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# What Is Wide Area Network (WAN): Live WAN Network Examples

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**All You Need to Know about Wide Area Network (WAN) Network Design:**

In this **Networking Training Series**, we learned all about **TCP/IP Model** in our previous tutorial.

This tutorial will explain all about WAN in detail along with Examples.

Wide area networks (WAN) is a telecommunication network which is spread over a large geographical area with a primary purpose of computer networking. A WAN network connects different small local area LAN and metro area MAN networks.

To construct the WAN network, a combination of various network devices such as bridges, switches, and routers are required.

The most well known WAN network is the Internet. WAN network covers cities, states, countries and even continents. WAN can be a public network or a private network.

As the network is spread over long distances, reliable and fast transmission media with high bandwidth is required, thus fiber optic cable is mostly used for WAN connectivity. The switching technology used in WAN includes both circuit and packet switching depending upon the network architecture.

The WAN networks are designed in such a way in which the enterprise's head office will be connected with the branch offices and centralized data center with internet connectivity to all the end users if they have relevance.

***In this tutorial, we will explore the designing aspects of the WAN networks with the significance of STM links in WAN technology.***

## Design Concerns

- The network should be designed in such a way in which the overall architecture designed should be cost-effective and within the budget.
- The links used for connectivity should be reliable and in protection. By provisioning protection, if one link fails the network will still be alive by using the protection link.
- The overall network throughput should come out best and packet delay should be as minimal as possible.
- The network should be designed in such a way in which there should be minimal interference, jitter, and packet loss.
- The basic goal of a well-designed network is to deliver data to the destination host from the source host by using the shortest path.
- The components equipped in the network should be well utilized and managed properly.
- A strong firewall system should be used to provide reliable and secure transmission.
- The network topology, transmission modes, routing policy and the other network parameters should be chosen depending upon the type and need of the system to be implemented.

# WAN Networking Technologies

There are two technologies used in the WAN network designing.

**Below are the classifications:**

1. **Circuit Switching:** The example of circuit switching includes DWDM, SDH, or TDM.
2. **Packet switching:** The type of switching includes ATM, frame relay, multi-protocol label switching (MPLS) and IPV4 or IPV6.

## #1) Circuit Switching

bandwidth throughout the communication process.

**SDH and DWDM** technologies use circuit switching for communication.

**Consider the Example of a software testing enterprise**, having the R&D center in Bangalore while the head office is in Mumbai and branch offices in Chennai, Hyderabad, and Pune respectively.

Now the need of the enterprise is to connect all the offices with each other along with the head office in Mumbai. The data center is also to be connected directly to the Head office.

As all the testing and development is done at the Bangalore office, the link should be in protection and must be reliable and secure. The size of the data exchanged between these links will be very large in size and may be a very large amount of data will flow at one time between these WAN links.

Thus keeping all these points in mind, high bandwidth and high capacity dual STM links are suggested for connectivity between all the cities and R&D center of the enterprise.

Of course, the optical fiber is used as the transmission media and we use STM links for connectivity over fiber.

**Synchronous Transport Module (STM):**

21 E1s (2 Mbps stream containing 30 voice/data channels) are combined to form a VC (Virtual Container). 3 numbers of VCs are combined to form an STM-1 module containing 63 E1s.

The STM links are of different bandwidths. The basic one is STM-1 and it is the first level of the synchronous digital hierarchy. It offers bandwidth of 155 Mbps. If we add four STM-1 together, then it becomes STM-4 which offers bandwidth of 622 Mbps.

Further, 4 number of STM-4 are combined to form STM-16 which occupies about 2.5 Gbps bandwidth and then 4 number of STM-16 are combined to form STM-64 which occupies about 10 Gbps bandwidth.

These SDH systems are very sleek in design and occupy even less than one-tenth of the space eaten by PDH systems. Also, the power requirement is remarkably quite less here.

If you need even more bandwidth than this, then we have to go in for DWDM systems which come in the form of 4 / 8 / 16 or 32 lambda configurations. Each lambda is capable of carrying any amount of bandwidth starting from PDH or STM-1 to STM-64 depending upon complexity and cost that we are able to bear as per our need.

DWDM enables bi-directional communication as well as multiplication of signal capacity.

| SDH Level | Payload Bandwidth (Mbps) | Line Rate (Mbps) |
|---|---|---|
| STM-1 | 150.336 | 155.52 |
| STM-4 | 601.344 | 622.08 |
| STM-16 | 2405.376 | 2488.32 |
| STM-64 | 9621.504 | 9953.28 |

The STM-1 frame is transmitted in exactly 125 μs, therefore, there are 8,000 frames per second on a 155.52 Mbps system. The STM-1 frame consists of overhead and pointers plus information payload.

**Main features of the frame are as follows:**

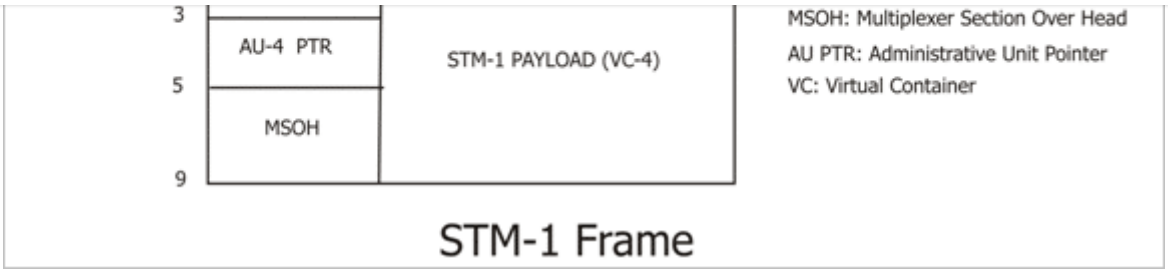
Payload information to be forwarded has a VC-4 frame.

**Section Over Head is the header of the frame which is further split into:**

1. **RSOH (Regenerator Section Over Head):** This section conducts frame alignment, scrambling, and regulation of the transmission line which mainly includes the regeneration of weak signals and examines error issues.
2. **MSOH ( Multiplexer Section Over Head):** This section handles the transmission among spots where the AUG (**Example:** AU-4) is assembled and disassembled. It supervises the multiplex section synchronization, state communication, and error examination.
3. **AU-4 (Administrative Unit) pointer:** The payload (VC-4) is not in a fitted phase situation when compared to the frame (dynamic framing) and the pointer gives the situation of the payload compared to the frame. We can equalize the difference of the phase and the rate between VC and payload with a change in the pointer.
4. **AU-4 PTR (Pointer):** It points to the first byte of the VC-4 frame (VC-4 POH J1 byte).

**The STM frame is transmitted in a continuous serial fashion:** byte by byte & row by row.

A PDH signal stream of 140 Mbps is map-able directly to the VC-4 frame.




**The main parameters of the frame are as follows:**

Frame time: 125 µs

The frame consists of 9 rows and 270 bytes by rows.

9 x 270 x 8 x 8000 = 155 520 000 bits per sec

| | + + frame/sec (frame time: 125 µs)

| | |

| | + one byte = 8 bits

| there are + 270 bytes in a row

+ number of rows in the frame

The frame consists of 2430 bytes (octets).

The payload consists of 2349 bytes (octets).

Overhead consists of 81 bytes (octets).

The above features of the SDH hierarchy for transmission make it best suited for the transmission media for high speed and high bandwidth for a reliable and synchronous long-distance communication.

## #2) Packet Switching

Packet switching is a kind of switching process in which data is sent in a network in the form of packets.

The big chunk of data is firstly broken into small variable length data called the packets. Then these are sent over the transmission media. At the destination end, these are reassembled and delivered to the destined host.

address through which it can reach the destination by following various paths.

If there is congestion at any hop level, then the packet will follow a different path to reach the destination. If the receiver discards the data packets, then it can be re-transmitted again.

Packet switching is of two types i.e. **Connection-oriented and Connectionless switching**.

(i) **Connectionless Switching**: In video streaming, online gaming, online TV, Internet etc., the connectionless packet switching is used as if some of the packets are lost during transmission, it doesn't impact the overall data much.

(ii) **Connection-oriented Switching**: In Invoice and data transmission, connection-oriented packet switching is used.

IPV4 and IPV6 are few common types of packet switching methods.

## WAN Network Topologies

There are several types of network topologies that are used in networking systems. However, the ones that are most commonly used for WAN purpose are Dual ring and mesh topologies.

As WAN systems are physically situated hundreds of kilometers apart, it is very important that they work in main with the protection link methodology in order to avoid any big outage if any media break down or device failure occurs.

Hence dual ring topology is deployed, where every host network device is connected via another provisioning last connected with the first one in both directions. Thus in case of any fiber cut or device failure, the data flow is done through the protection link by keeping the network alive.

It is cost-effective and switching is very fast. It is mostly used in telecommunication networking systems.

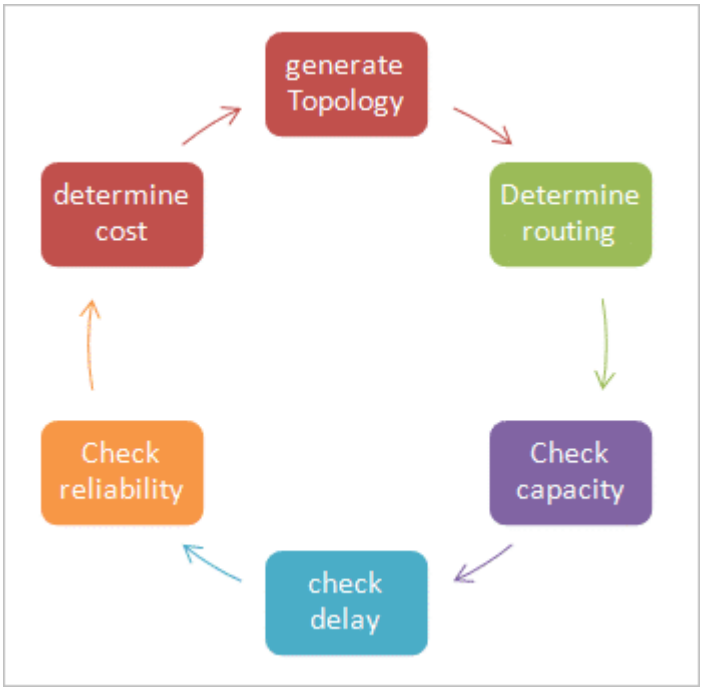
In a mesh topology, every node is connected via each other with a point to point topology. It is used for higher traffic volumes, like in Software MNC's. With mesh topology, it is simple to cover large areas and fault identification and restoration are easy as well. It offers a more flexible approach to re-configurations.

### Basic Design Model Components

**The Basic Design Model Components in the WAN Network include:**

important role in a good design solution.

- After selecting the topology, route the traffic to the destination according to the best suitable routing algorithm.
- The next task is to determine the outgoing and incoming traffic at each of the node of the network. Various types of mathematical formulas are used to determine the traffic. After the estimation of traffic, determine the capacity of each link and assign the capacity to each of the node and link accordingly.
- Now on the next level, we have to identify the types of delay in the network and check the delay points. Also, take measures and use such a methodology, where we can minimize the delay as much as possible. The minimal is the delay then the best will be the network solution. The most common delays include routing and queuing delays.
- Check the reliability of the network model by applying various tests and loading to the full capacity of the network. If the network works well, then it is a good approach otherwise change the approach.
- After performing all the suitable tests and completing all kinds of network designing activities finally calculate the cost of the network model. The optimal utilization of the network elements is very crucial. To add-on, the cost should be in the budget which is suggested by the customer.




## Live Examples Of WAN Networks

**Enlisted below are few LIVE examples of WAN Networks.**

**Example 1:**

STM-16 links for connectivity.

As the STM link provides secure, synchronous and swift transmission over hundreds of kilometers, it is deployed in the reservation system and connects the whole country on one network.

**Example 2:**

**UP-SWAN Network:** The UP government statewide area network is an example of WAN network design which is connecting all the districts and towns of the state to three core node districts – Lucknow, Gorakhpur, and Varanasi respectively and connects each core node with one another with STM-16 link which is working in the dual-ring topology.

As the core nodes are connected directly with each other, any data, voice or video can be exchanged between them easily in the real time. Also, the links work in the main & protection path. So if the fiber cuts between any one of them, then the network will be alive and data with the flow by the supporting link.

All the other districts and towns that are also connected with low capacity STM and DS3 links to their respective core nodes in accordance with the region they belong to. The UP-SWAN is a live network and is maintained by HCL technologies and National informatics center (NIC).

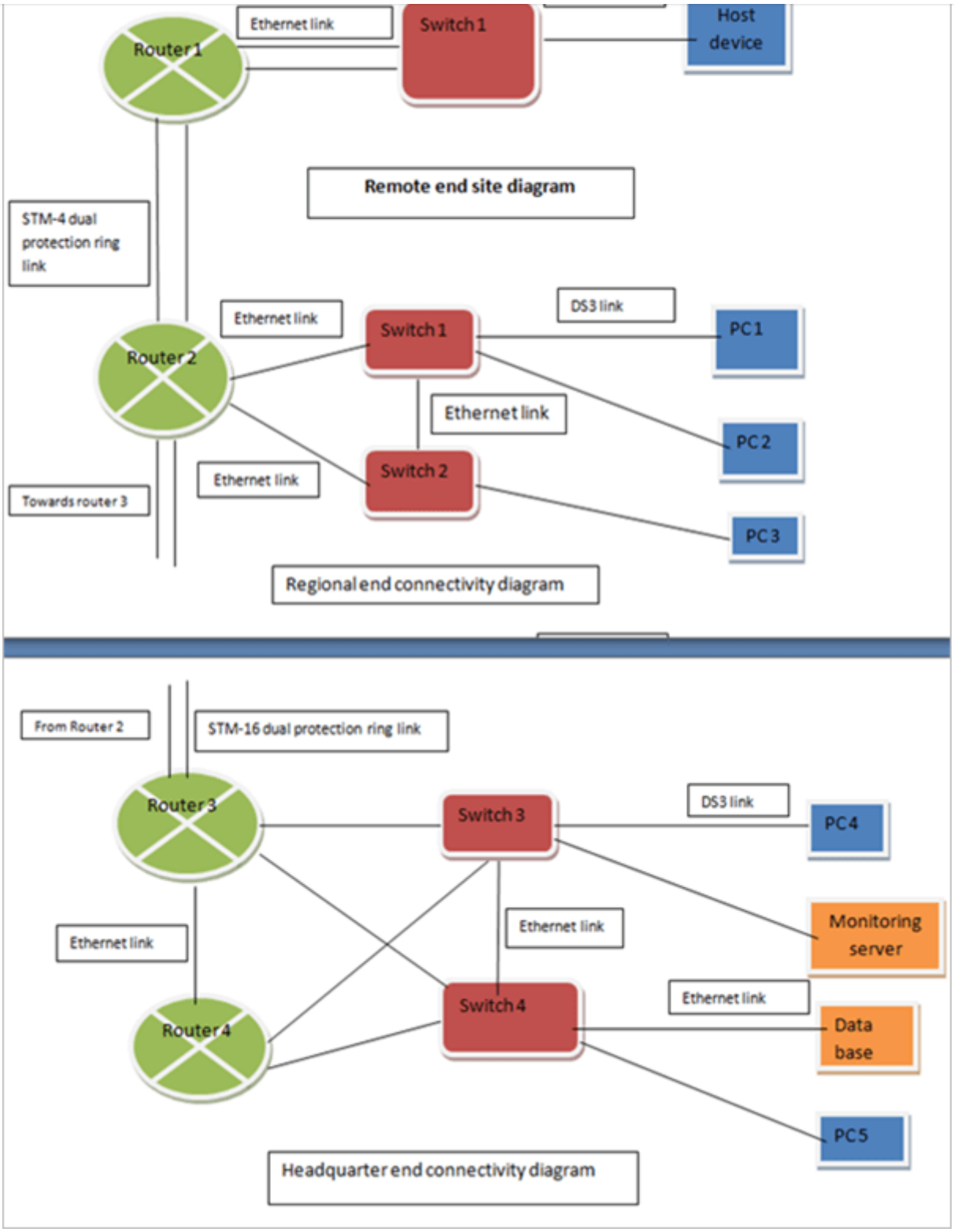
**Example 3:**

**Software MNC Network:** The people working in the field of software and information technology also use WAN network for connectivity between the head offices and regional offices to share data and put data on the centralized server like software testing tool or any other tool which can be accessible to the end hosts as per the rights that are given by IT administrators.

The organization can connect themselves through routers and switches and use packet switching instead of circuit switching as the transmission technology.

As they only exchange the data, image or video between the source and destination and not voice, there is no need to spend money on STM links. They can use IPV4 or IPV6 technologies, which is the latest and famous among the software field for connectivity.

## WAN Design for Multiple Office Connectivity




The above diagram shows the WAN design for the connectivity of the headquarter office i.e the core location of an office with its regional and remote end offices. The regional office location may be a big city and in turn, various districts can be connected with it. Whereas the remote site office is a particular location site or office.

If the number of remote site locations to be connected is only a few hundred then we need not use the router for it, but if the site count is in thousands, then we definitely need

one router and one switch at the remote end.

The switch is connected with the end device such as a PC or server. For the connectivity between Router and Switch, we use a high-speed Ethernet link known as Gigabit Ethernet which provides the speed of 1 gigabit.

We use a simple DS3 link for connectivity between the PC and the switch as there is no burden of data routing on these two devices. They just work on layer-1 and layer-2. The DS3 link provisions the speed of 45Mbps. There is no need of protection link at this level.

**Regional WAN Design:** The connectivity between Router 1 situated at a remote site and router 2 situated at the regional office is done with high speed and high bandwidth STM-4 dual-link provisions bandwidth 601.3 Mbps.

The dual link implies that two STM-4 links are established between them to provide redundancy. If any link fails due to some reasons, then the other one will take over the load and the connectivity will remain alive.

Again a gigabit Ethernet link is used to connect the router to the switch. At this level, two switches which work in master & slave mode and provide redundancy to the network are used for connectivity, These two are connected with each other via a patch cord on the Ethernet port, which provisions High-speed link.

The router is connected with both the switches. The design is done by keeping in mind that if due to heavy traffic or any other failure if one switch stops working then the data flow will remain continued via another switch. The end devices are connected with a Switch with a DS3 link.

**Core location WAN Design:** At the core location, dual router and dual-link connectivity scenario are deployed. As the core location of the enterprise carries huge traffic, two STM-16 links are used.

Please make a note here that the STM link is based on leased media fiber and we should take media on lease for connectivity of the same link with two different media providers always. Like-wise take one media from RAILTEL or another from TATA, and by doing this we will make our network more reluctant and efficient.

Again dual switch design is used and both the routers are connected with both the switches on the Ethernet link. The servers and PC's are connected through a switch on the Ethernet and DS3 links respectively.

**Traffic Flow:** The end user at the remote end wants to send some information in the form of data to the core office site. Here, the switch at the remote end will direct the data to the router for transmission towards the core office.

**The case of Link failure:** As shown in the above figure, if one link between Router 1 and Router 2 fails, then the traffic will flow via the protection link.

In the same way, at the core location, if Switch 3 is unable to deliver the data to a receiver or if it is busy, then the data is routed through Switch 4 as both are connected with each other. Thus link or device failure at any end will not affect the overall performance of the Network.

## Conclusion

We have learned about the Basic designing concepts of the WAN networks along with the importance of SDH links in WAN designing. Live examples of systems using WAN technology for networking systems is also explained here.

Being a software tester it is important to understand the significance of high speed and high bandwidth STM links in the field of software and information technology. The communication system has become more reliable, fast and cost-effective using WAN systems.

We have also analyzed the WAN design structure for multiple office connectivity in the network through a simple example.

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## Recommended Reading

- All About Layer 2 and Layer 3 Switches in Networking System
- TCP/IP Model With Different Layers
- A Complete Guide to Firewall: How to Build A Secure Networking System
- All About Routers: Types of Routers, Routing Table and IP Routing
- What is IP Security (IPSec), TACACS and AAA Security Protocols
- What are HTTP (Hypertext Transfer Protocol) and DHCP Protocols?
- Important Application Layer Protocols: DNS, FTP, SMTP, and MIME Protocols
- IPv4 vs IPv6: What's the Exact Difference

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