

# **1.264 Lecture 24**

**IP networks**

**Future telecommunications trends**

**Course summary**

## Internet routing

- **Within a domain (company, university, etc.), interior gateway protocols are used**
  - **Routing information protocol (RIP): simplest, ok for small networks: single path, max 15 hops**
  - **Open shortest path first (OSPF): look at speed, quality of hops**
  - **Integrated IS-IS: similar to OSPF**
- **Between domains, border gateway protocols are used:**
  - **BGP**

# Enterprise routing: IP and other protocols

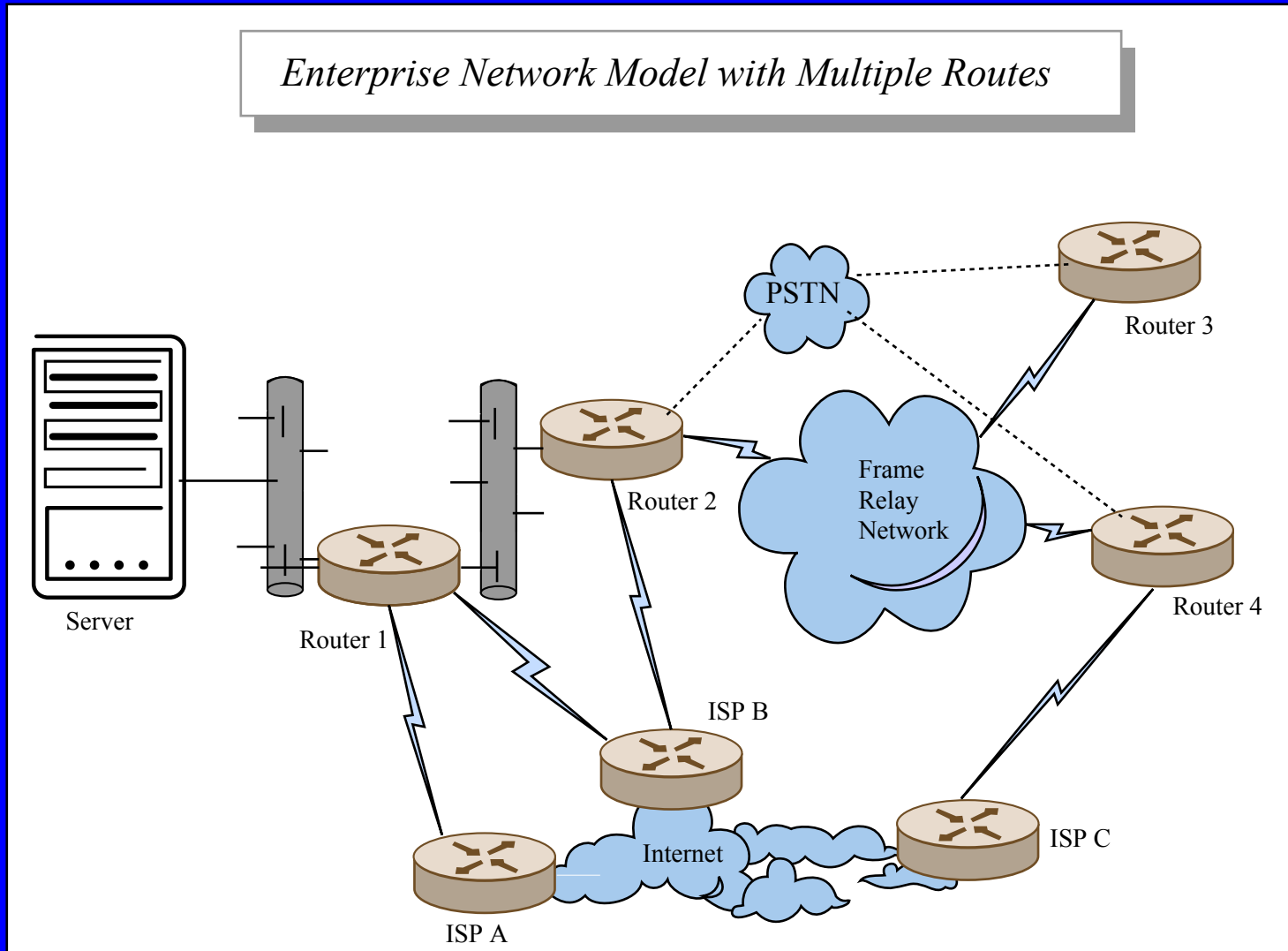


Figure by MIT OCW.

# Multiprotocol Label Switching (MPLS)

- **Label edge routers (LERs) assign a label that defines the path the packet will take through the IP network**
  - **Routing happens only once, at edge**
  - **Another 'hollowing out' of the network**
  - **Routing at interior routers (label switched routers, or LSRs) is done in hardware, not a software lookup of IP routing tables**
    - Much faster, cheaper**
    - A stack of labels allows complex, hierarchical networks**
  - **Label distribution protocol (LDP) used to distribute labels to all LSRs and LERs**
    - Uses TCP/IP**
  - **MPLS allows QoS, security (strict traffic rules)**
    - MPLS VPNs operate at layer 2 or layer 3**
    - Corporate routers don't need to support MPLS; they connect to LER via IP**

# Multiprotocol Label Switching

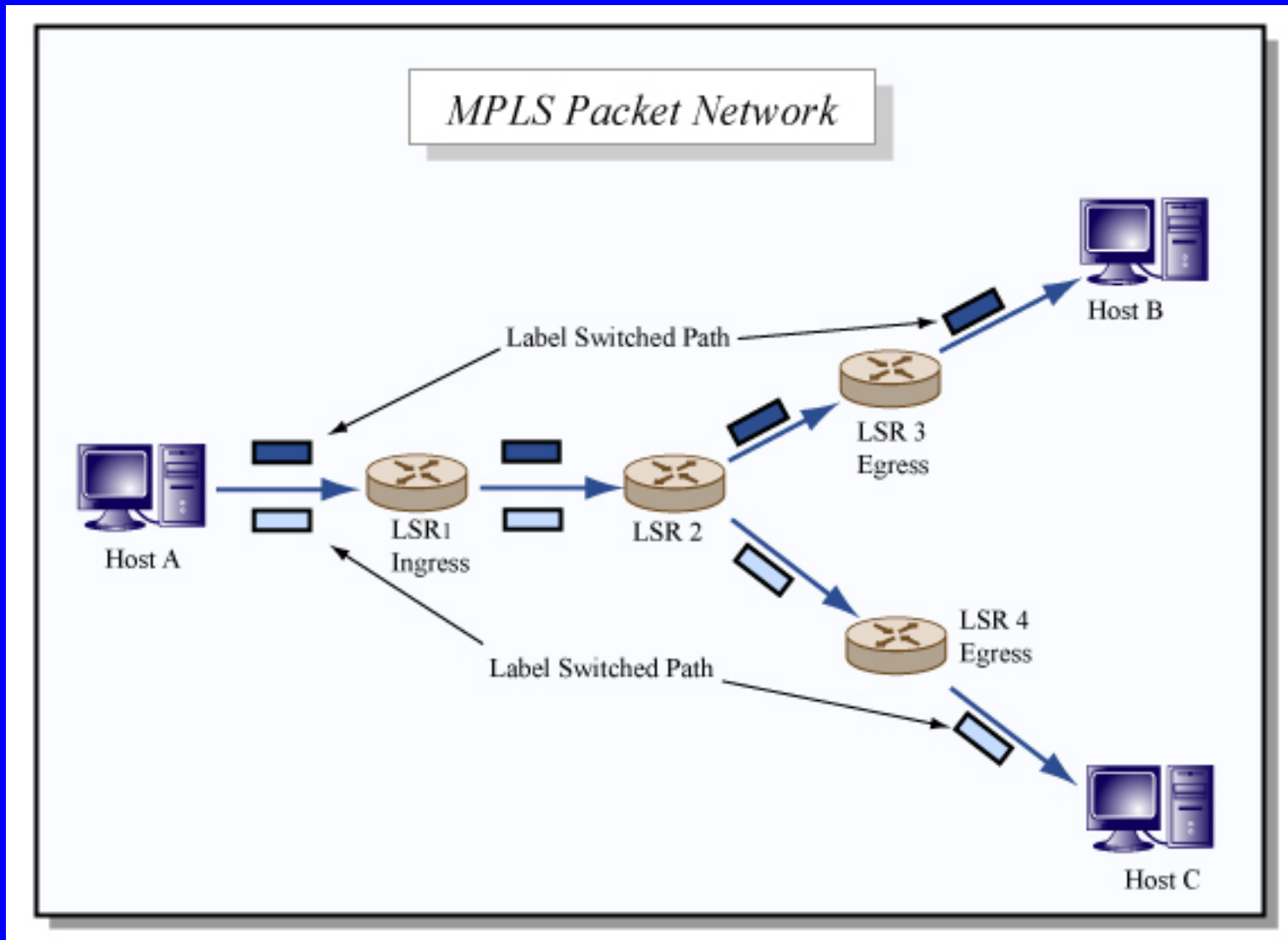


Figure by MIT OCW.

# Telecom convergence

- **Convergence: Moving all voice, data and video traffic on the Internet**
  - **Consumer service reasons:**
    - Smart cards and NFC (Near Field Communications) on mobile phones: browsers, phone as payment medium, smart posters, cameras
    - E-commerce generally
    - RFID, GPS, sensors, ...
  - **Cost reduction: one network versus many**
  - **Increased mobility services**
    - Tying wireless access to fiber optic backbone flexibly
  - **Barriers:**
    - Low quality, chaos of Internet
    - Security
    - Broadband in the 'last mile' to businesses and homes

## **Future trends**

- **End of telephone companies as we know them:**
  - Long distance gone first, then local exchange carriers
- **Wireless phones ubiquitous**
  - Wireless data, payments likely to become so too
  - WiFi as home solution, WiMax or 3G as metro solution
- **Cable TV in difficult position**
  - Direct broadcast satellite taking revenues needed to update undercapitalized plant
  - Telco fiber to home possibly competing for video
- **Digital divide issues**
- **Peer-to-peer versus central control in Internet**
  - Government control, industry control issues
- **Security issues unresolved**

## Exercise

- **Communications in warehouse**
  - What is the bandwidth required?
  - Would 10 Mbps Ethernet work?
  - Would 100 Mbps Ethernet work?
  - Would cellular 500 kbps link work?
  - Would 100 Mbps Ethernet be sufficient within warehouse?
  - If there are unresolved issues still, how would you resolve them?

# Solution

- **Communications in warehouse**

**What is the bandwidth required?**

$$100\ 000 \times 4 \times 256 / 60 = 2\ 000\ 000 \text{ bps} = 2 \text{ Mbps}$$

**Would 10 Mbps Ethernet LAN work?**

No. 3 km distance too great

**Would 100 Mbps Ethernet LAN work?**

No. Same reason

**Would cellular 500 kbps link work?**

No. Bandwidth too low

**Would 10 Mbps Ethernet be sufficient within warehouse?**

Yes. Bandwidth adequate (20% loading), range  $\ll$  2 km

**If there are unresolved issues still, how would you resolve them?**

MAN Ethernet from carrier

# Steps and skills for building these systems are same as we've covered in class this semester

- **Software engineering**
  - Select development method (often spiral model)
  - Requirements, design, resource estimation, development, QA
- **Process modeling**
  - UML: describe states, collaborations, classes, components, ...
  - May lead to executable models
- **Data modeling**
  - Data is persistent: model, normalize, referential integrity
  - Model business rules, verify with users (engineers, customers, ...)
- **Database**
  - Relational databases, SQL at core of applications, Web

## Steps, continued

- **World Wide Web:**
  - Connect clients and servers: SOAP/HTTP, XML, WSDL
  - Use HTTP, XML as 'data dial tone': universal data access
  - XML to allow human, machine and document interpretation
  - XML documents include business rules, database schema
- **Security**
  - Network uses SSL, encryption, certificates, digital signatures
  - Nodes (client, server) are people and process issues
    - Patches, passwords, audits/monitoring, culture, ...
- **Networks**
  - Multi tier architecture: Web server, application server, database server, with redundancy
  - 7 layer data comm model, with TCP/IP at layers 3 and 4
  - LANs, MANs based on Ethernet; WANs based on IP
  - Fiber optic core, wireless/copper/CATV for access
  - Machine-machine traffic dominant
  - Bandwidth available to share data effectively

## Course summary: process

- If you spent 12 hours per week for 14 weeks, that's 168 hours, or 4 40 hour weeks
- Ready for second spiral in software model after 8 person weeks of work (4 person weeks times 2 people)
  - This can be done in the wasted “up-front” time to prepare for an anticipated project
  - It will always take this long because you'll always be learning new technology
- You'll never know all of information technology, because there's too much, but you need to know enough to understand it
  - To work with software staff collaboratively in configuration, development or implementation projects
  - To work with systems, databases as an analyst or consultant
  - To manage development, if you have an engineering or logistics project

# What you know

- **You have all have built the most important components beyond straight programming:**
  - A data model and database,
  - A dynamic, database-enabled Web site with server technology
- **You have 5 books that introduce you to deeper knowledge of key areas. Reread them in the future, use them as references**
  - Rapid Application Development
  - SQL Server
  - UML Distilled (sort of)
  - Security Engineering
  - Telecommunications Handbook
  - (Dreamweaver book is very applied but still a good summary)
- **Read the online literature: Subscribe to daily email summaries:**
  - Internet Week, Information Week, Network Computing, ...

## Future steps

- **There are full courses in every one of the topics we covered in class**
  - **Software process: 16.355**
  - **Data models, database: 6.830**
    - Or Harvard has database classes
    - Or take an industry course after MIT
  - **Web as channel between databases:**
    - Few courses available; industry short courses on XML, SOAP, Web services, Java EE 5, Microsoft .NET, etc.
  - **Network classes: 6.263**
  - **Security classes: 6.857**
  - **Software development: 1.001**