

1.264 Lecture 23

**Telecom
Enterprise networks
MANs, WANs**

Enterprise networks

- **Connections within enterprise**
- **External connections**
 - Remote offices
 - Employees
 - Customers
 - Business partners, supply chain partners
 - Patients...
- **Principles of enterprise network design**
 - Standards based
 - Secure
 - Reliable: disruptions affect all external connections
 - Quality of service: latency, throughput, services, ...

Building blocks of enterprise network

- **Local area networks**
- **Wide- or metro-area networks**
 - Private lines (point to point circuits)
 - Ethernet over carrier fiber in metro areas
 - Virtual private net (VPN) over Internet
 - Frame relay or cell switched (ATM, MPLS) network
- **Voice network**
 - Integrated with data network
 - Private lines shared between data and voice
 - Voice carried over IP, ATM or MPLS network

Virtual private networks (VPNs)

- **Set of sites that**
 - Communicate over the open Internet but**
 - With the security and management capabilities of:**
 - Dedicated circuit or frame relay network**
- **VPN basic functions**
 - Membership discovery (identity, authorization)**
 - Establishment of secure tunnel (path) in network**
- **VPN objectives**
 - Security**
 - Connectivity: authorized sites, new users, mobile users**
 - Simplicity: applications work without modification**
 - Quality**

VPNs

- **A tunnel encapsulates data of one protocol inside the data field of another protocol**
 - In a VPN, we encrypt corporate data inside the IP data field**
 - The corporate data is encrypted via the VPN's security protocol (symmetric, asymmetric keys, message digests...)**
- **VPNs operate either at layer 2 or layer 3**
 - Layer 3: most common, routers use IP information to route**
 - Layer 2: uses Ethernet addresses; corporation responsible for routing packets across LANs**
- **Company can lease lines, buy routers and run its own 'Internet'**
 - Difficult to do; many nodes will be connected to Internet**
- **Company can purchase VPN service from carrier**
 - Often cheaper, easier, but not always**

VPNs

- **Intranet**
Portion of VPN connecting internal sites
- **Extranet**
Portion of VPN connecting external sites
- **Security protocols**
 - IPsec (secure IP standard)**
 - Can encrypt entire packet or just the data field
 - All devices must share a common (public) key
 - Use digital certificates
 - Devices negotiate secure tunnel using Internet Key Exchange (IKE) protocol
 - Layer 2 tunneling protocol (L2TP)**
 - Requires pre-arranged paths, between devices or to/from secure server
 - AAA (authentication, authorization and accounting)**
 - RADIUS (remote authentication dial-in user service) server
 - Firewalls**

Metropolitan area networks (MANs)

- **MAN is public network that bridges LAN and WAN, typically spanning 5 to 50 km**
 - **Legacy technologies**
 - Frame relay, ATM, FDDI, DQDB, SMDS
 - **Being rapidly superseded by Ethernet**
- **Applications**
 - **Connecting LANs (sites) within a metro area**
 - **Storage area networks (SANs) (replace FibreChannel)**
 - **WAN access: aggregate sites to one WAN POP**
 - **Video, voice, graphics: bursty, high bandwidth data**

Metro area Ethernet

- **Gigabit Ethernet**
 - Single mode or multimode fiber
 - 5 to 10 km range per hop
 - Many Ethernet switches needed per metro area
 - Available in US, Europe, east Asia metro areas
- **10G Ethernet**
 - Almost completely compatible with slower Ethernet
 - Full duplex only (no collisions), fiber only
 - Essentially compatible with SONET/SDH
 - 10G Ethernet is close to OC-192, and protocols map
 - Range up to 40 km
 - Becoming available

Metro area Ethernet, cont

- **Ethernet in the First Mile (EFM)**
 - **Copper: encapsulate Ethernet within modified DSL**
2 Mbps up to 2.7 km, 10 Mbps up to 0.8 km
 - **Fiber: essentially Gigabit Ethernet, up to 20 km**
- **Resilient Packet Ring (RPR)**
 - **Provides alternate routes and failover, like SONET**
Dual counter-rotating rings
 - **Keeps Ethernet simplicity for applications, management**
 - **Uses tags to allow network to scale**
Recall Ethernet switches discover all devices
MAN Ethernet can have 100,000s of devices

MAN Ethernet

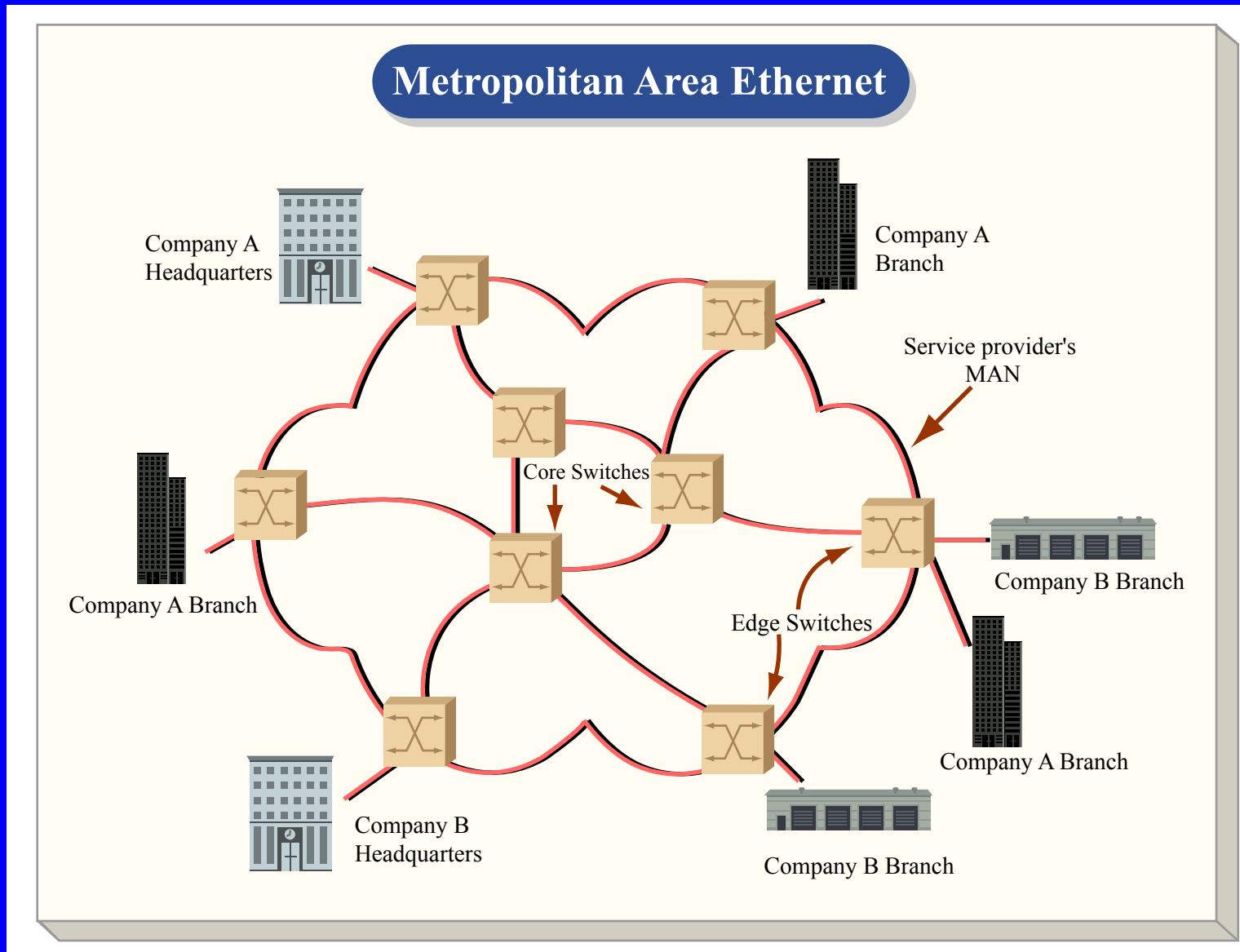


Figure by MIT OCW.

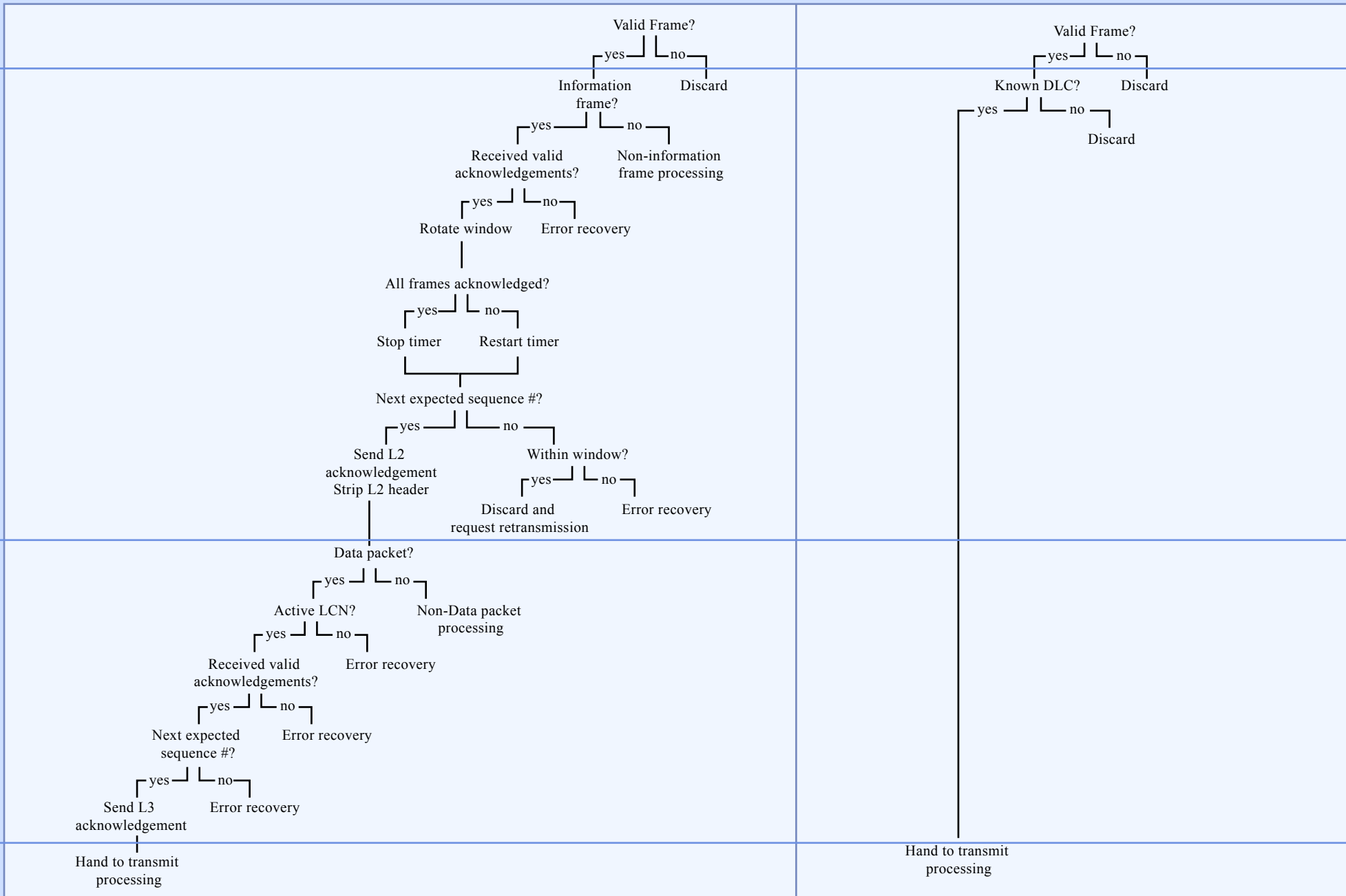
MAN applications

- **ATM was expected to be dominant backbone protocol**
Too complex, too expensive, unknown
Didn't reach the desktop
- **Gigabit Ethernet is displacing ATM**
Simpler, cheaper, known, at all desktops now
- **MANs in evolution**
Gigabit Ethernet, EFM, RPR being implemented
Fiber to the home being implemented by Verizon
Perhaps others will follow; needed for remote employees
Dedicated circuits, legacy MAN technologies slowly being displaced
- **Even a few years ago, it was very difficult to obtain cost-effective access from multiple sites to servers and each other**
MAN Ethernet is a dramatic change

Wide area networks (WANs)

- **Differences from MAN:**
 - Global in scope
 - Usually provided by multiple carriers (one is lead)
- **Legacy WANs are present but usually not good choices for new data comm needs:**
 - Private (point to point) circuits: expensive
 - Dialup circuits: low bandwidth
 - Frame relay: still viable, being superseded by IP (cost, reach)
 - Cell relay (ATM): viable, very expensive for all but largest companies
 - Multidrop networks
 - Used for ATMs, POS terminals, lottery terminals
 - Now that banks, stores have general Internet access, ATM and POS traffic goes over the general access
 - Packet networks (X.25): expensive, limited bandwidth
 - VSAT (satellite): widely dispersed, low bandwidth service
- **IP network is becoming dominant**
 - Security costs make IP cost similar to frame, private lines
 - IP costs dropping, reach expanding

Frame relay vs X.25



Frame relay vs. X.25

- **Difference between reliable and unreliable networks**
 - Fiber has error rate of 1 bit in 10^{14} ; can correct end-to-end
 - Copper has error rate of 1 bit in 10^6 ; must correct link-by-link
- **Difference between smart and dumb terminals**
 - Formerly, terminals had no CPU and just displayed what the communications line sent to them
 - Could not detect or correct errors
 - PCs as terminals can correct and detect errors
- **“Hollowing out of the network”**
 - Network used to have all the intelligence
 - Not network is just a set of ‘bit pipes’
 - Edge devices have the intelligence
- **IP is evolution of frame relay; same comparison holds**

Asynchronous transfer mode (ATM)

- **Used in carrier and large enterprise core networks only**
 - Platform for IP, private line, DSL, frame relay services
- **Never made it to the desktop**
 - Too expensive, complex
 - “Silver bullet” syndrome: all things to all people
 - Video, voice, data of all sorts
 - Nonstandard packet sizes, hardware, software
 - LAN connection not thought of
 - ATM LAN Emulation (LANE) inefficient

Exercise

- **Your transportation brokerage company also handles billing for freight shipments, collecting from shippers and forwarding payment to carriers.**

This data must be secure; you route funds directly to banks in some cases and between customers in other cases.

- **How would you communicate between your three major sites in New Jersey, Houston and Los Angeles?**

You transfer approximately 10,000 bills of lading in a 1 hour window at the end of each day from Houston and Los Angeles to New Jersey, which is the only one connected to banks and customers

Each bill is about 500 kB of data (documents and signatures are scanned)

- **Select the technology and bandwidth**

Will you use LAN (lecture 21), WAN or MAN technology?

Which specific technology will you use? Discuss options, pros/cons.

Solution

- **Bandwidth:**

500 kB x 8 bits/byte x 10 000 docs / 3600 seconds/hr

10 000 Mbps raw data rate

Connection should be at least 15 Mbps

If we route LA traffic via Houston, Houston-NJ needs 30 Mbps

Requires OC-1 (45-51 Mbps) bandwidth unless carrier splits it

- **Technology**

With only two links (LA-Houston and Houston-NJ), two point to point lines are a possible solution

Used only 1 hour a day, though...

Frame relay not good for bursty traffic; high CIR needed, which would be very expensive

ATM could handle this; custom agreement with carrier needed

IP network could handle it but large bursty traffic across the country would have reliability problems

Satellite bandwidth too low (network video has special deal!)