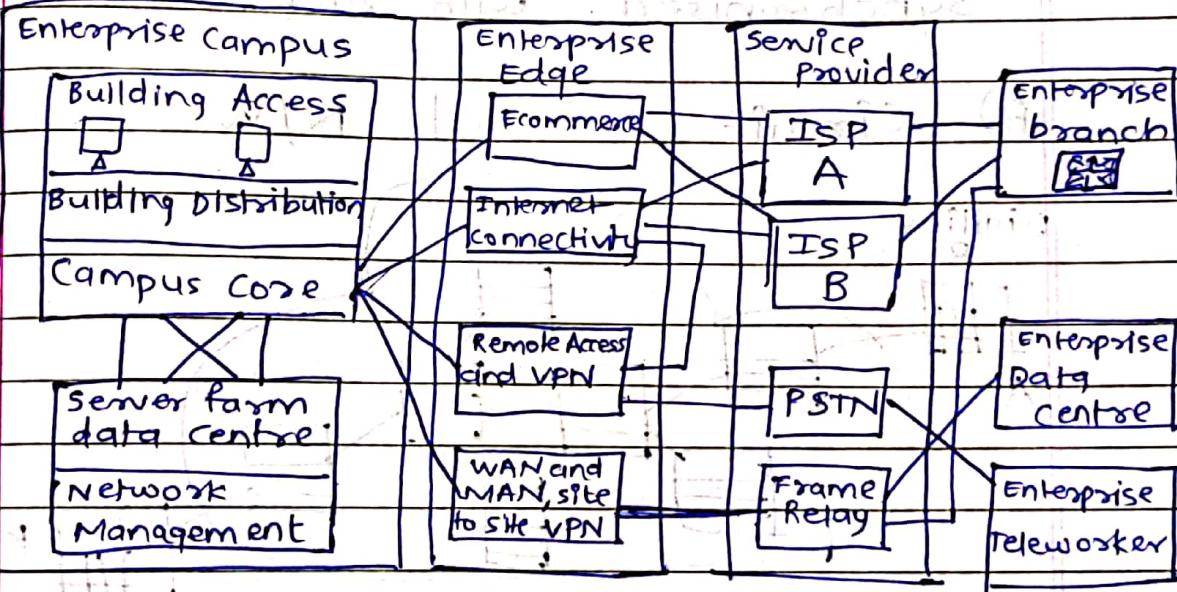


* WAN

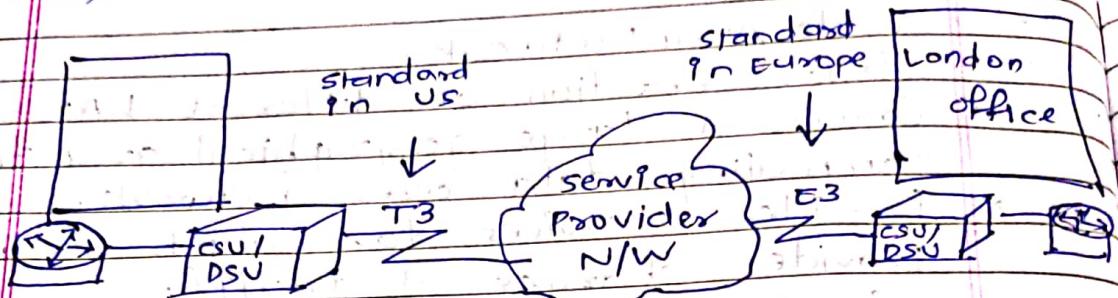
- Wide Area Network
- Interconnection of different LANs.
- Covers a large geographical area for commuting data over network.
- Provides services for which network provider charges a tariff.
- Main purpose is to connect to various application over the internet.
- Designed using leased lines, packet switching, circuit switching.

→ WAN Interconnections:



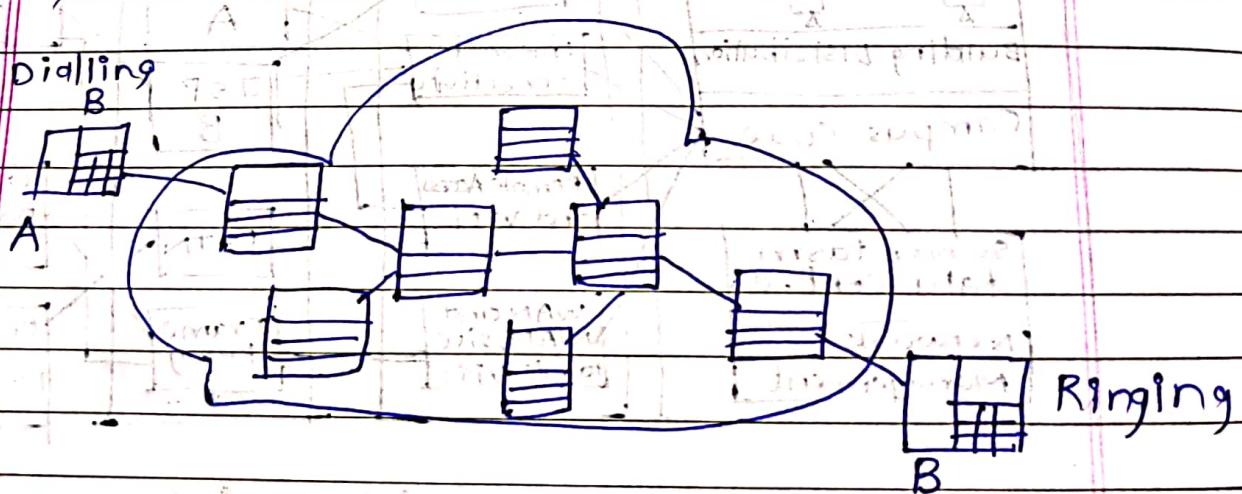
- It is of two types - point to point or connections to multipoint.
- It provides connection in 3 forms:
 - Enterprise Module (e.g. ISP, ka)
 - Various enterprise sites over ISP network
 - Various enterprise sites over PSTN.

* Traditional WAN technologies
A) Leased lines network



- Point to point connection
- Up all time, irrespective of requirement
- Either uses FDM or TDM
- Both sender and receiver are synchronised with each other.

B) Circuit switched N/W

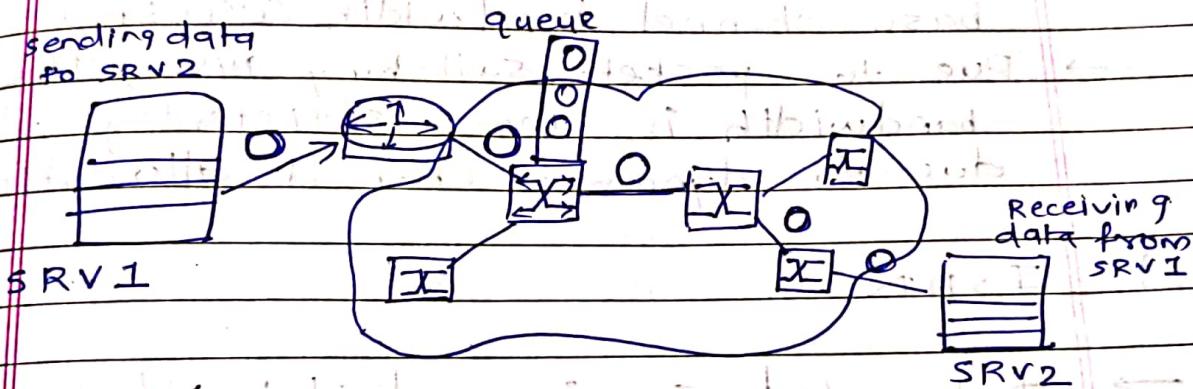


→ Jab Point A se point B communicate karnay toh pura iek dedicated circuit use hoga generate hoke, jo transmission ke bad band hojayega.

→ Uske bad agar A ko C se transmit karna hoga toh first ek naya dedicated circuit use hoga, thus called circuit switching.

→ Eg: PSTN, ISDN, Asynchronous serial transmission.

c) Packet switched / cell switched N/W



→ Isme packets transfer hotay between senders and receivers.

→ Unlike circuit switching, isme channel barabar change nahi hotay, usse channel se pass honevale packets switch hotay.

→ thus making efficient use of existing channels instead of generating new ones.

→ Eg: Frame Relay, switched Multimegabit Data service.

* WAN transport technologies.

1) TDM (Leased lines)

- Time division Multiplexing
- Signals from more than one user share same frequency channel in different time slots.
- Digital Signal Level 0 (DS0) is the base channel bandwidth (64 kbps)
- Due to packet switching N/W, the N/W bandwidth is more efficiently utilized due to dynamic channel allocation.

2) ISDN

- Integrated services digital N/W.
- This system allows voice and data to be transmitted simultaneously.
- It is a circuit switched technology
- Compared to old analog dial up; ISDN provides increased bandwidth, reduced call setup time, reduced latency and lower signal to noise ratio.

3) Frame Relay

- It is ~~a~~ packet switched technology.
- It handles multiple circuits simultaneously that may be permanent or temporary.
- Two connection types offered by Frame Relay are:
 - PVCs - Permanent Virtual Circuits data and voice are carried at 4 Mbps or higher.
 - SVCs - Switched virtual circuits are temporary which are created for data transfer and terminated after transfer completion.
- PVCs are more widely used than SVCs.

4) ATM

- Asynchronous transfer mode.
- cell switched technology
- Capable of transferring data, voice and video over private and public N/W.
- Transmits fixed size ATM cells of 53 bytes which are processed asynchronously.
- Due to small size of cells, network traffic does not need to wait for large pack transmission.
- Suitable for N/W with stringent QoS.

5) MPLS

- Multi Protocol Label switching.
- It is kind of routing technique.
- Instead of examining IP packet header info, MPLS nodes use this label to determine how to process data.
- Services provided by MPLS:
 - Traffic engineering
 - QoS support
 - Fast reroute
 - Easy deployment of MPLS VPNs.
 - Multi Protocol support - can be used over existing ATM, Frame Relay, etc.

* Other Technologies

- Metro Ethernet
- DSL - Digital subscriber line
- SONET
- Cable Technology (coaxial, tv.)
- Wireless technology
 - Bridged wireless (line of sight, Datacentre)
 - Mobile wireless
 - global system for mobile GPRS
 - general purpose packet radio service
 - CDMA - code division multiple access
- WLAN - wireless LAN.

* WAN Design

- Network Design steps
- Application Requirements
- Technical Requirements
- ~~• Bandwidth requirements~~
- WAN ownership
- Bandwidth optimization

A) Network Design Steps

- 1) Customer requirement analysis
 - Business reqs.
 - N/W requirements
 - N/W applications
 - Availability
 - security
 - QoS
- 2) Characterising existing N/W
 - existing SW, HW, link capacity
 - Documentation reviewed
 - Traffic analysis
 - types of servers, n/w devices
 - power sources
 - routing protocols
 - Redundancy

- 3) Networks topology and solution design
- Design of N/W topology
 - Routing protocols
 - cost of requirements
 - N/W infrastructure services implementation
 - Should be expandable and upgradable.

B) Application Reqs

- All application ke hisab se requirement values hotey.
- Various types of applications are
 - Data file transfer
 - Data interactive application
 - Real time voice application
 - Real time video application
- Various app. requirements are
 - Response time
 - Throughput
 - Packet Loss
 - Reliability
- For mission critical application, they all should have zero downtime.

c) Technical Req.

- These are mostly related to link utilization and bandwidth utilization.
- Network traffic
 - Ab isme user ke hisab se two factors matter karta h;
 - Normal user ke liye response time imp he and n/w link utilization ka koi importance nai and N/w manager ke liye uska ulta.
- Bandwidth
 - Bandwidth offered ranges from
 - Low - $\leq 1.5 \text{ Mbps}$
 - Medium - $1.5 - 4.5 \text{ Mbps}$
 - High - $4.5 - 100 \text{ Mbps}$
 - Higher - $100 \text{ Mbps} - 10 \text{ Gbps}$
 - IT ranges based on the type of WAN media used.

Various WAN media types are Copper, Fiber, Coaxial, WAN wireless.

D) WAN ownership

→ 1) Private WAN

- High security
- Better transmission rate
- Owner needs to buy media channel and network devices and configure them.
- Expensive and needs High Maintenance

→ 2) Leased WAN

- Carrier provider se bhadre pe lenka for TDM or SONET circuit.
- Terminal equipment (N/w devices) private ya fir leased koh bhi chaltay.
- Isme initial investment kam hoga but b/w utilization ke hisab se pay karna padtay provider ko.
- Provider maintenance sambhalta.

→ Shared WAN

- ye leased WAN jaise bihe channel and N/w devices provider dekha and maintain karata, but ye sab many users ke bich me shared hota.
- Isme circuit switch or packet switch use hota.
- MPLS and Frame Relay are good examples of shared WAN.

E) Bandwidth optimization

→ Pure N/W performance better ho saktega after BW optimization.

→ Various techniques are:

i) Data compression

- Data chota hogga to jaldi and kam bw se transmit ho Jayega. and so kam time me jyada data share ho sakte, also bw efficiently use hogta.
- Jitna jyada data compression utna lachha (kam) latency milega.
- These can be done in 3 ways
 - header only
 - payload only
 - entire packet (header + payload)
- Encoding techniques used to compress data are
 - statistical compression (for predictable and consistent data)
 - dictionary compression (for unpredictable and inconsistent data).
- Also there are hardware based data compression which are faster than software based data compression techniques.

2) Combined B/W

- Two nodes ko connect karne ki connection is established using PPP (Point to Point protocol).
- Agar ab aur extra b/w chahiye to hum directly MLP (Multi link PPP) use karke additional b/w de sakte connection me, as dono b/w aggregate hoke use hotay.

B) Window Size

- Sender maximum kitna no. of frames bhej sakay, receiver ke tick se pehle vom window size batatay.
- So jitna bad a window size utna latency acha hotay cos no. of acknowledgments bhi kam ho jata.
- But increasing the window size may also lead to compromised QoS, so samjh ke optimal window size rakhna chahiye.

- * Uses of WAN technologies
- Remote Access N/w design
 - VPN Design
 - WAN backup
 - Internet as backup WAN.

A) Remote Access N/W Design

- Access to remote N/W can be provided by data link or network layer connection.
- Selection of Remote technologies depends on application req. and service providers offerings.
- Remote Access technology selections include: Dial up (both analog and digital), DSL, cable and hot spot wireless service.
- Remote Access requirements include
 - Datalink layer WAN technologies from Remote sites to Enterprise Edge N/W.
 - Low to Medium volume data file transfer
 - Increasing need to support voice services

B) VPN Design

- VPN stands for Virtual Private Network
- It enables access to corporate N/W over shared infrastructure without compromising security.
- The shared infrastructure might be internet, Frame Relay N/W, ATM.

→ VPN Applications

- 1) Access VPN
 - Isme 2 types hotay client initiated or Network Access Server (NAS) initiated.
 - Client initiated matlab connection establish karne client VPN tunnel banatai req bhejne.
 - NAS initiated me client ka req anepe NAS VPN tunnel establish karke connection start kastay.

2) Intranet VPN

- Isme basic remote access hotay N/W ka vo extend kiyा jatai for corporate offices.
- Iske wajahse actual WAN ka khascha nai karne padta but iska performance kar guarantee nahi miltai.

3) Extranet VPN

- Ab iye intranet use bhik ek step agey extend hojay iye N/W ko suppliers business partners and customers tak jaray.
- Iska sabse main issue he security (maintain karne) cosine utna hi vulnurable banana N/W extend karke function kontinuitati basata hoga.

• utilisation performance issue

Di alpin kontinuitati basato SFT

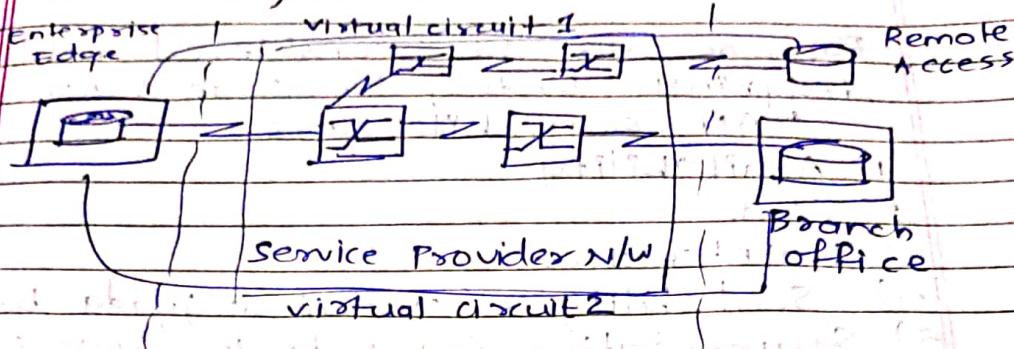
MTA, WiFi, wireless etc. form hoti

Benefits of VPN - Flexibility, Scalability, Lower N/W communication cost

Date: / /

VPN connectivity options

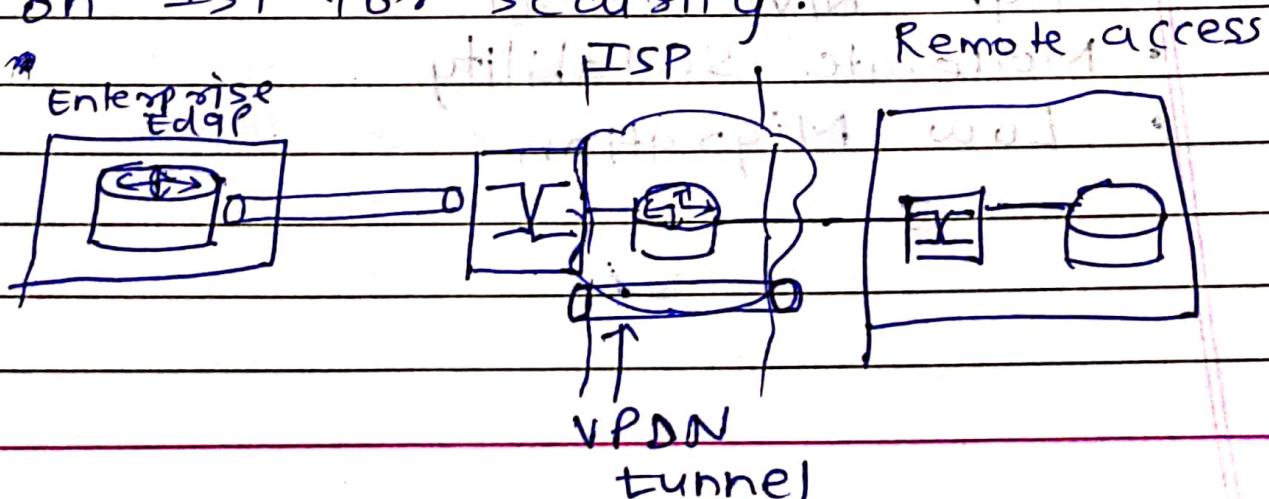
1) Overlay VPNs



- Is me ek point to point connection ke saathme hi multiple virtual circuits bhi use horey for remote access
- Overlay VPN uses combination of Layer 1 and Layer 2 technologies (like ISDN, SONET) & with Layer 3 IP based solutions (like IPsec) no doubt

2) VPDNs (Virtual Private Branch Networks)

- Ab VPDNs kya kar leta h? Enterprise Edge and Remote Access ko connect karte with help of VPDN tunnels controlled by ISP and they rely on ISP for security



* Enterprise Edge MAN and WAN Architecture :

→ Factors to be considered while designing Enterprise Edge WAN and MAN architecture.

- 1) Availability
- 2) Cost
- 3) Maintenance
- 4) Scalability (current se jyada badha par)
- 5) Segmentation (ek bade ko chote tukde mili)
- 6) Migration (private se leased or shared)
- 7) QoS (voice, video and kitna service support)

→ Types of Architecture technologies :

A) Private WAN

- Works on Frame Relay or ATM
- Encrypted private network using Digital Encryption Standard (DES), Triple DES, Advanced Encryption Standard (AES)
- Excellent availability
- Excellent voice and video support
- High operational costs
- High N.W. control cost
- Moderate scalability
- Low Migration

B) IPS Service

- Site-site and Remote Access IPsec VPN
- Good Availability
- Low voice and video support
- Low operational costs
- Moderate N/W control
- Good Scalability
- Moderate Migration

C) MPLS enabled IP VPN

- Supports N/W based IP VPN and cheaper than private N/W.
- Excellent Availability
- Excellent voice and video support
- Moderate operational costs
- Moderate N/W control
- Excellent scalability
- Moderate Migration.

D) Self deployed MPLS

- Logically separates N/W and supports N/W segmentation
- Excellent availability
- Excellent voice and video support
- Moderate operational costs
- High N/W control
- Excellent Scalability
- High Migration.

* Enterprise Branch Design

→ Factors to be considered while designing:

- Total no. of branch locations.
- Availability requirements at each branch location.
- No. of network devices at each branch location.
- Scalability level at each branch location.
- Security requirements at each branch location.
- Local server requirements.
- Wireless service req.
- Network Management (Central or local?)
- Budget.

→ Based on size of no. of users, Branch office can be of 3 types

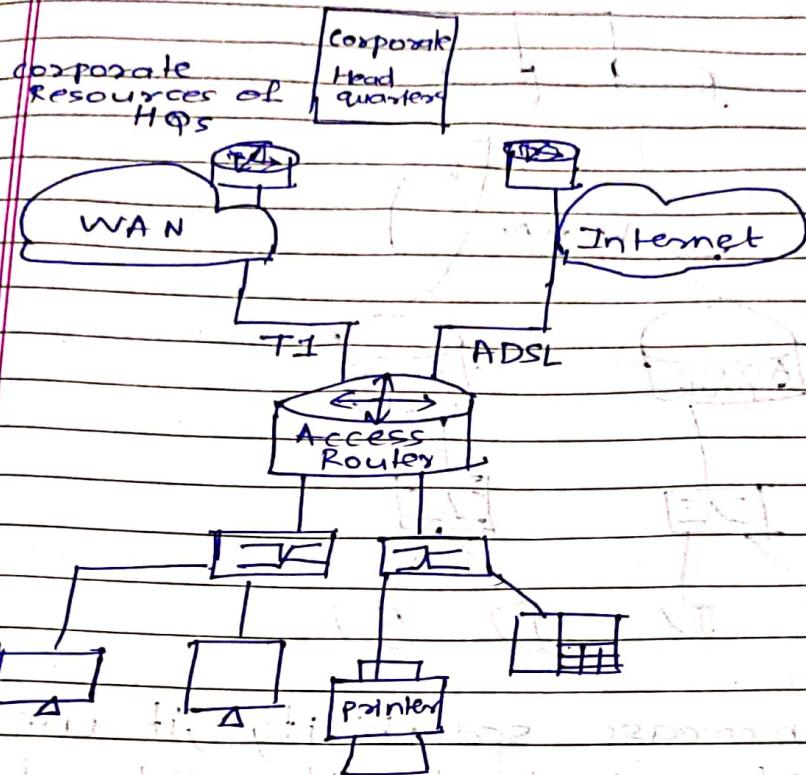
Small - 50+ users - Single tier

Medium - 50-100 - Two tier

Large - 100-200 - Three tier.

→ All types of offices will use an ISR (Integrated Service Router) that provides various services such as caching, converged voice and data services, network analysis, switching, security at branch level.

→ Small Branch office Design



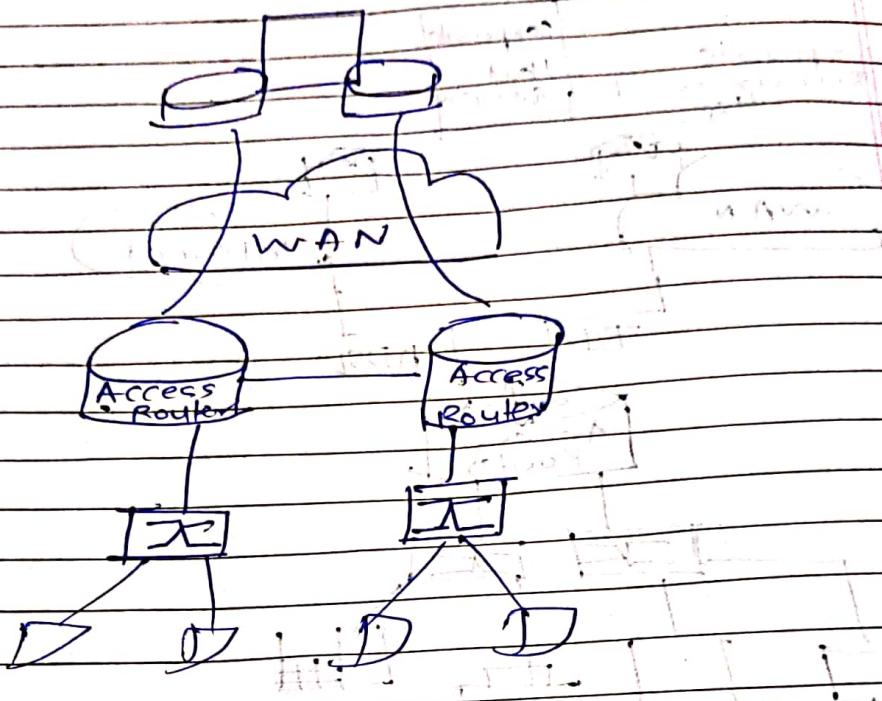
→ ISR connects with Layer 2 switch ports in one of 3 ways:

- Integrated switching within ISR
- Trunked interface (using POE)
- Logical Ether Channel Interface

→ T1 primary link, Internet for backup, Accessed by ADSL connection.

→ EIGRP routing protocol is used.

→ Medium branch office



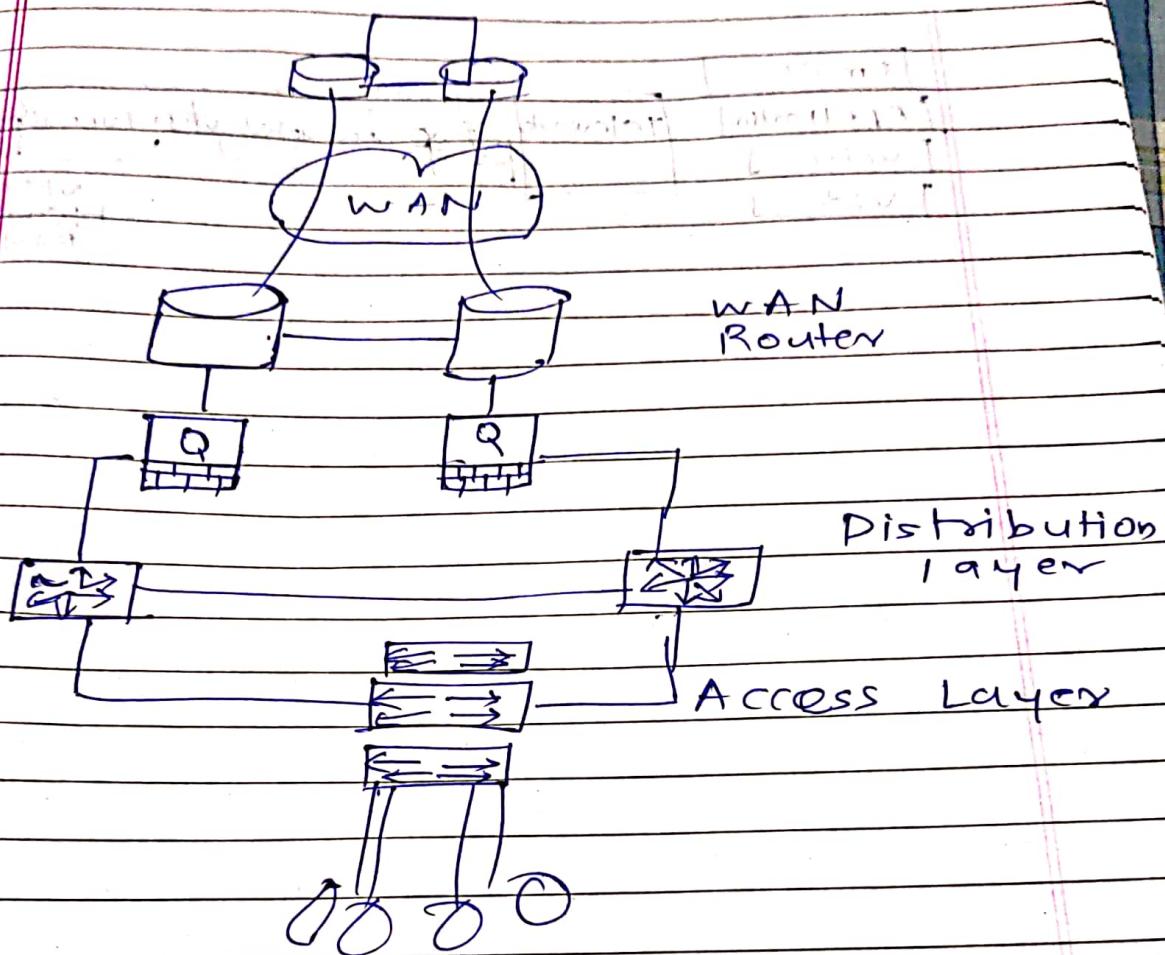
To increase scalability, it uses

- Higher port density external access switch
- ISDN module that supports switched access line and line termination
- Ether channel to provide redundant connection (backbone switch)

→ EIGRP is also used in medium branch office

branch office configuration

→ Large Branch office



Stackable switch is used
Distribution layer is added
with multi-layer switch

Access layer is used for link redundancy and device redundancy

MLS with dual connections is used

EIGRP is used.

Enterprise Telework Design

