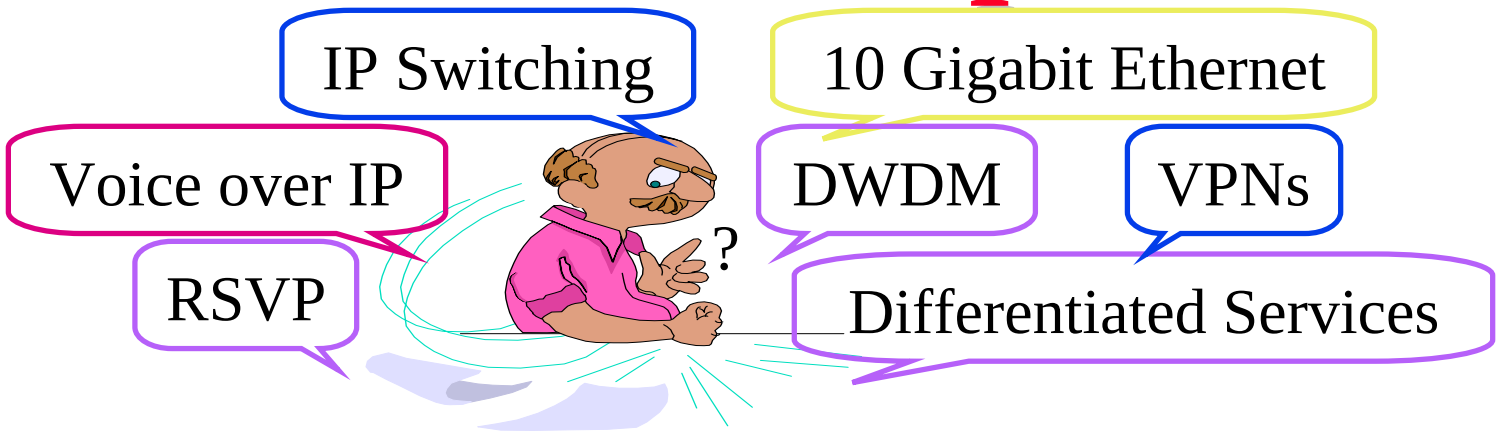
Networking Architecture: Recent Developments



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Overview

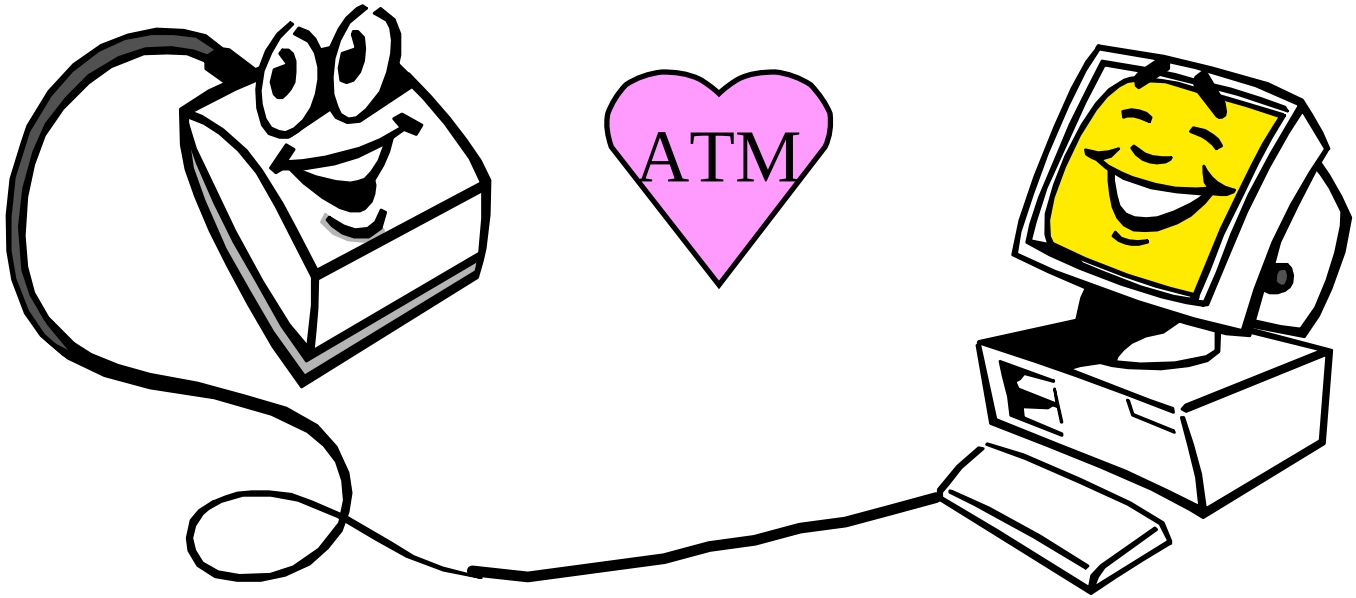
1. Networking Trends
2. QoS over Data Networks
3. Label Switching
4. Gigabit and 10 Gb Ethernet
5. Voice over IP

Trend: Traffic > Capacity

Expensive Bandwidth	Cheap Bandwidth
❑ Sharing	❑ No sharing
❑ Multicast	❑ Unicast
❑ Virtual Private Networks	❑ Private Networks
❑ Need QoS	❑ QoS less of an issue
❑ Likely in WANs	❑ Possible in LANs

ATM

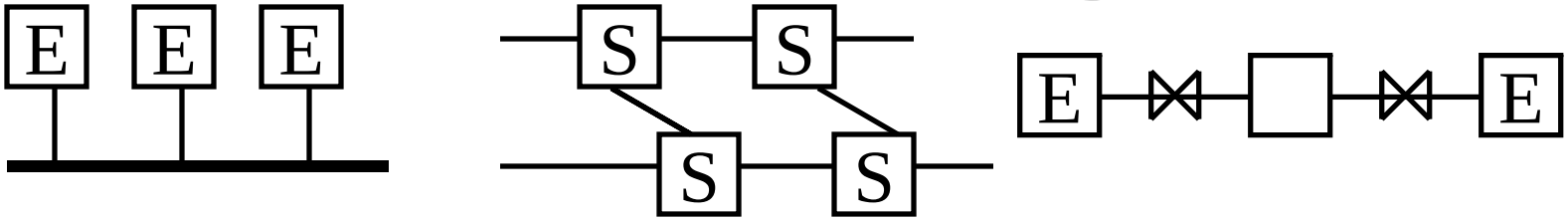
- Asynchronous Transfer Mode
- ATM Net = Data Net + Phone Net
- Traffic Management, Quality of Service, Signaling, Switching



Trend: Everything over IP

- Data over IP ⇒ IP needs Traffic engineering
- Voice over IP ⇒ Quality of Service, Signaling, virtual circuits (MPLS)
- Internet Engineering Task Force (IETF) is the center of action.
  Attendance at ITU is down.

LAN - WAN Convergence



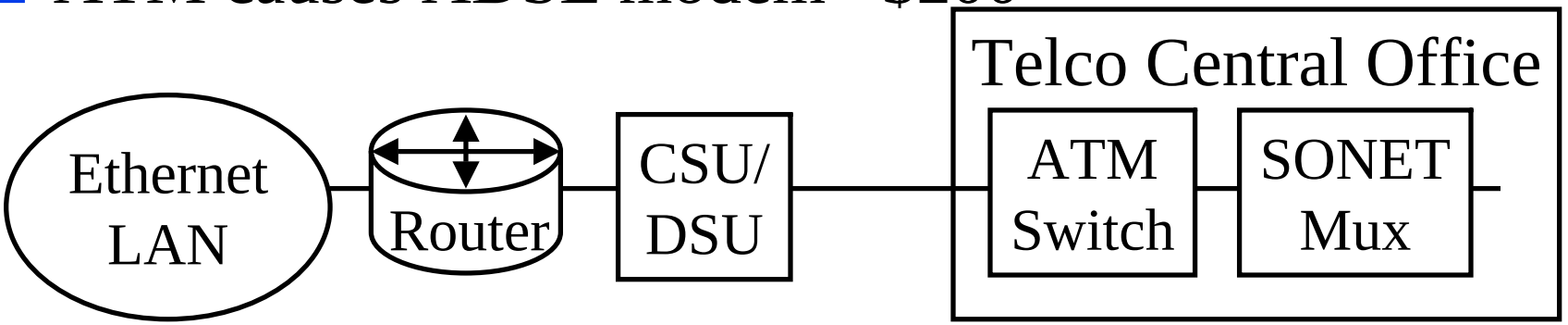
- Past: Shared media in LANs. Point to point in WANs.
- Future: No media sharing by multiple stations
  - Point-to-point links in LAN and WAN
  - No distance limitations due to MAC. Only Phy.
  - Datalink protocols limited to frame formats
- 10 GbE over 40 km without repeaters
- Ethernet End-to-end.
- Ethernet carrier access service:$1000/mo 100Mbps

Trend: Ethernet Everywhere

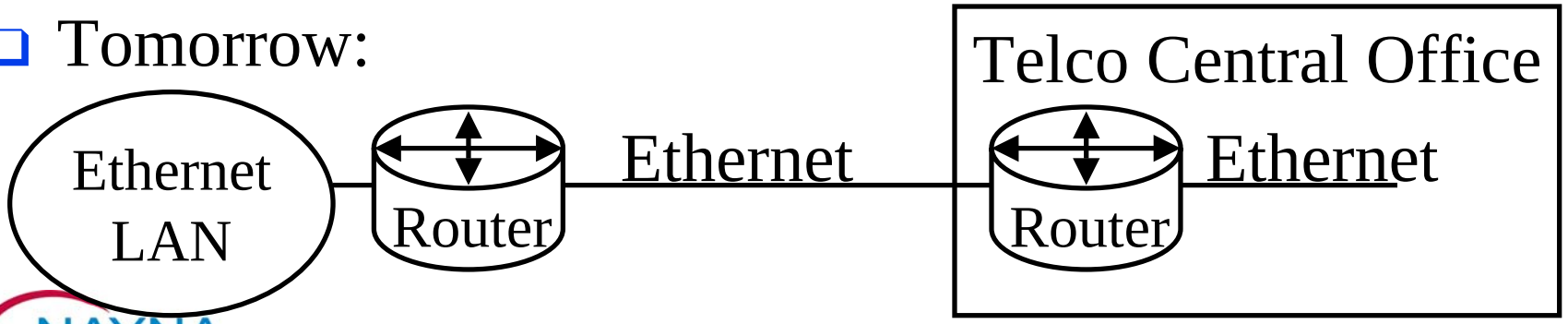
- Ethernet vs SONET in Metro:
  Survivability, Restoration
  Ring Topology
- Ethernet vs DSL in Access:
  Longer distances
- Ethernet vs ATM in Enterprise:
  Class of service
- Ethernet vs phone network in homes:
  Power over Ethernet

Ethernet in the First Mile

- IEEE 802.3 Study Group started November 2000
- Originally called Ethernet in the Last Mile
- ATM causes ADSL modem >$200

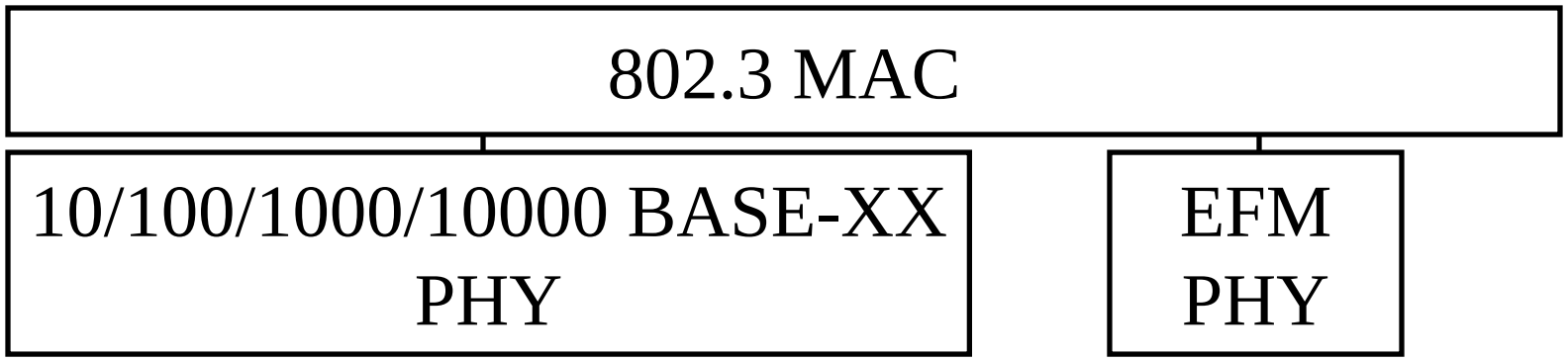


- Tomorrow:



EFM

- Current Technologies: ISDN, xDSL, Cable Modem, Satellite, Wireless
- EFM Goals: (To be determined)
  - Media: Single pair UTP-3, 4-pair UTP-5, Fiber, Air
  - Speed: 125 kbps to 1 Gbps
  - Distance: 1500 ft, 18000 ft, 1 km - 40 km
- Compatibility:



- Ref: http://www.ieee802.org/3/efm/public/index.htm

EFM (Cont)

- June 2001: Metro Ethernet Forum formed by 37 companies including vendors and carriers

Goals:

- Maximize deployment of Ethernet-based Metro nets
- Drive the standards and implementations
- Facilitate Interoperability
- Increase awareness

www.MetroEthernetForum.org

Power over MDI

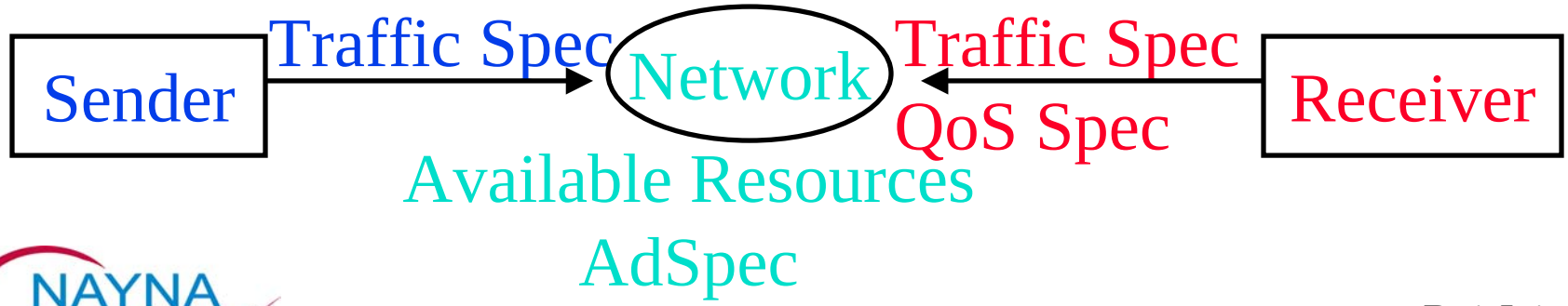
- IEEE 802.3af working group
- MDI = Media Dependent Interface
- Applications: Web Cams, PDAs, Intercoms, Ethernet Telephones, Wireless LAN Access points, Fire Alarms, Remote Monitoring, Remote entry
- Power over TP to a single Ethernet device: 10BASE-T, 100BASE-TX, 1000BASE-T (TBD)
- Interoperate with legacy RJ-45 Ethernet devices
- Allows Switch to Switch connections (both supplying power)

Power over MDI (Cont)

- Allows:
  - Cross-over cables
  - Shorted conductors, loopback plugs
- Approx 40V, 350mA at source
- One standard for worldwide use
- PAR approved: 30 January 2000
- Standard Expected: November 2002
- Email: subscribe stds-802-3-pwrviamdi <email> to majordomo@mail.ieee.org
- Ref: http://grouper.ieee.org/groups/802/3/power_study/public/nov99/802.3af_PAR.pdf

RSVP

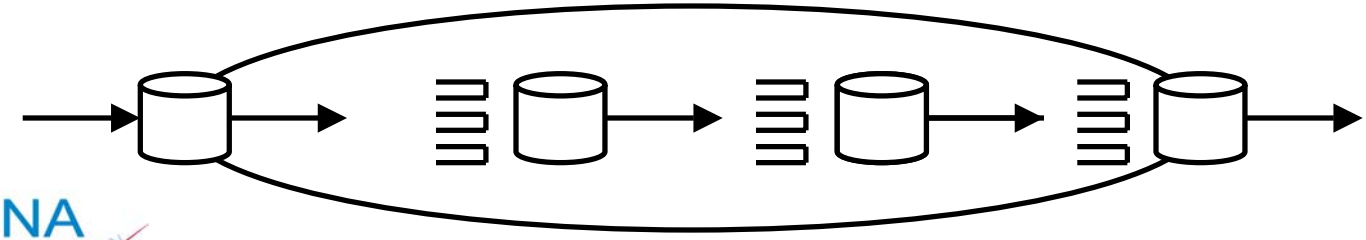
- Resource ReSerVation Protocol
- Internet signaling protocol
- Carries resource reservation requests through the network including traffic specs, QoS specs, network resource availability
- Sets up reservations at each hop



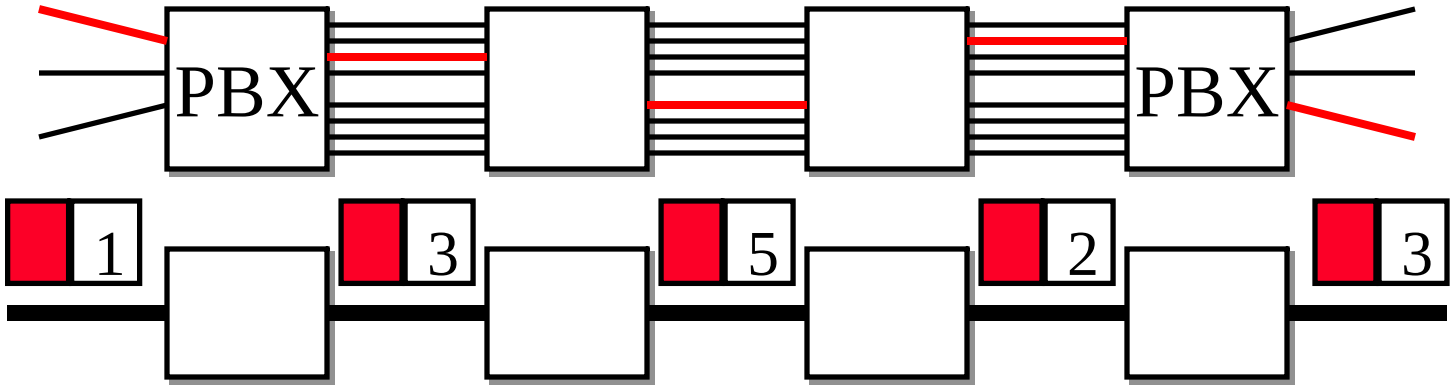
Differentiated Services

Ver	Hdr Len	Precedence	ToS	Unused	Tot Len
4b	4b	3b	4b	1b	16b

- IPv4: 3-bit precedence + 4-bit ToS
- Many vendors use IP precedence bits but the service varies ⇒ Need a standard ⇒ Differentiated Services
- DS working group defined ds byte (IPv4 ToS field)
- Key Issue: How to ensure resource availability inside the network?

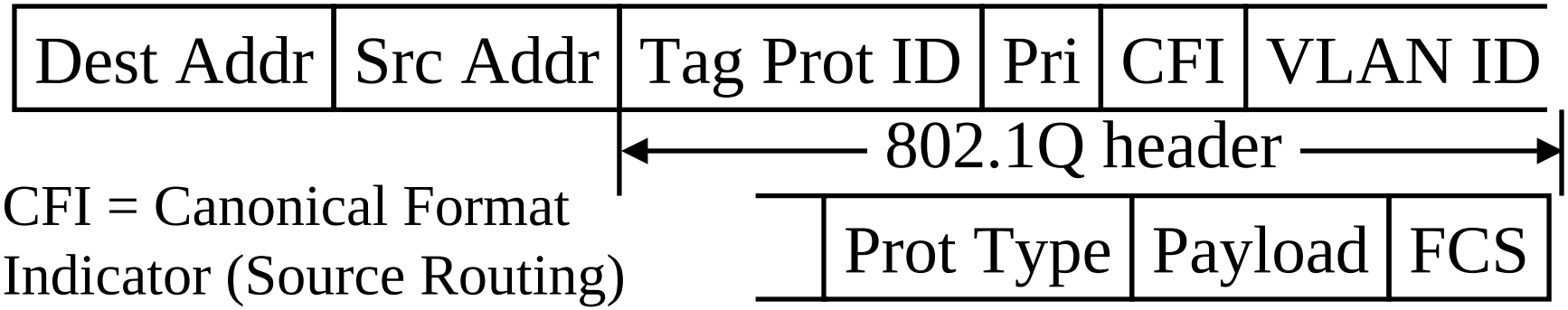


Multiprotocol Label Switching (MPLS)



- Allows circuits in IP Networks (May 1996)
- Each packet has a circuit number
- Circuit number determines the packet's queuing and forwarding
- Circuits have be set up before use
- Circuits are called Label Switched Paths (LSPs)

IEEE 802.1D Model

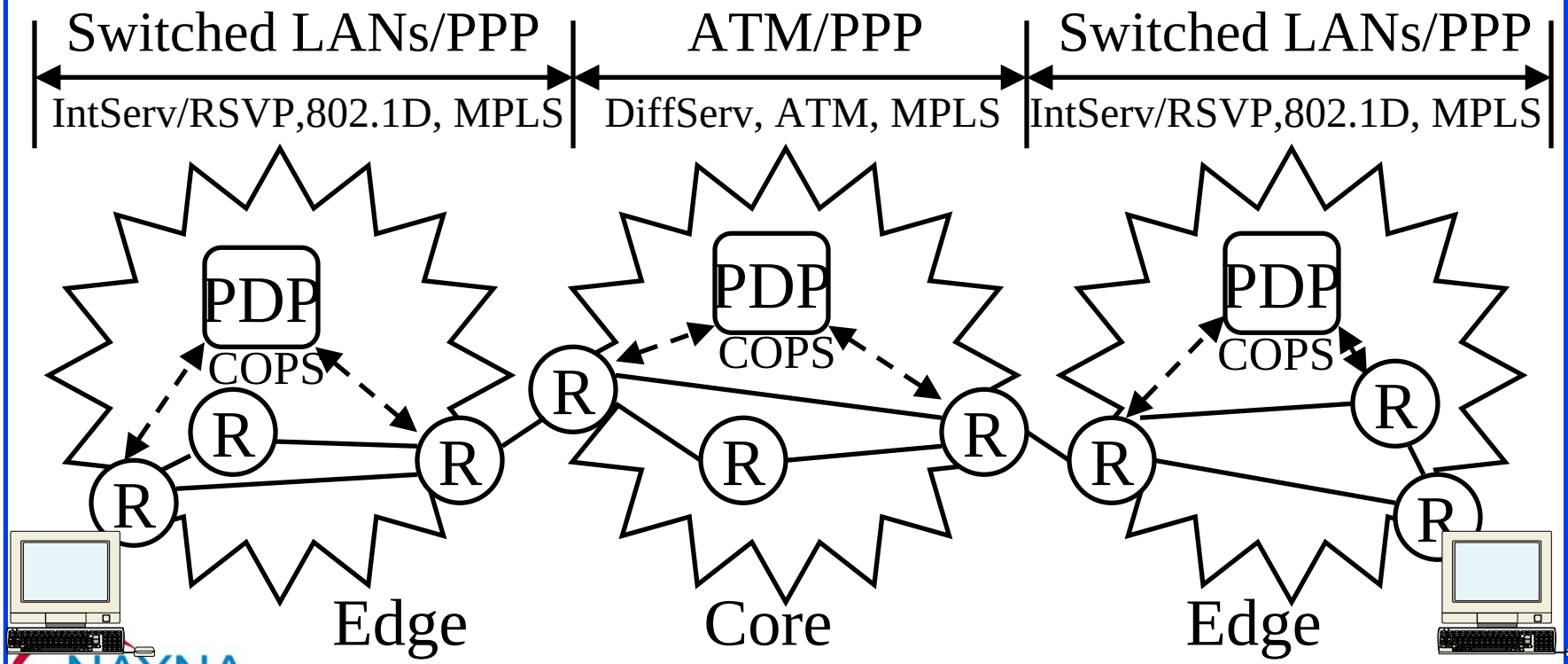


CFI = Canonical Format Indicator (Source Routing)

- **Up to eight priorities:** Strict.
  1 Background
  2 Spare
  0 Best Effort
  3 Excellent Effort
  4 Control load
  5 Video (Less than 100 ms latency and jitter)
  6 Voice (Less than 10 ms latency and jitter)
  7 Network Control

End-to-end View

- ATM/PPP backbone, Switched LANs/PPP in Stub
- IntServ/RSVP, 802.1D, MPLS in Stub networks
- DiffServ, ATM, MPLS in the core



Gigabit Ethernet

- 1000Base-LX: 1300-nm laser transceivers
  - 2 to 550 m on 62.5-μm or 50-μm multimode, 2 to 5000 m on 10-μm single-mode
- 1000Base-SX: 850-nm laser transceivers
  - 2 to 275 m on 62.5-μm, 2 to 550 m on 50-μm. Both multimode.
- 1000Base-CX: Short-haul copper jumpers
  - 25 m 2-pair shielded twinax cable in a single room or rack.
- 1000Base-T: 100 m on 4-pair Cat-5 UTP

  ⇒ Network diameter of 200 m

10 GbE: Key Features

- P802.3ae ⇒ Update to 802.3
- Compatible with OC-192c Payload rate
- Compatible with 802.3 frame format, services, management
- LAN and WAN PHY families
- Cost = 3 × 1GbE
- Same min and max frame size as 10/100/1000 Mbps
- Full-duplex only ⇒ No CSMA/CD
- Star-wired point-to-point links
- 10.000 Gb/s at MAC interface

10 GbE PMD Types

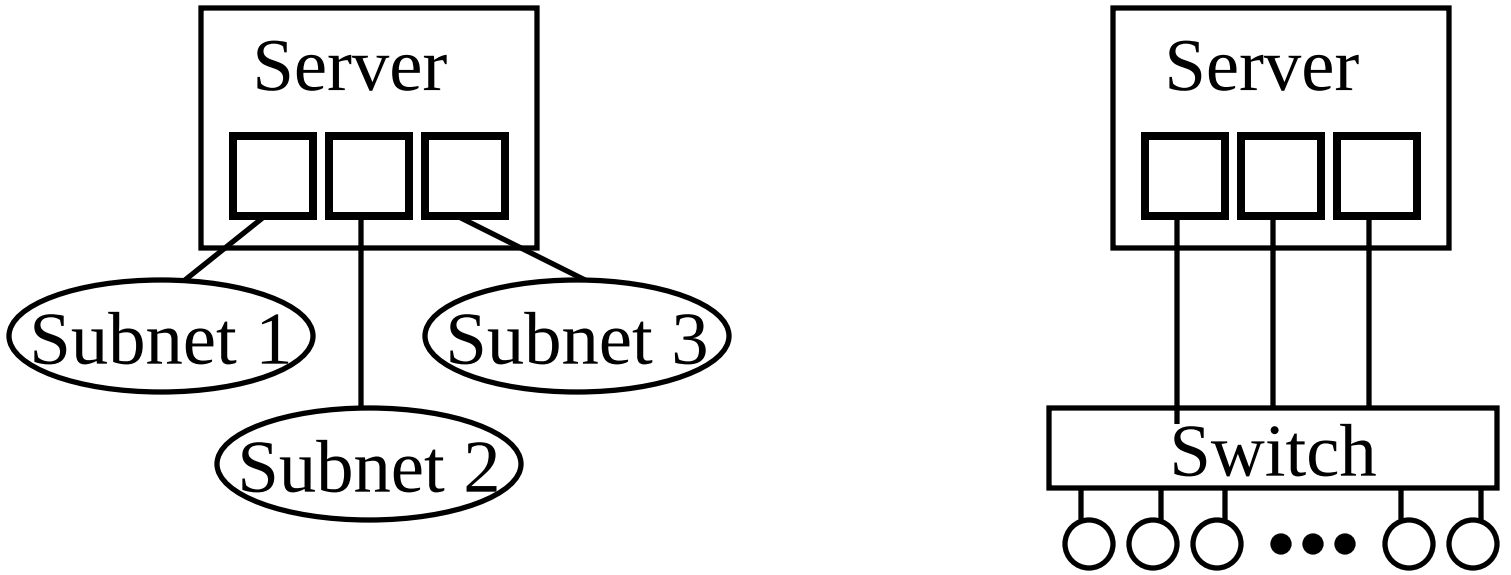
PMD	Description	MMF	SMF
10GBASE-R:			
10GBASE-SR	850nm Serial LAN	300 m	N/A
10GBASE-LR	1310nm Serial LAN	N/A	10 km
10GBASE-ER	1550nm Serial LAN	N/A	40 km
10GBASE-X:			
10GBASE-LX4	1310nm WWDM LAN	300 m	10 km
10GBASE-W:			
10GBASE-SW	850nm Serial WAN	300 m	N/A
10GBASE-LW	1310nm Serial WAN	N/A	10 km
10GBASE-EW	1550nm Serial WAN	N/A	40 km
10GBASE-LW4	1310nm WWDM WAN	300 m	10 km

- S = Short Wave, L=Long Wave, E=Extra Long Wave
- R = Regular reach (64b/66b), W=WAN (64b/66b + SONET Encapsulation), X = 8b/10b, 4 = 4 λ's

1G/10G Ethernet Switch Features

- Stackable or Standalone
- Blocking or non-blocking
- Number of 10/100/1000/10G Ports
- Other LAN ports: ATM, FDDI
- Quality of Service: 802.1p+802.1Q, RSVP, WFQ
- Virtual LAN Support: 802.1Q, port, MAC, L3
- Layer 3 Switching: IP, IPX,AppleTalk
- Flow Control: 802.3x
- Link Aggregation
- Jumbo Frames (9 - 16 kB)

802.3ad Link Aggregation

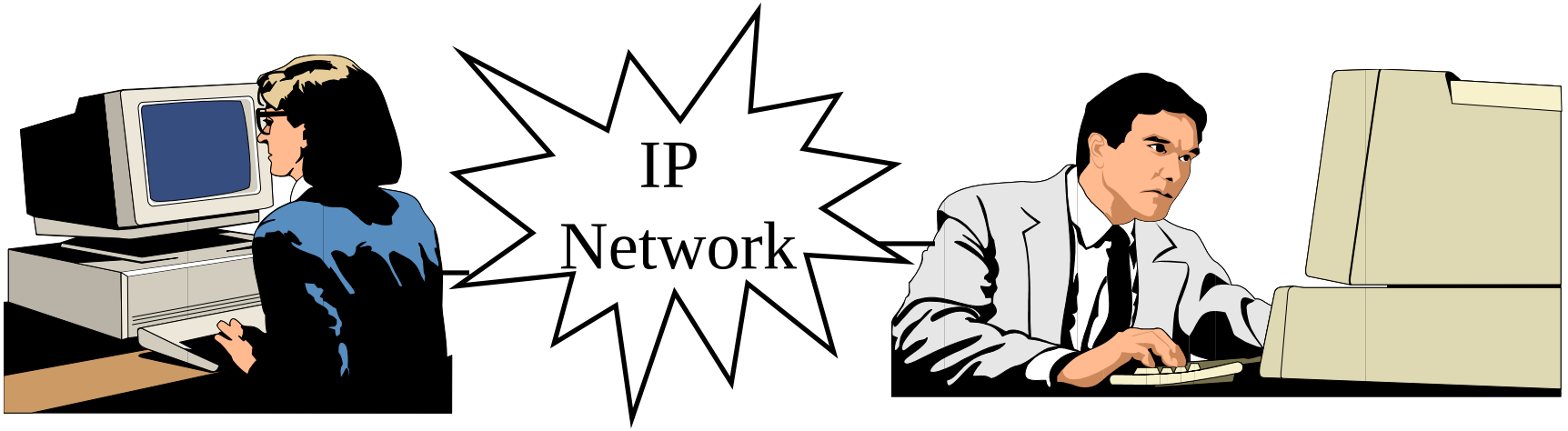


- Allows n parallel links to act as one link
  $\Rightarrow$ Server needs only one IP address.
- For redundancy and incremental bandwidth
- Cost < nX
- Ideal up to 4 links. Approved March 2000.

Future Possibilities

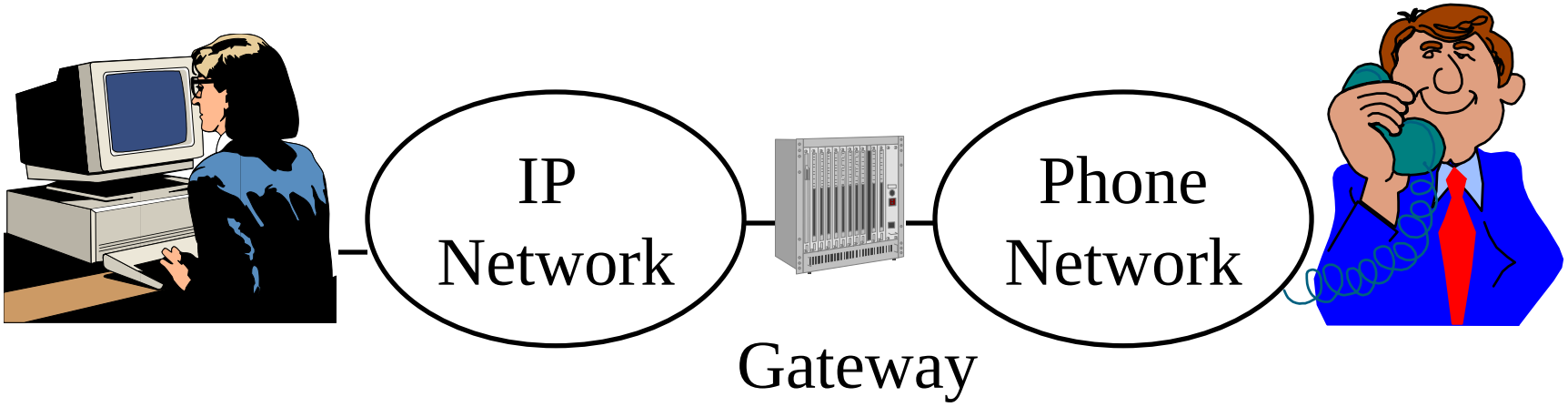
- 40 Gbps
- 100 Gbps:
  - 16λ×6.25 Gbps
  - 8λ × 12.5 Gbps
  - 4λ × 12.5 using PAM-5
- 160 Gbps
- 1 Tbps:
  - 12 fibers with 16λ × 6.25 Gbps
  - 12 fibers with 8λ × 12.5 Gbps
- 70% of 802.3ae members voted to start 40G in 2002

VOIP Scenario 1: PC to PC



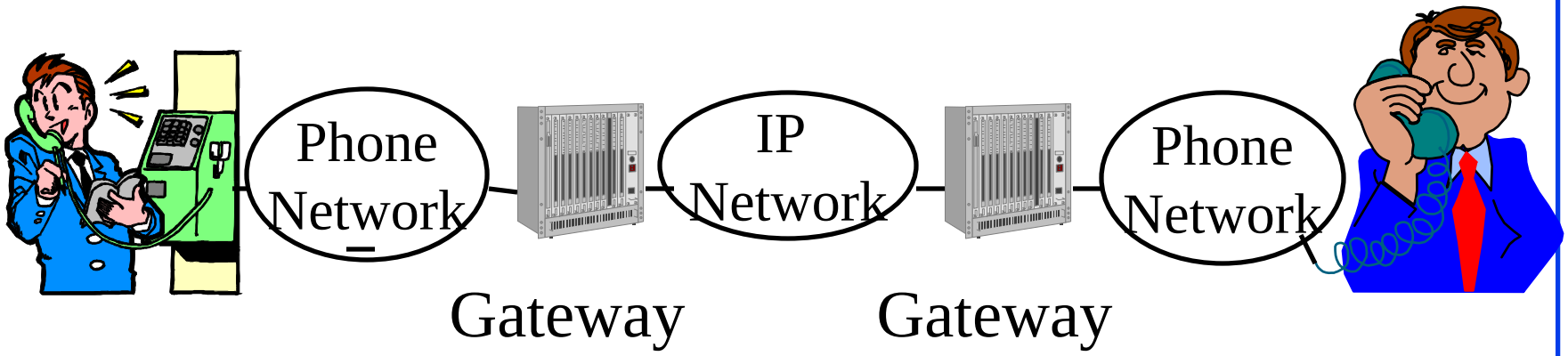
- Need a PC with sound card
- IP Telephony software: Cuseeme, Internet Phone, ...
- Video optional

Scenario 2: PC to Phone



- Need a gateway that connects IP network to phone network (Router to PBX)

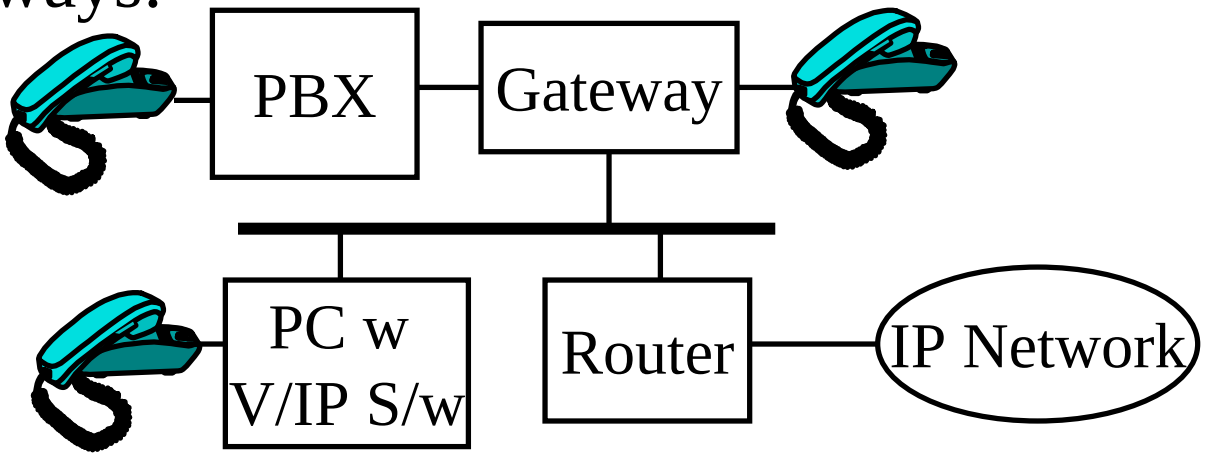
Scenario 3: Phone to Phone



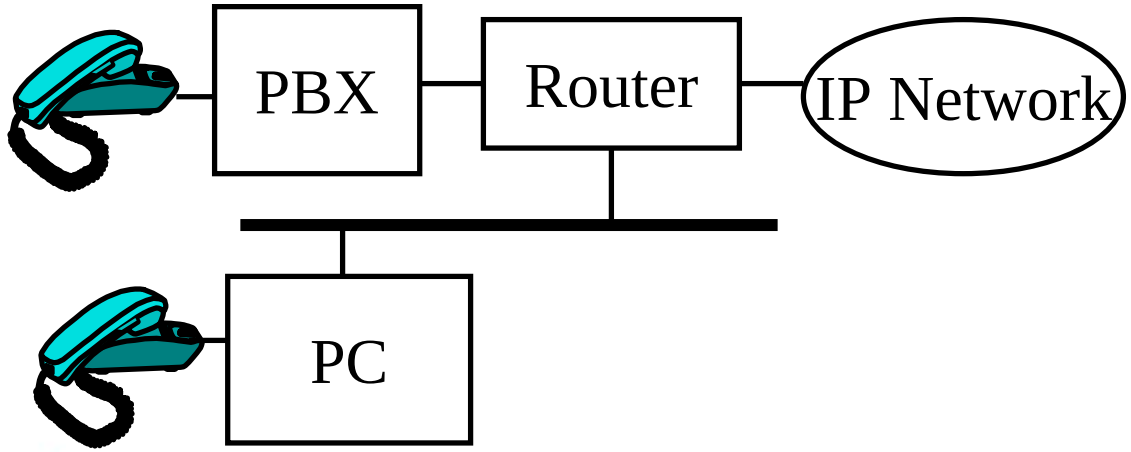
- Need more gateways that connect IP network to phone networks
- The IP network could be dedicated intra-net or the Internet.
- The phone networks could be intra-company PBXs or the carrier switches

Sample Products

- Gateways:

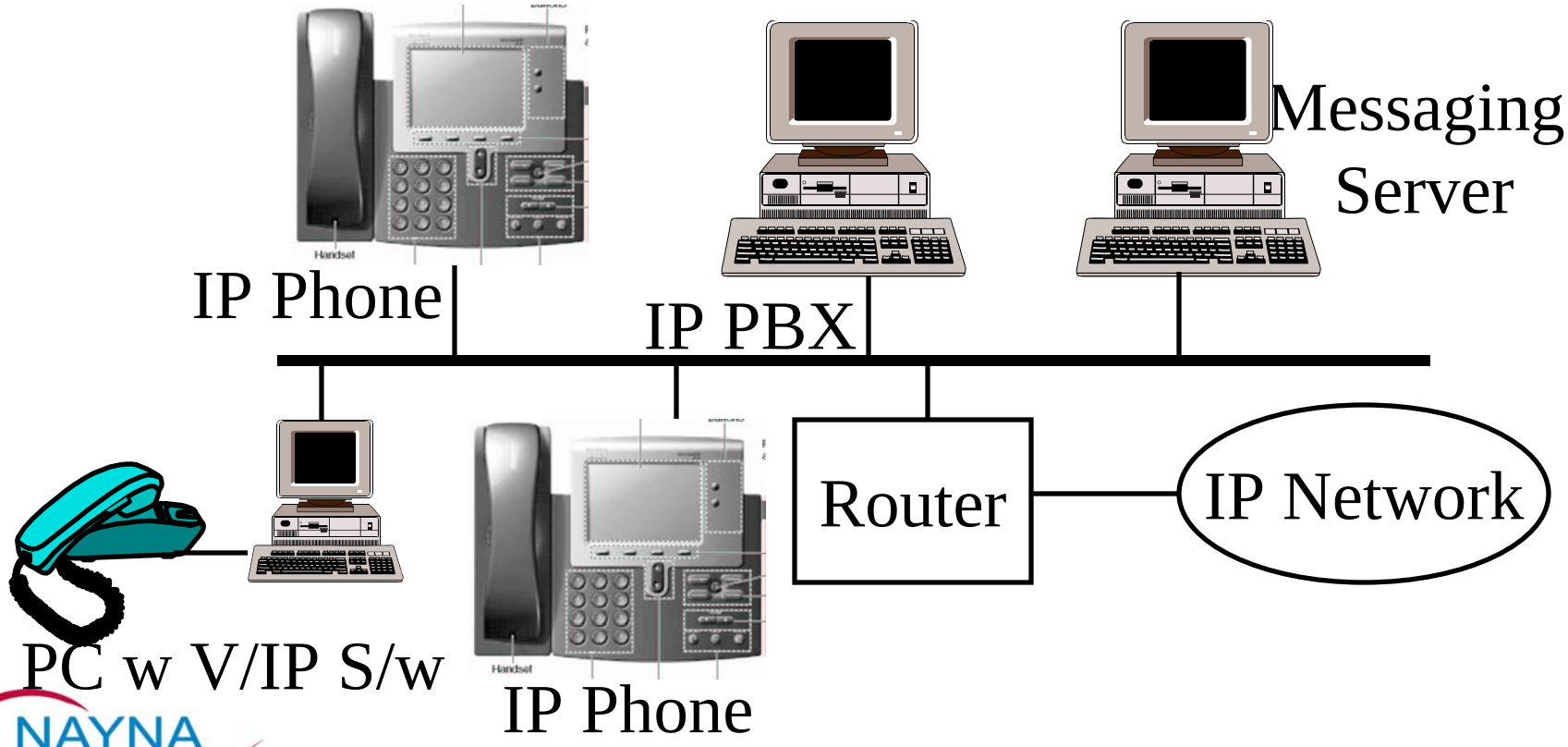


- Voice Enabled Routers:



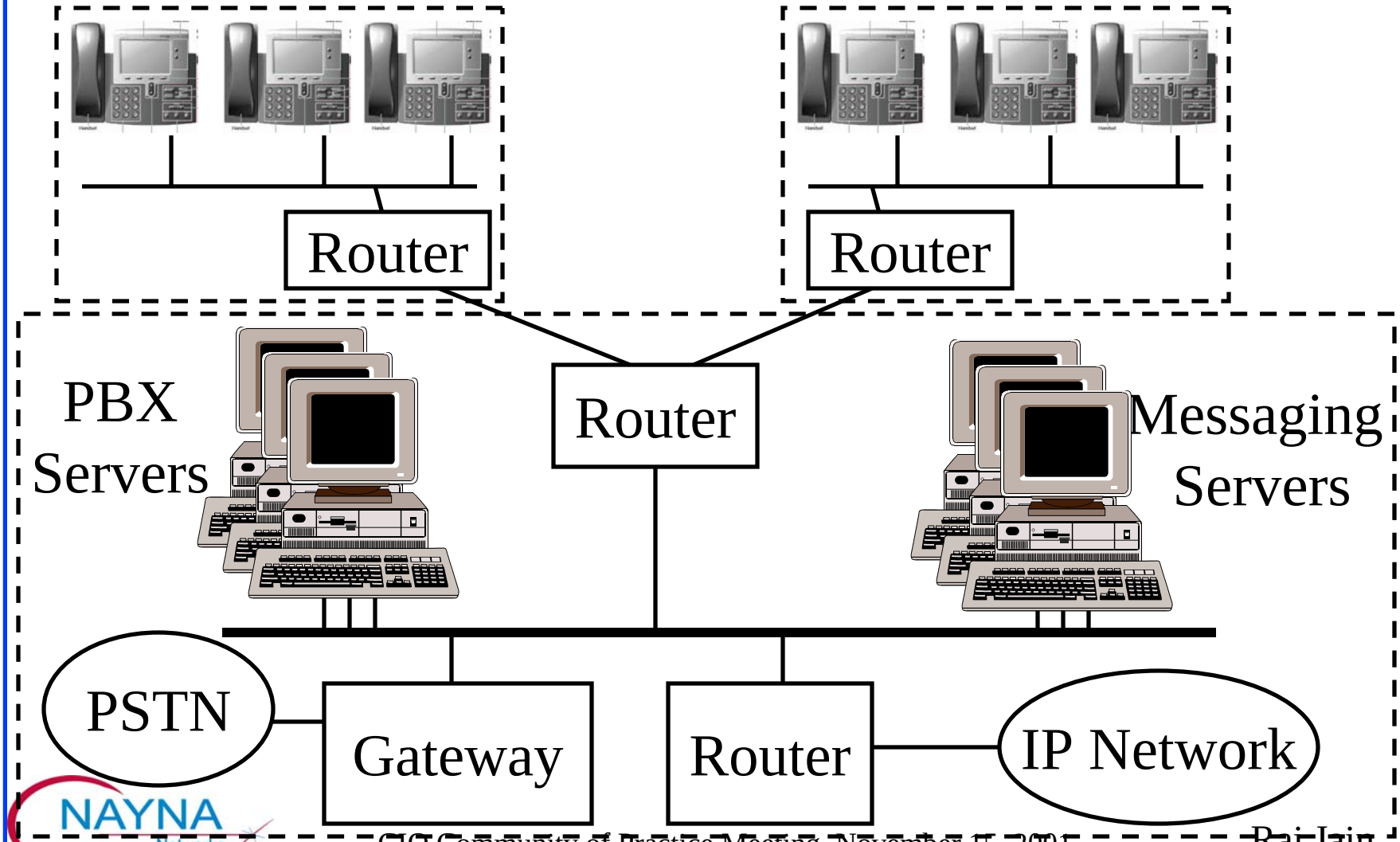
Products (Cont)

- IP Phone/IP PBX: Designed for enterprise market
- IP Voice Mail



Services (Cont)

- Hosted PBX Service



Summary:15 Hot Facts

1. Networking is the key to productivity
2. Data traffic is exceeding voice traffic leading to carriers converting to data networks ⇒ voice over IP
3. Traffic growth is more than capacity leading to need for QoS and Traffic Engineering
4. Everything over Ethernet ⇒ LAN-WAN convergence
5. RSVP allows signaling in IP networks

Summary (Cont)

6. Differentiated services will allow ISPs to monitor traffic and mark them with proper classes and drop precedences
7. MPLS allows packets to be switched based on tags (circuit numbers)
8. MPLS allows interoperability, traffic engineering, and QoS.
9. Gigabit Ethernet comes in four varieties: SX, LX, and CX, T

Summary (Cont)

10. Gigabit Ethernet supports both shared and full-duplex links. Most links are full-duplex
11. Ten-GbE will be not have a shared mode.
12. Ten-GbE will come in several varieties for various distances
13. Ten-GbE will run at two speeds: 10G and OC-192
14. VOIP is ideal for computer-based communications
15. IP needs QoS for acceptable quality