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
Data virtual private networks (VPN)
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

Metropolitan Area 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

Valid Frame?

Information frame?

Valid Frame?

Known DLC?

Discard

Discard

Discard

Discard

Discard

Discard

Discard

Discard

Discard

Discard

Discard

Discard

Discard

Discard
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!)