. Similarly, messages emitted may also involve more than one service role.We can formalize the distinction by noting that a service role is typically associated with a particular property of messages. For ultimate processing, the service role may be to determine some final disposition of messages received. However, other service roles may be associated with more generic properties of messages — such as their encryption, or whether they reference a customer or inventory item.Service roles identify the points of interest that a service owner has in the processing of messages. As such, they are established by the party that offers in the service.

4.5.2.15 Service Semantics

The semantics of a service is the behavior expected when interacting with the service. The semantics expresses a contract (not necessarily a legal contract) between the provider entity and the requester entity. It expresses the intended real-world effect of invoking the service. A service semantics may be formally described in a machine readable form, identified but not formally defined, or informally defined via an "out of band" agreement between the provider entity and the requester entity.Service semantics is the contract between the provider entity and the requester entity concerning the effects and requirements pertaining to the use of a service.

Service semantics describes the intended effects of using a service .Service semantics is about the service tasks that constitute the service. Service semantics should be identified in a service description. Service semantics may be described in a formal, machine-processable language.

Knowing the type of a data structure is not enough to understand the intent and meaning behind its use. For example, methods to deposit and withdraw from an account typically have the same type signature, but with a different effect. The effects of the operations are the semantics of the operation. It is good practice to be explicit about the intended effects of using a Web service; perhaps even to the point of constructing a machine readable description of the semantics of a service.

Machine processable semantic descriptions provide the potential for sophisticated usage of Web services. For example, by accessing such descriptions, a requester agent may autonomously choose which provider agent to use.

Apart from the expected behavior of a service, other semantic aspects of a service include any policy restrictions on the service, the relationship between the provider entity and the requester entity, and what manageability features are associated with the service.

4.5.2.16 Service Task

A service task is an action or combination of actions that is associated with a desired goal state. Performing the task involves executing the actions, and is intended to achieve a particular goal state.A service task is an action or combination of actions. A service task is associated with one or more intended goal states. A service task is performed by executing the actions associated with the task. A service task has a service interface. A service task is an abstraction that encapsulates some intended effect of invoking a service.

Tasks are associated with goal states — characterized by predicates that are satisfied on successful completion.The performance of a task is made observable by the exchange of messages between the requester agent and the provider agent. The specific pattern of messages is what defines the choreography associated with the task.

In addition to exchanged messages, there may be other private actions associated with a task. For example, in a database update task, the task may be signaled by an initiating message and a completion message, which are public, and the actual database update, which is typically private.

In the case of a service oriented architecture only the public aspects of a task are important, and these are expressed entirely in terms of the messages exchanged.Tasks represent a useful unit in modeling the semantics of a service and indeed of a service role a given service may consist of a number of tasks.

4.5.3 The Resource Oriented Model

The Resource Oriented Model focuses on those aspects of the architecture that relate to resources. Resources are a fundamental concept that underpins much of the Web and much of Web services; for example, a Web service is a particular kind of resource that is important to this architecture.

The ROM focuses on the key features of resources that are relevant to the concept of resource, independent of the role the resource has in the context of Web services. Thus we focus on issues such as the ownership of resources, policies associated with resources and so on. Then, by virtue of the fact that Web services are resources, these properties are inherited by Web services.

We illustrate the basic concepts and relationships in the ROM in Figure 2-9:

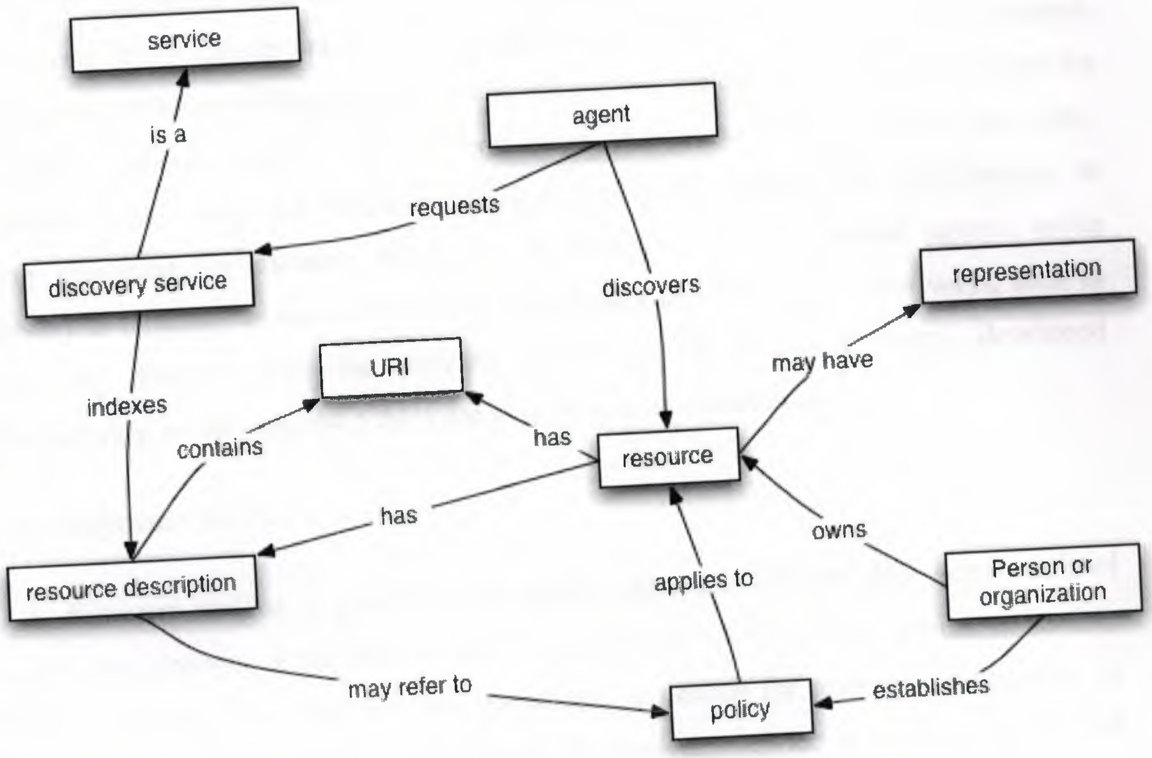


Figure 2.9 Resource Oriented Model

4.5.3.1 Discovery

Discovery is the act of locating a machine-processable description of a Web service-related resource that may have been previously unknown and that meets certain functional criteria. It involves matching a set of functional and other criteria with a set of resource descriptions. The goal is to find an appropriate Web service-related resource.[WS Glossary] .Discovery is the act of locating a resource description .Discovery involves matching a set of functional and other criteria with a set of resource descriptions. Discovery may be performed by an agent, or by an end-user. Discovery may be realized using a discovery service .

In the context of Web services, the resources being discovered are usually service descriptions. If a requester entity does not already know what service it wishes to engage, the requester entity must discover one. There are various means by which discovery can be performed. Various things — human end users or agents — may initiate discovery. Requester entities may find service descriptions during development for static binding, or during execution for dynamic binding. For statically bound requester agents, using discovery is optional, as the service description might be obtained in other ways, such as being sent directly from the provider entity to the requester entity, developed collaboratively, or provided by a third party, such as a standards body.

4.5.3.2 Discovery Service

A discovery service is a service that enables agents to retrieve Web service-related resource descriptions. A discovery service is a service .A discovery service is used to publish descriptions .A discovery service is used to search for resource descriptions. A discovery service may be used by an agent .A discovery service is used to publish and search for descriptions meeting certain functional or semantic criteria. It is primarily intended for use by requester entities, to facilitate the process of finding an appropriate provider agent for a particular task. However, depending on the implementation and policy of the discovery service (3.4.2 Discovery: Registry, Index or Peer-to-Peer?), it may also be used by provider entities to actively publish their service descriptions. Although the resource model is general purpose, the most important resource for our purposes is the Web service. Furthermore, the primary role of a discovery service is to facilitate the discovery of Web services. For dynamic discovery, the requester agent may interact directly with the discovery service to find an appropriate provider agent to engage. For static discovery, a human may interact with the discovery service through an appropriate software agent, such as a browser. The use of an automated discovery service is optional, since other means can be used to enable a requester entity and provider entity to agree on the service description that will govern the interaction. For example, the requester entity might obtain the service description directly from the provider entity, the two parties might develop the service description collaboratively, or, in some circumstances, the service description may be created by the requester entity and dictated to the provider entity. (For example, a large company may require its suppliers to provide Web services that conform to a particular service description.) Likewise, a requester entity can obtain a service description from other sources besides a discovery service, such as a local file system, FTP site, URL, or WSIL document.

4.5.3.3 Identifier

An identifier is an unambiguous name for a resource. An identifier should be realized a URI .An identifier identifies a resource that is relevant to the architecture. Identifiers are used to identify resources. In the architecture we use Uniform Resource Identifiers [RFC 2396] to identify resources.

4.5.3.4 Representation

A representation is a piece of data that describes a resource state. A resource may have a representation .Representations are data objects that reflect the state of a resource. A resource has a unique identifier (a URI). Note that a representation of a resource need not be the same as the resource itself; for example the resource associated with the booking state of a restaurant will have different representations depending on when the representation is retrieved. A representation is usually retrieved by performing an HTTP "GET" on a URI.

4.5.3.5 Resource

A resource is defined by [RFC 2396] to be anything that can have an identifier. Although resources in general can be anything, this architecture is only concerned with those resources that are relevant to Web services and therefore have some additional characteristics. In particular, they incorporate the concepts of ownership and control: a resource that appears in this architecture is a thing that has a name, may have reasonable representations and which can be said to be owned. The ownership of a resource is critically connected with the right to set policy on the resource.A resource has an identifier .A resource may have zero or more representations . A resource may have zero or more resource descriptions .A resource is owned by a person or organization .A resource may be governed by zero or more policies .Resources form the heart of the Web architecture itself. The Web is a universe of resources that have URIs as identifiers, as defined in [RFC 2396].

From a real-world perspective, a most interesting aspect of a resource is its ownership: a resource is something that can be owned, and therefore have policies applied to it. Policies applying to resources are relevant to the management of Web services, security of access to Web services and many other aspects of the role that a resource has in the world.

4.5.3.6 Resource description

A resource description is any machine readable data that may permit resources to be discovered. Resource descriptions may be of many different forms, tailored for specific purposes, but all resource descriptions must contain the resource's identifier. A resource description contains the resource's identifier. A resource description may reference the policies applicable to the resource .A resource description may reference the semantics applicable to the resource.A resource description is a machine-processable description of a resource. Resource descriptions are used by and within discovery services to permit agents to discover the resource.The precise contents of a resource description will vary, depending on the resource, on the purpose of the description and on the accessibility of the resource. However, for our purposes it is important to note that the description must contain the resource's identifier. I.e., a description of the form: "the new resource that is owned by XYZ co." is not regarded as a valid resource description because it does not mention the resource's identifier.

A primary purpose of resource descriptions is to facilitate the discovery of the resource. To aid that purpose, the description is likely to contain information about the location of the resource, how to access it and potentially any policies that govern the policy. Where the resource is a Web service, the description may also contain machine-processable information about how to invoke the Web service and the expected effect of using the Web service.

4.5.4 The Policy Model

The Policy Model focuses on those aspects of the architecture that relate to policies and, by extension, security and quality of service.Security is fundamentally about constraints; about constraints on the behavior on action and on accessing resources. Similarly, quality of service is also about constraints on service. In the PM, these constraints are modeled around the core concept of policy; and the relationships with other elements of the architecture. Thus the PM is a framework in which security can be realized.However, there are many other kinds of constraints, and policies that are relevant to Web services, including various application-level constraints.

The concepts and relationships in the PM are illustrated in Figure 2-10:

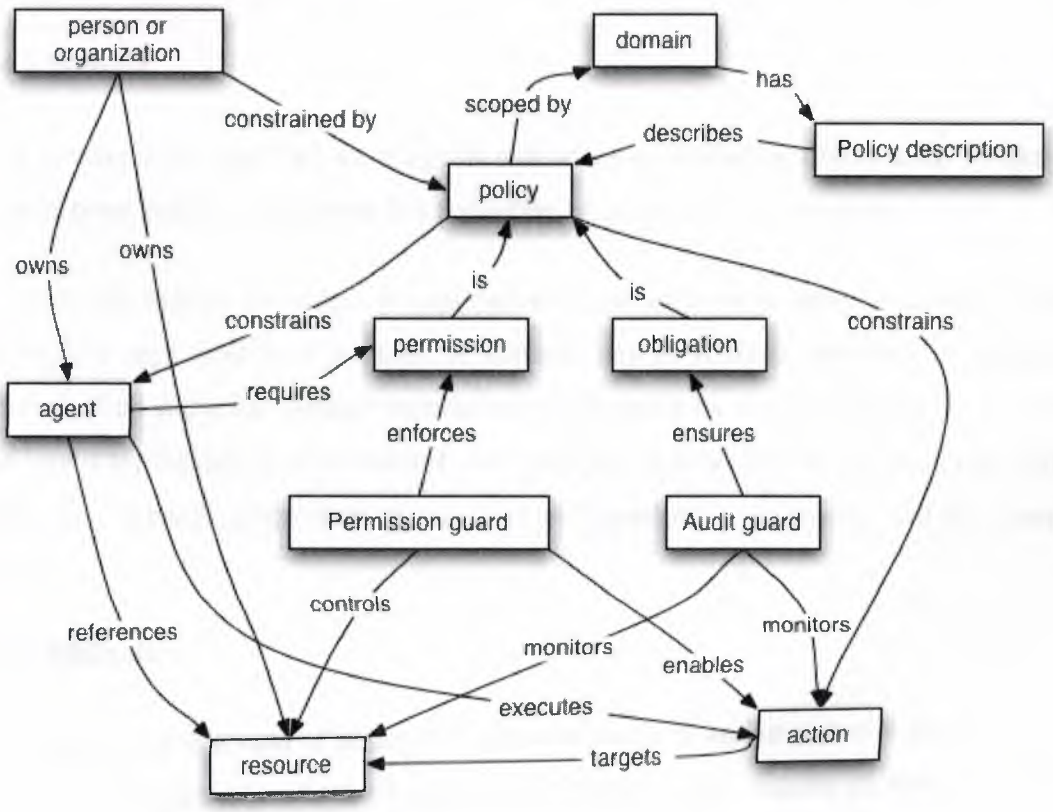


Figure 2.10 Policy Model

4.5.4.1 Audit Guard

An audit guard is a mechanism used on behalf of an owner that monitors actions and agents to verify the satisfaction of obligations.A audit guard is a policy guard .An audit guard may monitor one or more resources. An audit guard may monitor actions relative to one or more services. An audit guard may determine if an agent's obligations have been discharged. An audit guard is an enforcement mechanism. It is used to monitor the discharge of obligations. The role of the audit guard is to monitor that agents, resources and services are consistent with any associated obligations established by the service's owner or manager.Typically, an audit guard monitors the state of a resource or a service, ensuring that the obligation is satisfied. It determines whether the associated obligations are satisfied.By their nature, it is not possible to proactively enforce obligations; hence, an obligation violation may result in some kind of retribution after the fact of the violation.

4.5.4.2 Domain

A domain is an identified set of agents and/or resources that is subject to the constraints of one of more policies. A domain is a collection of agents and/or resources.

A domain defines the scope of application of one or more policies .A domain defines the scope of applicability of policies. A domain may be defined explicitly or implicitly. Members of an explicitly defined domain are enumerated by a central authority; members of an implicitly defined domain are not. For example, membership in an implicitly defined domain may depend on the state of the agent or something it possesses, and thus may be dynamic.

4.5.4.3 Obligation

An obligation is a kind of policy that prescribes actions and/or states of an agent and/or resource.An obligation is a kind of policy .An obligation may require an agent to perform one or more actions .An obligation may require an agent or service to be in one or more allowable states. An obligation may be discharged by the performance of an action or other event. An obligation is one of two fundamental types of policies. When an agent has an obligation to perform some action, then it is required to do so. When the action is performed, then the agent can be said to have satisfied its obligations.

Not all obligations relate to actions. For example, an agent providing a service may have an obligation to maintain a certain state of readiness. (Quality of service policies are often expressed in terms of obligations.) Such an obligation is typically not discharged by any of the obligee's actions; although an event (such as a certain time period expiring) may discharge the obligation.

Obligations, by their nature, cannot be proactively enforced. However, obligations are associated with enforcement mechanisms: audit guards. These monitor controlled resources and agents and may result in some kind of retribution; retributions are not modeled by this architecture.

An obligation may continue to exist after its requirements have been met (for example, an obligation to maintain a particular credit card balance), or it may be discharged by some action or event.

4.5.4.4 Permission

Permission is a kind of policy that prescribes the allowed actions and states of an agent and/or resource.A permission is a type of policy. A permission may enable one or more actions .A permission may enable one or more allowable states .A permission is one of two fundamental types of policies. When an agent has permission to perform some action, to access some resource, or to achieve a certain state, then it is expected that any attempt to perform the action etc., will be successful. Conversely, if an agent does not have the required permission, then the action should fail even if it would otherwise have succeeded.

Permissions are enforced by guards, in particular permission guards, whose function is to ensure that permission policies are honored.

4.5.4.5 Permission Guard

A permission guard is a mechanism deployed on behalf of an owner to enforce permission policies.A permission guard is a policy guard .A permission guard is a a mechanism that enforces permission policies. A permission guard may control one or more resources. A permission guard enables actions relative to one or more services. A permission guard is an enforcement mechanism that is used to enforce permission policies. The role of the permission guard is to ensure that any uses of a service or resource are consistent with the policies established by the service's owner or manager.

Typically, a permission guard sits between a resource or service and the requester of that resource or service. In many situations, it is not necessary for a service to be aware of the permission guard. For example, one possible role of a message intermediary is to act as a permission guard for the final intended recipient of messages.A permission guard acts by either enabling a requested action or access, or by denying it. Thus, it is normally possible for permission policies to be proactively enforced.

4.5.4.6 Person or Organization

A person or organization may be the owner of agents that provide or request Web services. A person or organization may own an agent .A person or organization may belong to a domain .A person or organization may establish policies governing resources that they own .The WSA concept of person or organization is intended to refer to the real-world people that are represented by agents that perform actions on their behalf. All actions considered in this architecture are ultimately rooted in the actions of humans.

4.5.4.7 Policy

A policy is a constraint on the behavior of agents or people or organizations. A policy *is a constraint on the allowable actions or states of an agent* or person or organization. A policy may have an identifier .A policy may be described in a policy description .A policy may define a capability. A policy is a constraint on the behavior of agents as they perform actions or access resources.There are many kinds of policies, some relate to accessing resources in particular ways, others relate more generally to the allowable actions an agent may perform: both as provider agents and as requester agents. Logically, we identify two types of policy: permissions and obligations. Although most policies relate to actions of various kinds, it is not exclusively so. For example, there may be a policy that an agent must be in a certain state (or conversely may not be in a particular state) in relation to the services it is requesting or providing. Closely associated with policies are the mechanisms for establishing policies and for enforcing them. This architecture does not model the former. Policies have applications for defining security properties, quality of service properties, management properties and even application properties.

4.5.4.8 Policy Description

A policy description is a machine-processable description of a policy or set of policies.A policy description describes a policy .A policy description is a machine processable description of some constraint on the behavior of agents as they perform actions, access resources.The policy description itself is not the policy, but it may define the policy and it may be used to determine if the policy applies in a given situation..Policy descriptions may include specific conditions, such as "agents of XXX Co. may access files in directory FFF". They may also include more general rules, such as "if an entity has the right to access files in the directory FFF, it also has the obligation to close them after 20 seconds".

4.5.4.9 Policy Guard

A policy guard is a mechanism that enforces one or more policies. It is deployed on behalf of an owner.A policy guard has an owner responsible for establishing the guard .A policy guard is an abstraction that denotes a mechanism that is used by owners of resources to enforce policies.The architecture identifies two kinds of policy guards: audit guards and permission guards. These relate to the core kinds of policies (obligation and permission policies respectively).

4.6 Relationships

The X is a Y relationship denotes the relationship between concepts X and Y, such that every X is also a Y.Assuming that X is a Y, then: true of if P is true of Y then P is true of X contains if Y has a P then X has a Q such that Q is a P. transitive if P is true of Y then P is true of X .Essentially, when we say that concept X is a Y we mean that every feature of Y is also a feature of X. Note, however, that since X is presumably a more specific concept than Y, the features of X may also be more specific variants of the features of Y.

For example, in the service concept, we state that every service has an identifier. In the more specific Web service concept, we note that a Web service has an identifier in the form of a URI identifier.

4.6.1 The describes relationship

The concept Y describes X if and only if Y is an expression of some language L and that the values of Y are instances of X.Assuming that Y describes X, then: if Y is a valid expression of L, then the values of Y are instances of concept X

For example, in the service description concept, we state that service descriptions are expressed in a service description language. That means that we can expect legal expressions of the service description language to be instances of the service description concept.

4.6.2 The has a relationship

Saying that "the concept X has a Y relationship" denotes that every instance of X is associated with an instance of Y.Assuming that X has a Y, then: if E is an instance of X then Y is valid for E.When we say that "concept X has a Y" we mean that whenever we see an X we should also see a Y .For example, in the Web service concept, we state that Web services have URI identifiers. So, whenever the Web service concept is found, we can assume that the Web service referenced has an identifier. This, in turn, allows implementations to use identifiers to reliably refer to Web services. If a given Web service does not have an identifier associated with it, then the architecture has been violated.

4.6.3 The owns relationship

The relationship "X owns Y" denotes the relationship between concepts X and Y, such that every X has the right and authority to control, utilize and dispose of Y. Assuming that X owns Y, then: policy X has the right to establish policies that constrain agents and other entities in their use of Y disposal X has the right to transfer some or all of his rights with respect to Y to another entity. Transitive if P is true of Y then P is true .Essentially, when we say that X owns Y we mean that X has a significant set of rights with respect to Y, and that those rights are transferrable. In general, ownership is partial, and there may be many entities that have rights with respect to some service or resource.

4.6.4 The realized relationship

The statement "concept X is realized as Y" denotes that the concept X is an abstraction of the concept Y. An equivalent view is that the concept X is implemented using Y.Assuming that X is realized as Y, then: implemented if Y is present, or true of a system, then the concept X applies to the system reified Y is a reification of the concept X. When we say that the concept or feature X is realized as Y, we mean that Y is an implementation or reification of the concept X. I.e., if Y is a valid concept of a system then we have also ensured that the concept X is valid of the same system. For example, in the correlation feature, we state that message correlation requires that we associate identifiers with messages. This can be realized in a number of ways — including the identifier in the message header, message body, in a service binding and so on. The message identifier is a key to the realization of message correlation.

4.7 Stakeholder's Perspectives

This section examines the architecture from various perspectives, each perspective representing one coherent view of the architecture. For example, security represents one major stakeholder's perspective of the architecture itself.

4.7.1 Web Services and Architectural Styles

Distributed object systems have a number of architectural challenges. [Dist Comp] and others point out:Problems introduced by latency and unreliability of the underlying transport. The lack of shared memory between the caller and object. The numerous problems introduced by partial failure scenarios. The challenges of concurrent access to remote resources. The fragility of distributed systems if incompatible updates are introduced to any participant.

These challenges apply irrespective of whether the distributed object system is implemented using COM/CORBA or Web services technologies. Web services are no less appropriate than the alternatives if the fundamental criteria for successful distributed object architectures are met. If these criteria are met, Web services technologies may be appropriate if the benefits they offer in terms of platform/vendor neutrality offset the performance and implementation immaturity issues they may introduce.

Conversely, using Web services technologies to implement a distributed system doesn't magically turn a distributed object architecture into an SOA. Nor are Web services technologies necessarily the best choice for implementing SOAs -- if the necessary infrastructure and expertise are in place to use COM or CORBA as the implementation technology and there is no requirement for platform neutrality, using SOAP/WSDL may not add enough benefits to justify their costs in performance, etc.

In general SOA and Web services are most appropriate for applications:That must operate over the Internet where reliability and speed cannot be guaranteed; Where there is no ability to manage deployment so that all requesters and providers are upgraded at once; Where components of the distributed system run on different platforms and vendor products; Where an existing application needs to be exposed for use over a network, and can be wrapped as a Web service.

4.7.2 Relationship to the WWW and REST Architectures

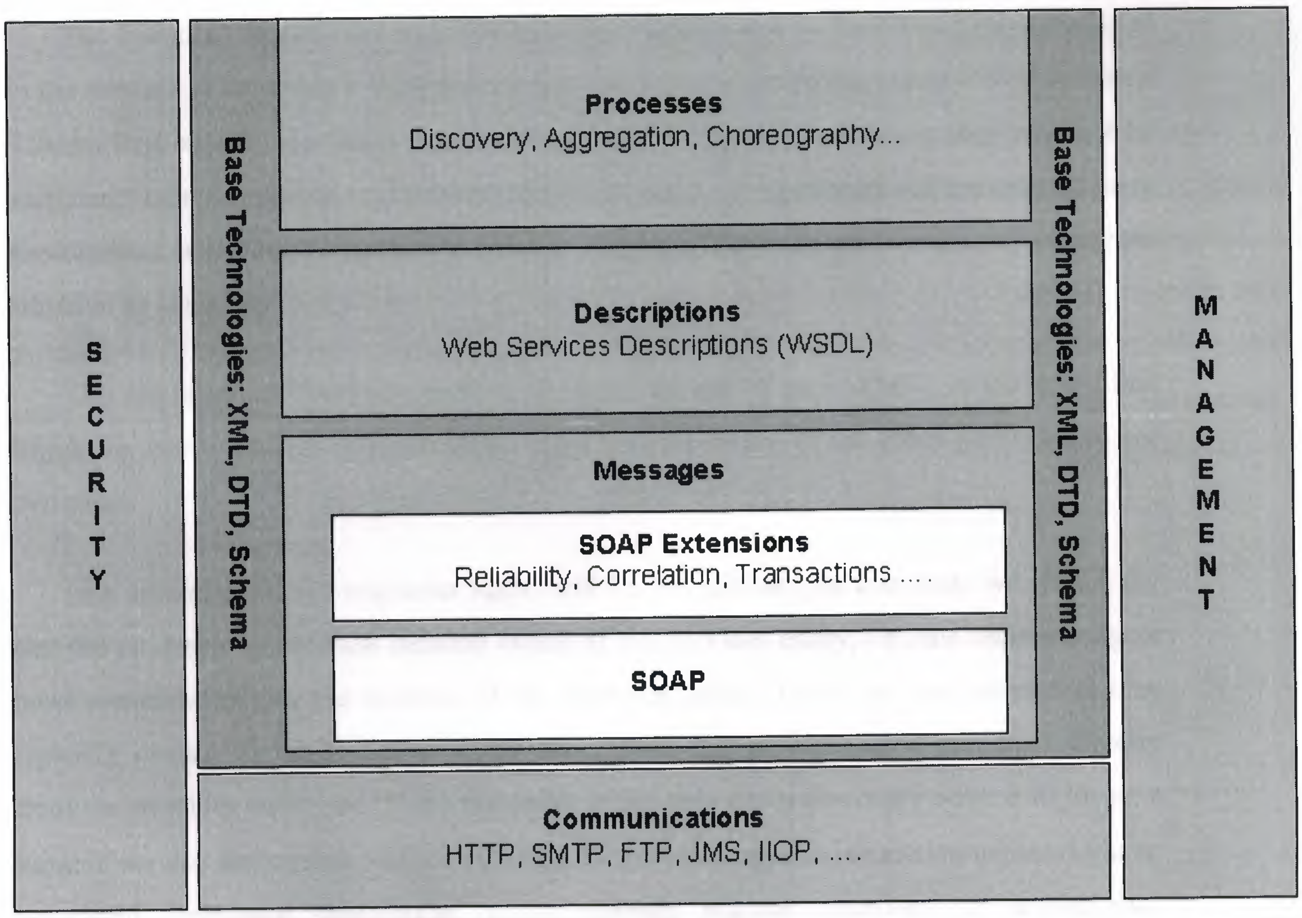
The World Wide Web operates as a networked information system that imposes several constraints: Agents identify objects in the system, called resources, with Uniform Resource Identifiers (URIs). Agents represent, describe, and communicate resource state via representations of the resource in a variety of widely-understood data formats (e.g. XML, HTML, CSS, JPEG, PNG). Agents exchange representations via protocols that use URIs to identify and directly or indirectly address the agents and resources. [Web Arch]

An even more constrained architectural style for reliable Web applications known as Representation State Transfer (REST) has been proposed by Roy Fielding and has inspired both the W3C Technical Architecture Group's architecture document [Web Arch] and many who see it as a model for how to build Web services [Fielding]. The REST Web is the subset of the WWW (based on HTTP) in which agents provide uniform interface semantics essentially create, retrieve, update and delete -- rather than arbitrary or application-specific interfaces, and manipulate resources only by the exchange of representations. Furthermore, the REST interactions are "stateless" in the sense that the meaning of a message does not depend on the state of the conversation.We can identify two major classes of Web services:REST-compliant Web services, in which the primary purpose of the service is to manipulate XML representations of Web resources using a uniform set of "stateless" operations; and arbitrary Web services, in which the service may expose an arbitrary set of operations.

Both classes of Web services use URIs to identify resources and use Web protocols (such as HTTP and SOAP 1.2) and XML data formats for messaging. (It should be noted that SOAP 1.2 can be used in a manner consistent with REST. However, SOAP 1.2 can also be used in a manner that is not consistent with REST.)

4.7.3 Web Services Technologies

Web service architecture involves many layered and interrelated technologies. There are many ways to visualize these technologies, just as there are many ways to build and use Web services. Figure 3-1 below provides one illustration of some of these technology families.



SECURITY
Base Technologies: XML, DTD, Schema
Processes
Discovery, Aggregation, Choreography...
Descriptions
Web Services Descriptions (WSDL)
Messages
SOAP Extensions
Reliability, Correlation, Transactions ....
SOAP
Base Technologies: XML, DTD, Schema
MANAGEMENT
Communications
HTTP, SMTP, FTP, JMS, IIOP, ...

Figure 3.1 Web Services Architecture Stack

In this section we describe some of those technologies that seem critical and the role they fill in relation to this architecture. This is a necessarily bottom-up perspective, since, in this section, we are looking at Web services from the perspective of tools which can be used to design, build and deploy Web services.

The technologies that we consider here, in relation to the Architecture, are XML, SOAP, WSDL. However, there are many other technologies that may be useful. (For example, see the list of Web services specifications compiled by Roger Cutler and Paul Denning.) See also B An Overview of Web Services Security Technologies

4.7.4 Using Web Services

The introduction outlined and illustrated (in Figure 1-1) the four broad steps involved in the process of engaging a Web service (see 1.4.5 Overview of Engaging a Web Service). This section expands on these steps. Although these steps are necessary, they may not be sufficient: many scenarios will require additional steps, or significant refinements of these fundamental steps. Furthermore, the order in which the steps are performed may vary from situation to situation.

The requester and provider entities "become known to each other", in the sense that whichever party initiates the interaction must become aware of the other party. There are two cases.

In a typical case, the requester agent will be the initiator. In this case, we would say that the requester entity must become aware of the provider entity, i.e., the requester agent must somehow obtain the address of the provider agent. There are two ways this may typically occur: (1) the requester entity may obtain the provider agent's address directly from the provider entity; or (2) the requester entity may use a discovery service to locate a suitable service description (which contains the provider agent's invocation address) via an associated *functional description, either through manual discovery or autonomous selection. These cases are described more fully in 3.4 Web Service Discovery.*

In other cases, the provider agent may initiate the exchange of messages between the requester and provider agents. In this case, saying that the requester and provider entities become known to each other actually means that the provider entity becomes aware of the requester entity, i.e., the provider agent somehow obtains the address of the requester agent. How this occurs is application dependent and irrelevant to this architecture. Although this case is expected to be less common than when the requester agent is the initiator, it is important in some "push" or subscription scenarios.

The requester entity and provider entity agree on the service description (a WSDL document) and semantics that will govern the interaction between the requester agent and the provider agent. (See the note below on "Agreeing on the Same Semantics and Service Description for further explanation of what is meant here by "agree".)

This does not necessarily mean that the requester and provider entities must communicate or negotiate with each other. It simply means that both parties must have the same (or compatible) understandings of the service description and semantics, and intend to uphold them. There are many ways this can be achieved, such as:

The requester and provider entities may communicate directly with each other, to explicitly agree on the service description and semantics. The provider entity may publish and offer both the service description and semantics as take-it-or-leave-it "contracts" that the requester entity must accept unmodified as conditions of use.

The service description and semantics (excepting the network address of the particular service) may be defined as a standard by an industry organization, and used by many requester and provider entities. In this case, the act of the requester and provider entities reaching agreement is accomplished by both parties independently conforming to the same standard.

The service description and semantics (perhaps excepting the network address of the service) may be defined and published by the requester entity (even if they are written from provider entity's perspective), and offered to provider entities on a take-it-or-leave-it basis. This may occur, for example, if a large company requires its suppliers to provide Web services that conform to a particular service description and semantics. In this case, agreement is achieved by the provider entity adopting the service description and semantics that the requester entity has published. Depending on the scenario, Step 2 (or portions of Step 2) may be performed prior to Step 1.

The service description and semantics are input to, or embodied in, both the requester agent and the provider agent as appropriate. In other words, the information in them must either be input to, or implemented in, the requester and provider agents. There are many ways this can be achieved, and this architecture does not specify or care what means are used. For example: An agent could be hard coded to implement a particular, fixed service description and semantics. An agent could be coded in a more general way, and the desired service description and/or semantics could be input dynamically. An agent could be created first, and the service description and/or semantics could be generated or deduced from the agent code. For example, a tool could examine a set of existing class files to generate a service description.

Regardless of the approach used, from an information perspective both the semantics and the service description must somehow be input to, or implemented in, both the requester agent and the provider agent before the two agents can interact. (This is a slight simplification; see the note below on "Agreeing" on the Same Semantics and Service Description for further explanation.) The requester agent and provider agent exchange SOAP messages on behalf of their owners.

4.7.5 Web Service Discovery

If the requester entity wishes to initiate an interaction with a provider entity and it does not already know what provider agent it wishes to engage, then the requester entity may need to "discover" a suitable candidate. Discovery is "the act of locating a machine-processable description of a Web service that may have been previously unknown and that meets certain functional criteria. " [WS Glossary] The goal is to find an appropriate Web service.A discovery service is a service that facilitates the process of performing discovery. It is a logical role, and could be performed by either the requester agent, the provider agent or some other agent. Figure 3-2 ("Discovery Process") expands on Figure 1-1 to describe the process of engaging a Web service when a discovery service is used.

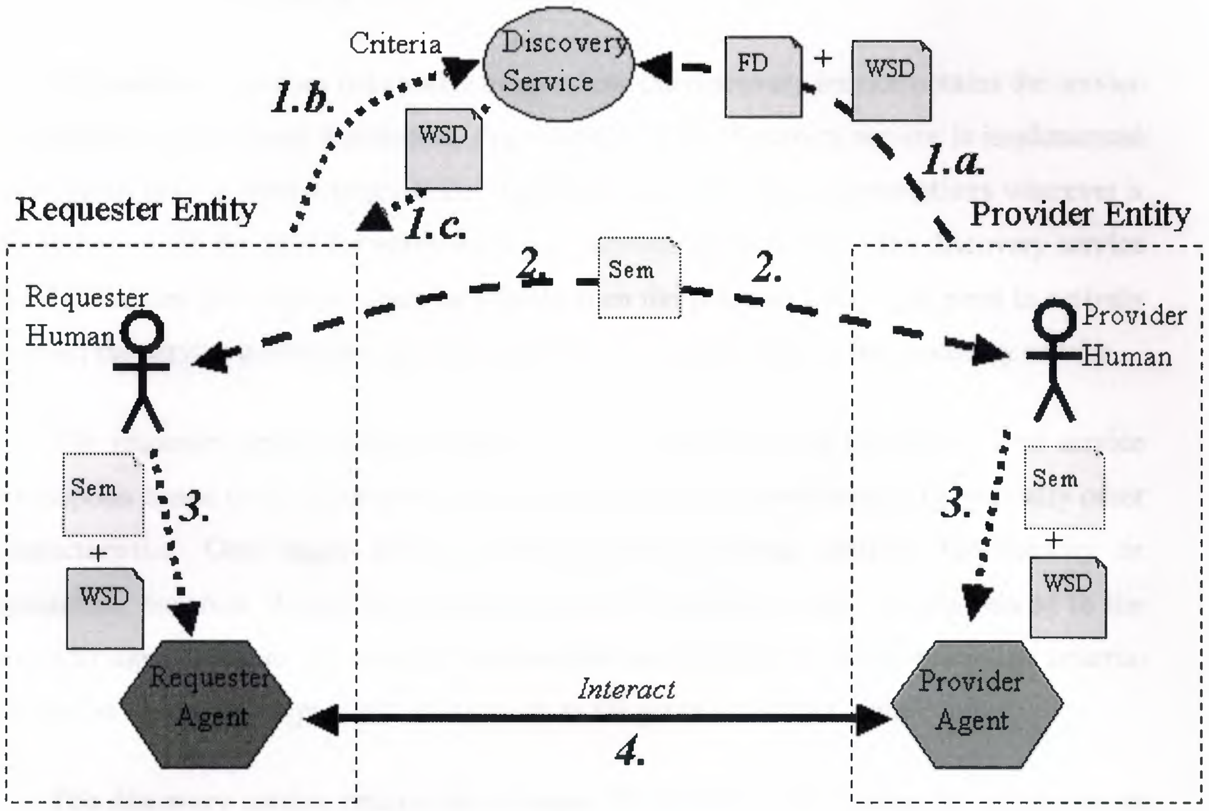


Figure 3.2 Discovery Process

Service engagement using a discovery service proceeds in roughly the following steps. The requester and provider entities "become known to each other": The discovery service somehow obtains both the Web service description ("WSD" in Figure 3-2) and an associated functional description ("FD") of the service. The functional description ("FD" in Figure 3-2) is a machine-processable description of the functionality (or partial semantics) of the service that the provider entity is offering. It could be as simple as a few words of meta data or a URI, or it may be more complex, such as a TModel (in UDDI) or a collection of RDF, DAML-S or OWL-S statements.

This architecture does not specify or care how the discovery service obtains the service description or functional description. For example, if the discovery service is implemented as a search engine, then it might crawl the Web, collecting service descriptions wherever it finds them, with the provider entity having no knowledge of it. Or, if the discovery service is implemented as a registry (such as UDDI), then the provider entity may need to actively publish the service description and functional description directly to the discovery service.

The requester entity supplies criteria to the discovery service to select a Web service description based on its associated functional description, capabilities and potentially other characteristics. One might locate a service having certain desired functionality or semantics; however, it may be possible to specify "non-functional" criteria related to the provider agent, such as the name of the provider entity, performance or reliability criteria, or criteria related to the provider entity, such as the provider entity's vendor rating.

The discovery service returns one or more Web service descriptions (or references to them) that meet the specified criteria. If multiple service descriptions are returned, the requester entity selects one, perhaps using additional criteria.

The requester and provider entities agree on the semantics ("Sem" in Figure 3-2) of the desired interaction. Although this may commonly be achieved by the provider entity defining the semantics and offering them on a take-it-or-leave-it basis to the requester entity, it could be achieved in other ways. For example, both parties may adopt certain standard service semantics that are defined by some industry standards body. Or in some circumstances the requester could define the semantics. The important point is that the parties must agree (in the sense described in 3.3 Using Web Services) on the semantics, regardless of how that is achieved.

Step 2 also requires that the parties agree (in the sense described in 3.3 Using Web Services) on the service description that is to be used. However, since the requester entity obtained the Web service description in Step 1.c, in effect the requester and provider entities have already done so.

The service description and semantics are input to, or embodied in, both the requester agent and the provider agent, as appropriate. The requester agent and provider agent exchange SOAP messages on behalf of their owners.

4.7.6 Peer-to-Peer (P2P) Discovery

Peer-to-Peer (P2P) computing provides an alternative that does not rely on centralized registries; rather it allows Web services to discover each other dynamically. Under this view, a Web service is a node in a network of peers, which may or may not be Web services. At discovery time, a requester agent queries its neighbors in search of a suitable Web service. If any one of them matches the request, then it replies. Otherwise each queries its own neighboring peers and the query propagates through the network until a particular hop count or other termination criterion is reached.

Peer-to-peer architectures do not need a centralized registry, since any node will respond to the queries it receives. P2P architectures do not have a single point of failure, such as a centralized registry. Furthermore, each node may contain its own indexing of the existing Web services. Finally, nodes contact each other directly, so the information they they receive is known to be current. (In contrast, in the registry or index approach there may be significant latency between the time a Web service is updated and the updated description is reflected in the registry or index.)

The reliability provided by the high connectivity of P2P systems comes with performance costs and lack of guarantees of predicting the path of propagation. Any node in the P2P network has to provide the resources needed to guarantee query propagations and response routing, which in turn means that most of the time the node acts as a relayer of information that may be of no interest to the node itself. This results in inefficiencies and large overhead especially as the nodes become more numerous and connectivity increases. Furthermore, there may be no guarantee that a request will spread across the entire network, therefore there is no guarantee to find the providers of a service.

4.7.7 Web Service Semantics

For computer programs to successfully interact with each other a number of conditions must be established:There must be a physical connection between them, such that data from one process may reach another

There must be agreement (in the sense discussed in 3.3 Using Web Services) on the form of the data such as whether the data is lines of text, XML structures, etc. The two (or more) programs must share agreement (in the sense discussed in 3.3 Using Web Services) as to the intended meaning of the data. For example, whether the data is intended to represent an HTML page to be rendered, or whether the data represents the current status of a bank account; the expectations and the processing involved in processing the data is different — even if the form of the data is identical.

There must be agreement (in the sense discussed in 3.3 Using Web Services) as to the implied processing of messages exchanged between the programs. For example, purchase ordering Web service is expected — by the agent that places the order — to process the document containing the purchase order as a purchase order, as opposed to simply recording it for auditing purposes.

4.7.8 Web Services Security

Threats to Web services involve threats to the host system, the application and the entire network infrastructure. To secure Web services, a range of XML-based security mechanisms are needed to solve problems related to authentication, role-based access control, distributed security policy enforcement, message layer security that accommodate the presence of intermediaries.

At this time, there are no broadly-adopted specifications for Web services security. As a result developers can either build up services that do not use these capabilities or can develop ad-hoc solutions that may lead to interoperability problems.Web services implementations may require point-to-point and/or end-to-end security mechanisms, depending upon the degree of threat or risk. Traditional, connection-oriented, point-to-point security mechanisms may not meet the end-to-end security requirements of Web services. However, security is a balance of assessed risk and cost of countermeasures. Depending on implementers risk tolerance, point-to-point transport level security can provide enough security countermeasures.

4.7.9 Web Services Security Requirements

There are many security challenges for adopting Web services. At the highest level, the objective is to create an environment, where message level transactions and business processes can be conducted securely in an end-to-end fashion. There is a need to ensure that messages are secured during transit, with or without the presence of intermediaries. There may also be a need to ensure the security of the data in storage. The requirements for providing end-to-end security for Web services are summarized in the next sub-sections.

4.7.10 Authorization

Authorization is needed in order to control access to resources. Once authenticated, authorization mechanisms control the requester access to appropriate system resources. There should be controlled access to systems and their components. Policy determines the access rights of a requester. The principle of least privilege access should be used when access rights are given to a requester.

4.7.11 Peer-to-Peer Interaction

To support Web services interacting in a peer to peer style, the architecture must support peer to peer message exchange patterns, must permit Web services to have persistent identity, must permit descriptions of the capabilities of peers and must support flexibility in the discovery of peers by each other.

In the message exchange pattern concept we allow for Web services to communicate with each other using a very general concept of message exchange. Furthermore, we allow for the fact that a message exchange pattern can itself be identified — this permits interacting Web service agents to explicitly reference a particular message pattern in their interactions.

A Web service wishing to use a peer-to-peer style interaction may use, for example, a publish-subscribe form of message exchange pattern. This kind of message exchange is just one of the possible message exchange patterns possible when the pattern is explicitly identifiable.

In the agent concept we note that agents have identifiers. The primary role of an agent identifier is to permit long running interactions spanning multiple messages. Much like correlation, an agent's identifier can be used to link messages together. For example, in a publish and subscribe scenario, a publishing Web service may include references to the Web service that requested the subscription, separately from and additionaly to, the actual recipient of the service.

The agent concept also clarifies that a given agent may adopt the role of a provider agent and/or a requester agent. I.e., these are roles of an agent, not necessarily intrinsic to the agent itself. Such flexibility is a key part of the peer to peer mode of interaction between Web services.

In the service concept we state that services have a semantics that may be identified in aservice description and that may be expressed in a service description language. This identification of the semantics of a service, and for more advanced agents the description of the service contract itself, permits agents implementing Web services to determine the capabilities of other peer agents. This is turn, is a critical success factor in the architecture supporting peer-to-peer interaction of Web services.

Finally, the fact that services have descriptions means that these descriptions may be published in discovery agencies and also retrieved from such agencies. In effect, the availability of explicit descriptions enables Web services and agents to discover each other automatically as well as having these hard-coded.

4.7.12 Web Services Reliability

Dealing with errors and glitches is an inescapable fact of life, especially in the context of a global network linking services belonging to many different people. While we cannot eliminate errors and glitches, our goal is to both reduce the the error frequency for interactions and, where errors occur, to provide a greater amount of information about either successful or unsuccessful attempts at service.

Note that our focus on reliability is not really on issues such as syntax errors, or even badly written applications. There is sufficient scope for things to go wrong at the level of network connections being broken, servers being switched off and on in the middle of transactions and even people entering incorrect information in some description file.

In the context of Web services, we can address the issues of reliability at several distinct levels: the reliable and predictable delivery of infrastructure services, such as message transport and service discovery, of reliable and predictable interactions between services, and of the reliable and predictable behavior of individual requester and provider agents. This analysis is generally separate from concerns of fault tolerance, availability or security, but there may of course be overlapping issues.

In the context of security, deliberate acts can cause things to go wrong -- for example, denial of service attacks. This is a sufficiently important case that we deal with it in a separate section.

4.7.13 Web Service Management

Web service management is the management of Web services through a set of management capabilities that enable monitoring, controlling, and reporting of, service qualities and service usage. Such service qualities include health qualities such as availability (presence and number of service instances) and performance (e.g. access latency and failure rates), and also accessibility (of endpoints). Facets of service usage information that may be managed include frequency, duration, scope, functional extent, and access authorization.

A Web service becomes manageable when it exposes a set of management operations that support management capabilities. These management capabilities realize their monitoring, controlling and reporting functions with the assistance of a management information model that models various types of service usage and service quality information associated with management of the Web service. Typical information types include request and response counts, begin and end timers, lifecycle states, entity identifiers (e.g. of senders, receivers, contexts, messages, etc.).

Although the provision of management capabilities enables a Web service to become manageable, the extent and degree of permissible management are defined in management policies that are associated with the Web service. Management policies therefore are used to define the obligations for, and permissions to, managing the Web service.

Just as the Web service being managed needs to have common service semantics that are understood by both the requester and provider entities, Web service management also requires common management semantics, in relation to management policies and management capabilities, to be understood by the requester and provider entities.

Figure 3-5 illustrates how the concepts of service, policy and capability defined in this architecture can be applied to management.

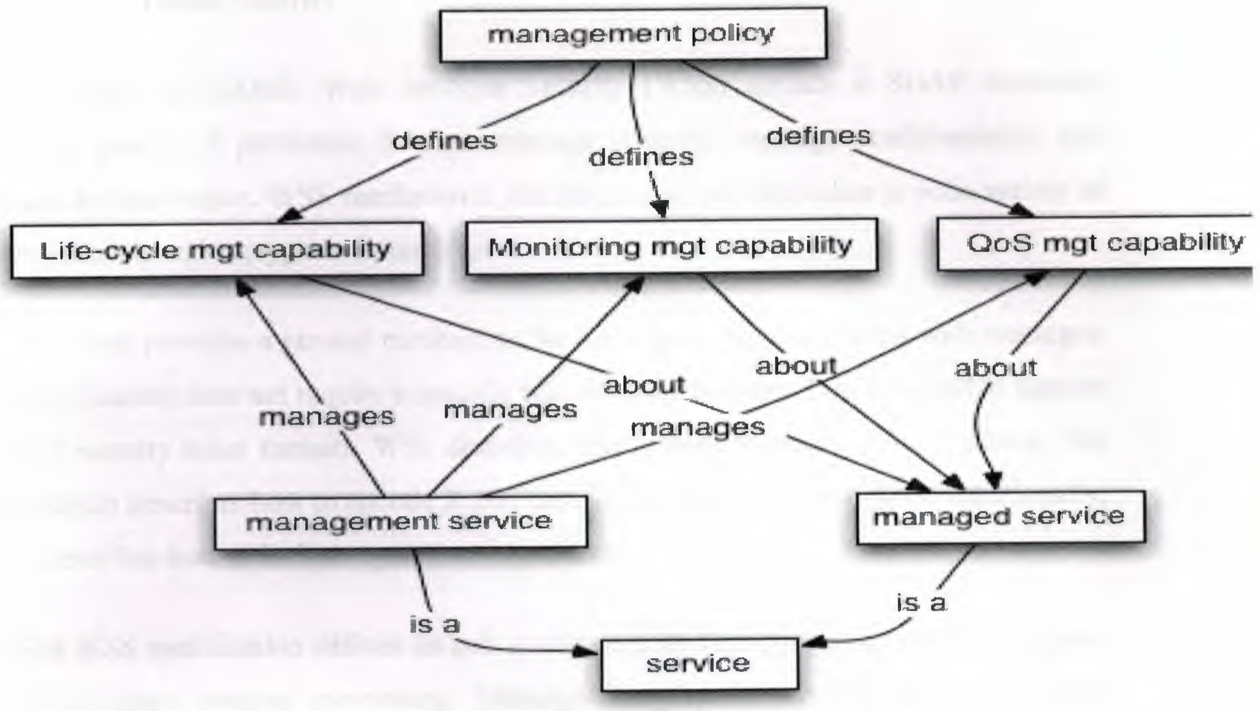


Figure 3.5 Management Concepts and Relationships

More detailed information about Web services management is available in the management documents that were produced by the Management Task Force of this Working Group.

4.7.14 Web Services and EDI: Transaction Tracking

One of the basic assumptions that many people make about the role of Web services is that they will be used for functions similar to those presently provided by Electronic Data Interchange (EDI). Since EDI is a well established technology, it is useful to examine the expectations that current EDI users may have for a technology that is to be used as a replacement. That is, what do they do now that they will also expect from a new technology? The most basic of these expectations concern security, message reliability and a function that we will call "tracking". Since security and message reliability are covered elsewhere in this document, this section will focus on tracking.

4.7.15 Web Services Security

Developed at OASIS, Web Services Security (WSS) defines a SOAP extension providing quality of protection through message integrity, message confidentiality, and message authentication. WSS mechanisms can be used to accommodate a wide variety of security models and encryption technologies.

The work provides a general mechanism for associating security tokens with messages. The specification does not require a specific type of security token. It is designed to support multiple security token formats. WSS describes how to encode binary security tokens. The specification describes how to encode X.509 certificates and Kerberos tickets. Additionally, it also describes how to include opaque encrypted keys.

The WSS specification defines an end to end security framework that provides support for intermediary security processing. Message integrity is provided by using XML Signature in conjunction with security tokens to ensure that messages are transmitted without modifications. The integrity mechanisms can support multiple signatures, possibly by multiple actors. The techniques are extensible such that they can support additional signature formats. Message confidentiality is granted by using XML Encryption in conjunction with security tokens to keep portions of SOAP messages confidential. The encryption mechanisms can support operations by multiple actors.

CONCLUSION

This Project presents inclusive information for technology of Wide Area Network (WAN), devices and its cabling. Wide Area Networks are today's need as we can connect many LANs working in different buildings. We can establish communication between many regions and between their terminals. Every one can share information easily without wastage of time from any terminal attached to a WAN. There are some basic components for WAN which help to establish this communication between each terminal and between other LANs. It also uses some reference models, which are some standards communications and protocols. One of the main disadvantages of WAN is security. As WAN is use to communicate between the systems at a distance ad many terminals are attached so it is difficult to maintain security and also difficult to reduce bad traffic on a line. The main advantage of WAN is only subscribed user can share or manipulate information. Today many big companies are using WANs. Such as all the Air reservation Companies Uses WAN for reservation of a person from any of their regional office or travel agency. We believe this architecture substantially meets the requirements defined in [WSA Reqs], with the exception of security and privacy. Although this architecture contains substantial material that lays the foundation for addressing these, more work is needed. The Working Group wanted to do more to address these but was not able to do so with the available resources.
This architecture lays the conceptual foundation for establishing interopable Web services. The architecture identifies a number of important abstractions and their interdependencies. Contributions of this work include the following:

- Provides a coherent framework that allows specific technologies to be considered in a logical context and facilitates the work of specification writers and architects.
- Defines a consistent vocabulary, including an authoritative definition of "Web service" that has received widespread acceptance in industry [WS Glossary].
- Clarifies the architectural relationship between the Web and Web services
- Clarifies the relationship between Web services and REST.
- Identifies gaps and inconsistencies in existing Web services specifications.

REFERENCES

[1] Tanebaum Andrew S., *Computer Networks*, 1996

[2] Martin Michael J., *Understanding the Network: A Practical Guide to Internetworking*, Macmillan Computer publishing, USA, 2000

[3] Mahler, Kevin. *CCNA Training Guide*. Indianapolis: New Riders, 1999.

[4] *Cisco IOS Wide Area Networking Solutions*. Indianapolis: Cisco Press, 1999.

[5] http://www.w3.org/TR/2004/NOTE-ws-arch-20040211/

[6] http://www.w3.org/TR/ws-arch/

[7] http://www.w3.org/TR/2003/WD-ws-arch-20030808/