15.561
Information Technology Essentials

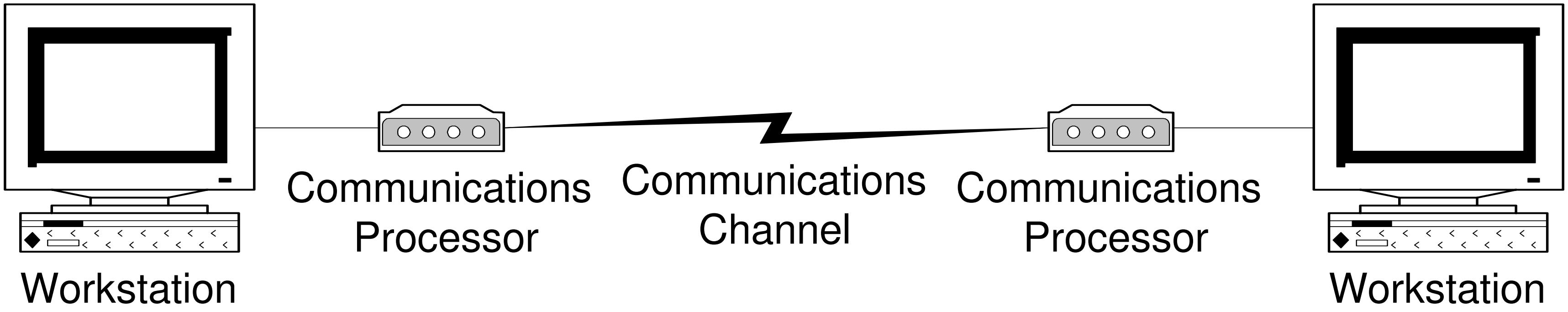
Session 3
Networks I

Acknowledgments:
Slides marked “SM” are adapted from Stuart Madnick, MIT.
Slides marked “CD” are adapted from Chris Dellarocas, U. Md..

Outline

- Point to point connections
  - Representing information
    - Analog vs digital
    - Representing words and pictures
  - Communications media and bandwidth
- Networks
  - LANs vs WANs
  - Circuit switched vs packet switched
- Example: The Internet

A simple point-to-point connection



- processors convert data into signals
- signals are transported through channels
- channels utilize one or more connection media

Data: Analog vs. Digital

- Analog data
  - can take on any value within a continuous range
  - Examples:
    - » human voice
    - » Boston’s temperature

- Digital data
  - can take on only a finite set of discrete values
  - Examples:
    - » data stored in binary computers
    - » the US standard sizes of clothes

Representing Numbers

1 0 1 1

$$1\times2^3 + 0\times2^2 + 1\times2^1 + 1\times2^0$$

$$1\times8 + 0\times4 + 1\times2 + 1\times1$$

$$11$$

Number	4-bit binary representation
1	0001
2	0010
3	0011
…	…

Representing Characters

Character	ASCII* representation
A	1010 0001
B	1010 0010
C	1010 0011
…	…
0	0101 0000
1	0101 0001
…	

* American Standard Code for Information Interchange

Formatted Documents

- In addition to text, must contain information about how it appears on paper
  - » bold, italic, underlined text
  - » different sizes of type
  - » page breaks
- "Invisible" formatting characters are embedded in text
  - » special "begin formatting" character
  - » format specification character (i.e. "bold type")
  - » text string for which formatting applies
  - » special "end formatting" character
- Same character codes have different meaning when interpreted as letters and when as format specifications
  - » 65 could mean either 'A' or 'bold' depending on context

Formatted Documents (cont'd)

Example:

– This is a <u>nicely</u> formatted line.

Could be stored internally as:

– <BG PAR> 'T' 'h' 'i' 's' ' ' 'i' 's' ' ' 'a' <BG UNDERLINE> 'n' 'I' 'c' 'e' 'l' 'y' ' '<EN UNDERLINE> <BG COLOR> 1 'f' 'o' 'r' 'm' 'a' 't' 't' 'e' 'd' <EN COLOR> ' ' 'l' 'i' 'n' 'e' '.' <CR>

Where:

– <BG PAR>, <BG UNDERLINE>, <EN UNDERLINE>, <BG COLOR>, <EN COLOR>, <CR> are special byte sequences that denote the beginning and end of various formatting features

– Different word processors use different byte sequences, that's why documents require conversion to be used by a different wp

Thomas W. Malone Home Page - Microsoft Internet Explorer

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Thomas W. Malone

MIT Sloan MANAGEMENT

Thomas W. Malone is the Patrick J. McGovern Professor of Management at the MIT Sloan School of Management. He is also the founder and director of the MIT Center for Coordination Science and was one of the two founding co-directors of the MIT Initiative on "Inventing the Organizations of the 21st Century". Professor Malone teaches classes on leadership and information technology, and his research focuses on how new organizations can be designed to take advantage of the possibilities provided by information technology.

For example, Professor Malone predicted, in an article published in 1987, many of the major developments in electronic business over the last decade: electronic buying and selling, electronic markets for many kinds of products, "outsourcing" of non-core functions in a firm, and the use of intelligent agents for commerce. The past two decades of Professor Malone's research are summarized in his critically acclaimed book, *The Future of Work: How the New Order of Business Will Shape Your Organization, Your Management Style, and Your Life* (Harvard Business School Press, 2004). This book has been translated into Japanese, Chinese, and Spanish, and editions in three other languages are forthcoming.

Professor Malone has also published over 75 articles, research papers, and book chapters;

Publications

Research projects

Internet

CD

malone[1] - Notepad

File Edit Format View Help

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN">
<!-- saved from url=(0026)http://ccs.mit.edu/malone/ -->
<HTML><HEAD><TITLE>Thomas W. Malone Home Page</TITLE>
<META http-equiv=Content-Type content="text/html; charset=iso-8859-1"><LINK
href="../Thomas%20W_%20Malone%20Home%20Page_files/text.css" type=text/css rel=stylesheet>
<META content="MSHTML 6.00.2800.1400" name=GENERATOR></HEAD>
<BODY bgcolor="#EAEBB1">
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  <!--DWLayoutTable-->
  <TBODY>
  <TR>
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      <DIV align=center><IMG height=310
      src="../test/malone%20photo.jpg" width=259></DIV>
    </TD>
    <TD width="789" rowSpan=7

         bordercolor="EAEBB1">
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        <div align="right">
          <table width="85%" border="0" height="136">
            <tr>
              <td>
                <div align="center"><strong><font size=+2>Thomas W. Malone</font></strong></div>
              </td>
              <td width="23%" height="113"><strong><font size=+2><img src="../test/logo-black.jpg" width="81"
            </tr>
          </table>
          <STRONG></STRONG> <STRONG></STRONG> <strong><font size=+2> </font></strong></div>
      </blockquote>
      <DIV align=center>
        <P align="left">Thomas W. Malone is the Patrick J. McGovern Professor
          of Management at the <A href="http://mitsloan.mit.edu/">MIT Sloan School
          of Management</A>. He is also the founder and director of the <A
      href="../index.html">MIT Center for Coordination Science</A> and was one
          of the two founding co-directors of the <A
      href="http://ccs.mit.edu/21c/">MIT Initiative on "Inventing the Organizations
          of the 21st Century".</A> Professor Malone teaches classes on leadership
          and information technology, and his research focuses on how new organizations
          can be designed to take advantage of the possibilities provided by information
          technology.
      </DIV>
        <P>For example, Professor Malone predicted, in an article published in
          1987, many of the major developments in electronic business over the
```
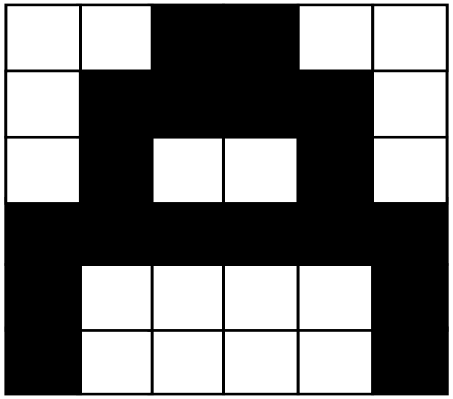

CD

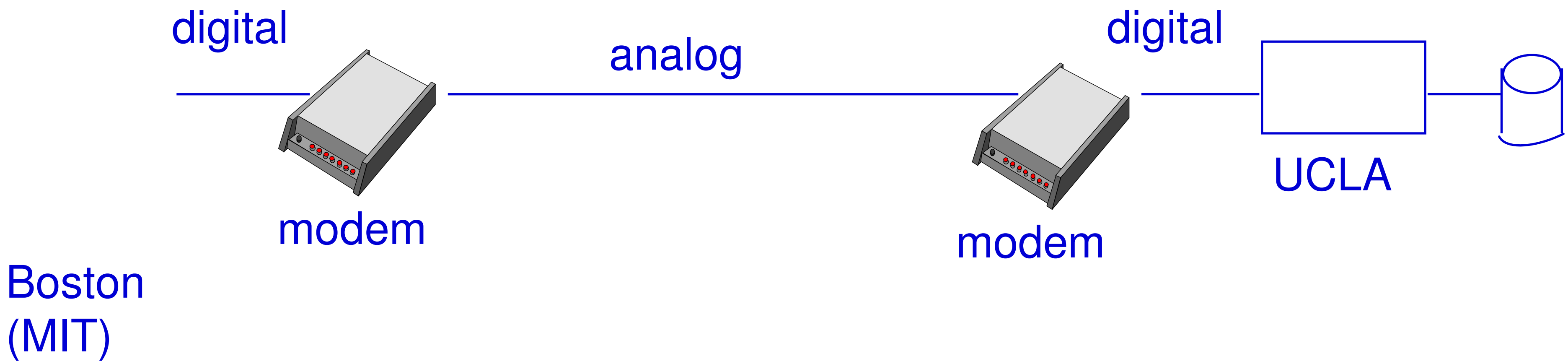
Bitmapped graphics

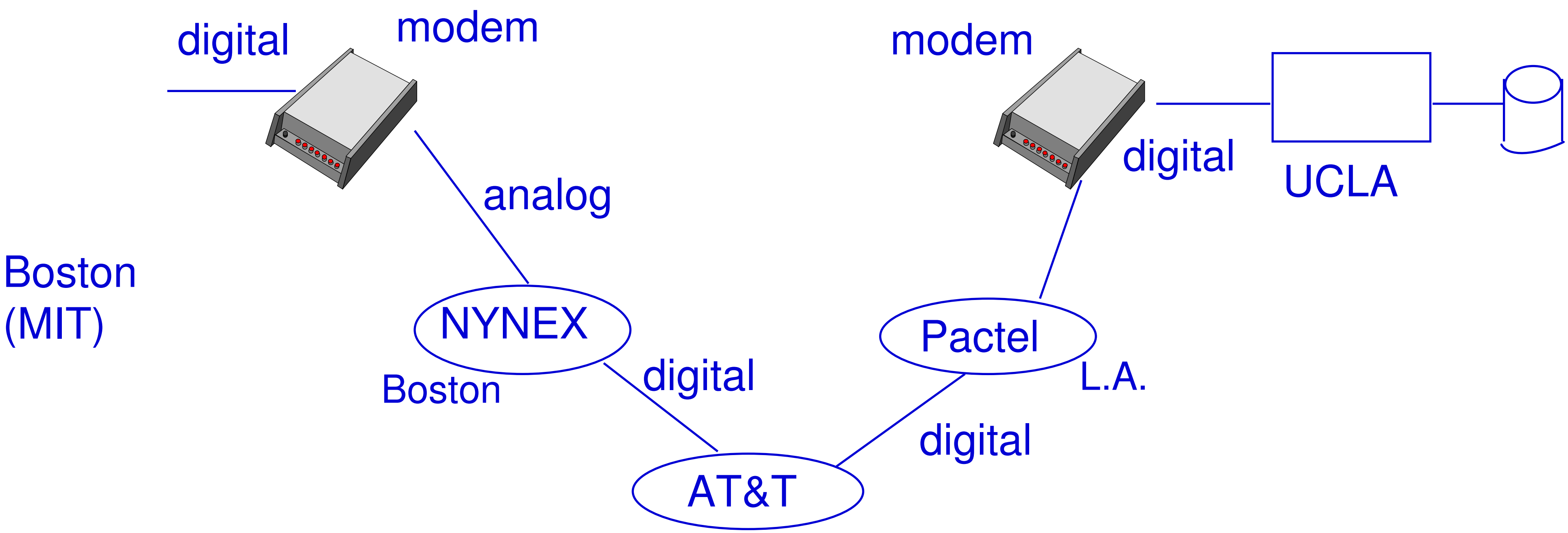
- Numbers, letters, and words are not enough: we want pictures



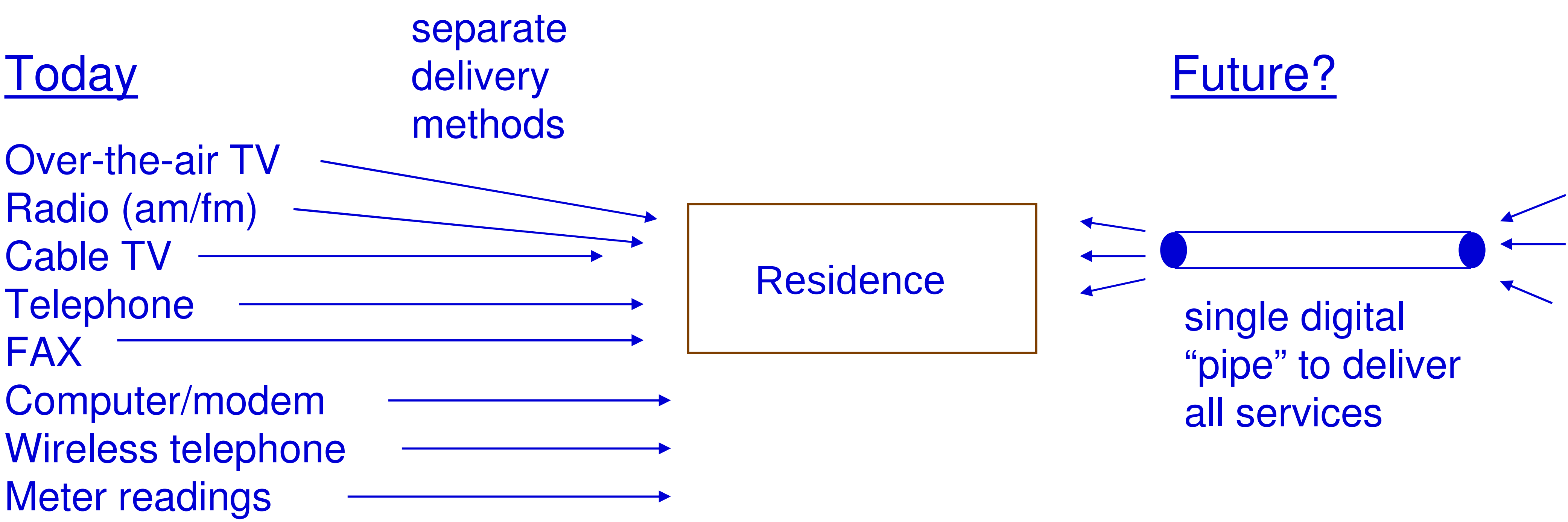
- Representing a picture
  - Draw a very fine grid on it
    - » grid cells are called pixels or dots
  - See what is in each grid cell
    - » bitmap: is cell empty or full?
    - » grayscale: how dark is the cell?
    - » color: what color is the cell?
  - Represent each cell with a prespecified # of bits (how many?)
  - Store the bits for the cells in a prespecified order
    - » e.g., all the cells for the top row, then the next row, etc.

Movement Towards Digital





Digital Convergence



Connection media – Examples

Medium	Speed	Cost
Twisted wire	300 BPS – 10 MBPS	Low
Microwave	256 KBPS – 100 MBPS	
Coaxial cable	56 KBPS – 200 MBPS	
Optical fiber	500 KBPS – 10 GBPS	High

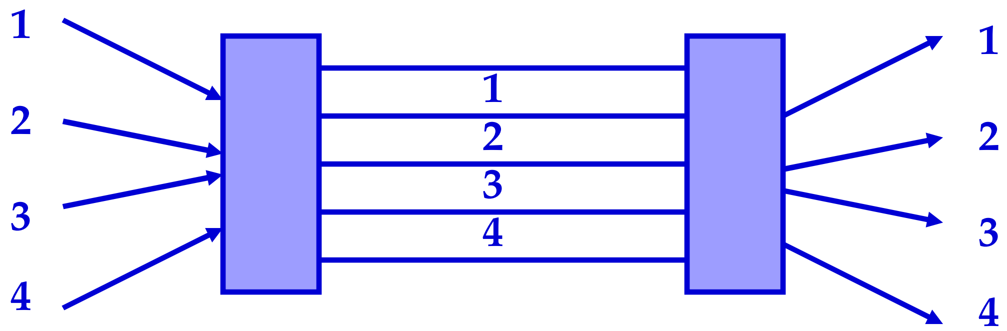
BPS = bits per second

From Laudon & Laudon, *Management Information Systems: Organization and Technology*, Prentice Hall, 1998

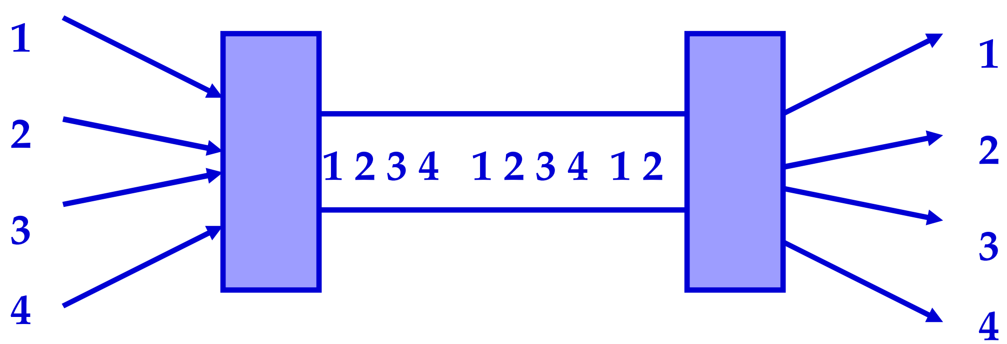
What is bandwidth?

- **Technically:**
  - **The range of usable frequencies in a communications medium**
- **Practically:**
  - **The amount of information that can be carried by a communications medium per unit of time**

Multiplexing: Squeezing many channels into one



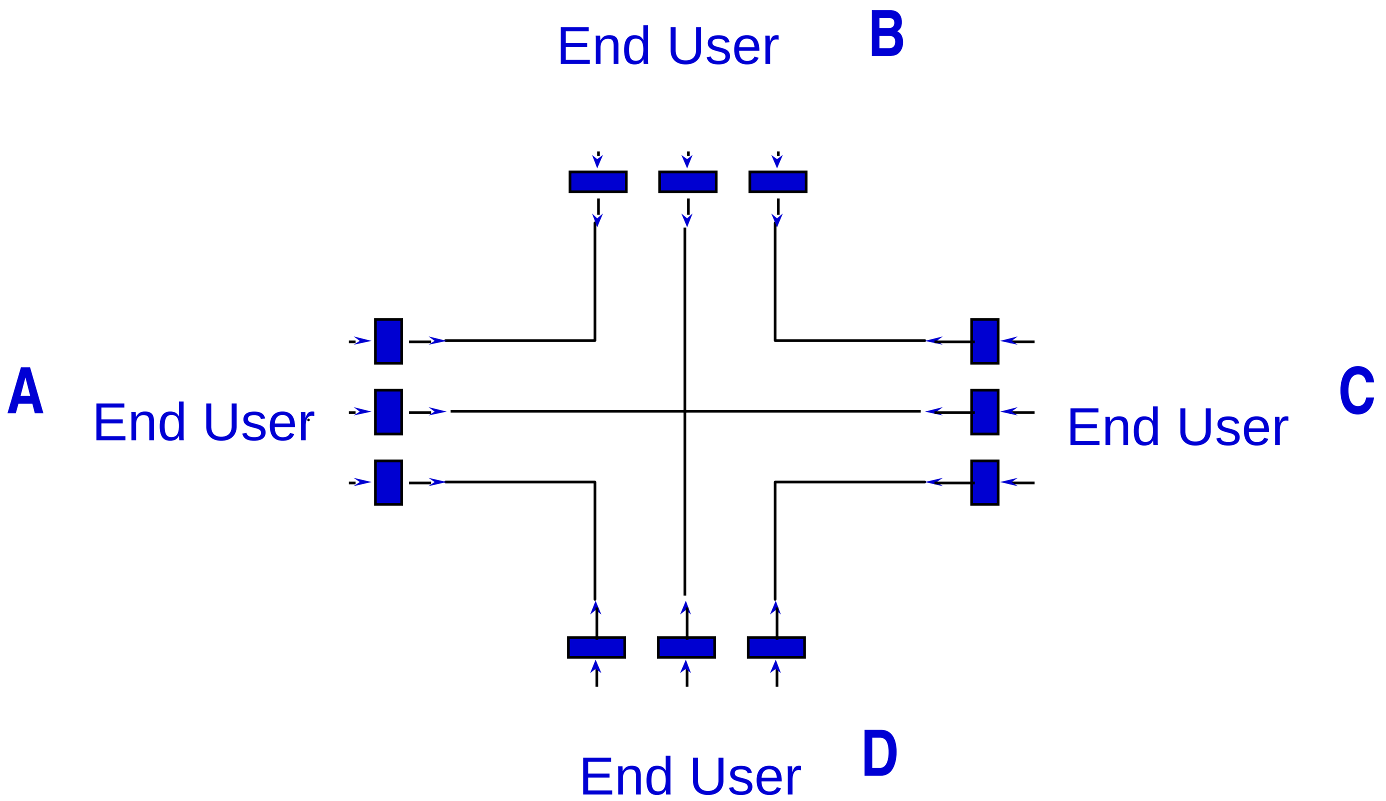
Frequency Division Multiplexing (FDM)



Time Division Multiplexing (TDM)

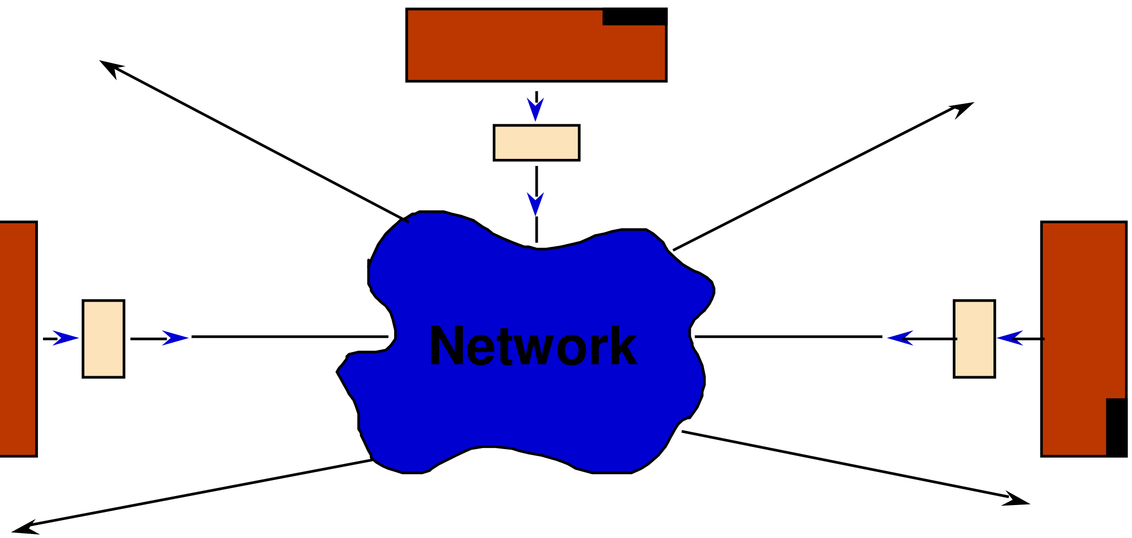
Multiplexer Multiplexer

Why build networks?



Full Connectivity doesn't scale!

Networks are about sharing



- The network allows an entity to switch its attention among a large number of others
- Permits sharing of resources attached to the network, including the resources of the network itself.

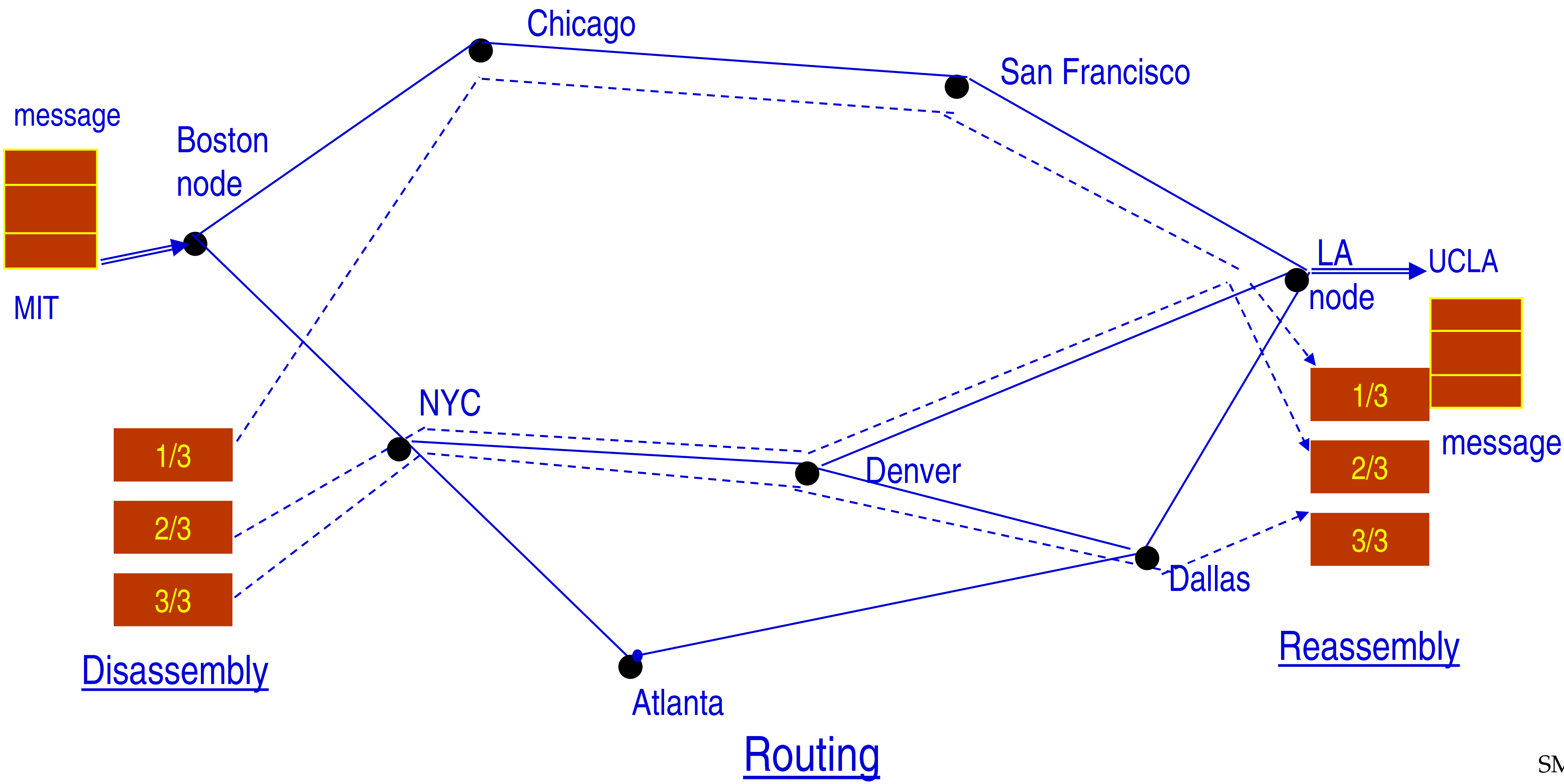
Local and Wide Area Networks

- **Local Area Networks (LANs)**
  - Short distances
  - Within organizations
  - Typical technology: Ethernet or Token Ring
- **Wide Area Networks (WANs)**
  - Long distances
  - Across organizations (typically multiple LANs)
  - Typical technology: Public Switched, Leased Line

Two forms of network connection

- **Circuit switching**
  - A dedicated end-to-end connection is established for the duration of the connection
  - Used in telephone network
- **Packet switching**
  - Messages are divided into small packets
  - Each packet is separately routed to the destination
  - Different packets can take different paths and times
  - Missing or garbled packets are retransmitted, if necessary
  - Packets are reassembled into messages at the destination

Packet switching



SM

Comparison

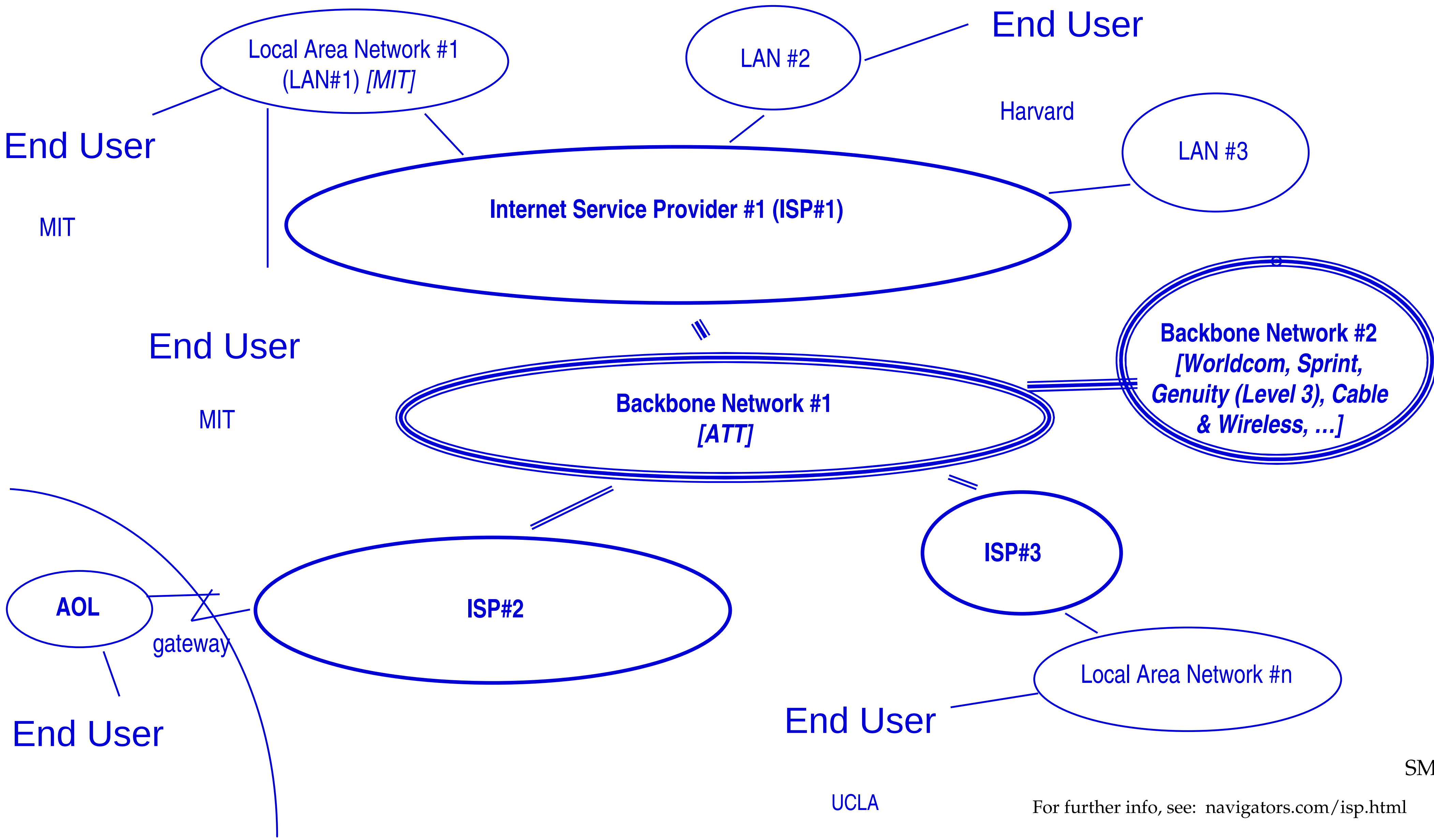
Circuit switching	Packet switching
Minimum delay	Variable delay
Very inefficient use of connection capacity	Much more efficient use of connection capacity
When overloaded, unable to make connection at all	Can almost always connect, but may be long delays
Both ends of connection must use same data rate	Data-rate conversion is easy

The Internet

- **What is the Internet?**
  - **Outgrowth of ARPANET**
  - **Based on TCP/IP**
  - **A collection of interconnected networks**
  - **Provides *appearance* of widespread connectivity**

- **What is it used for?**
  - **E-mail, file transfer, terminal access, client-server traffic, information browsing (aka Web), distributed work, electronic commerce, etc.**

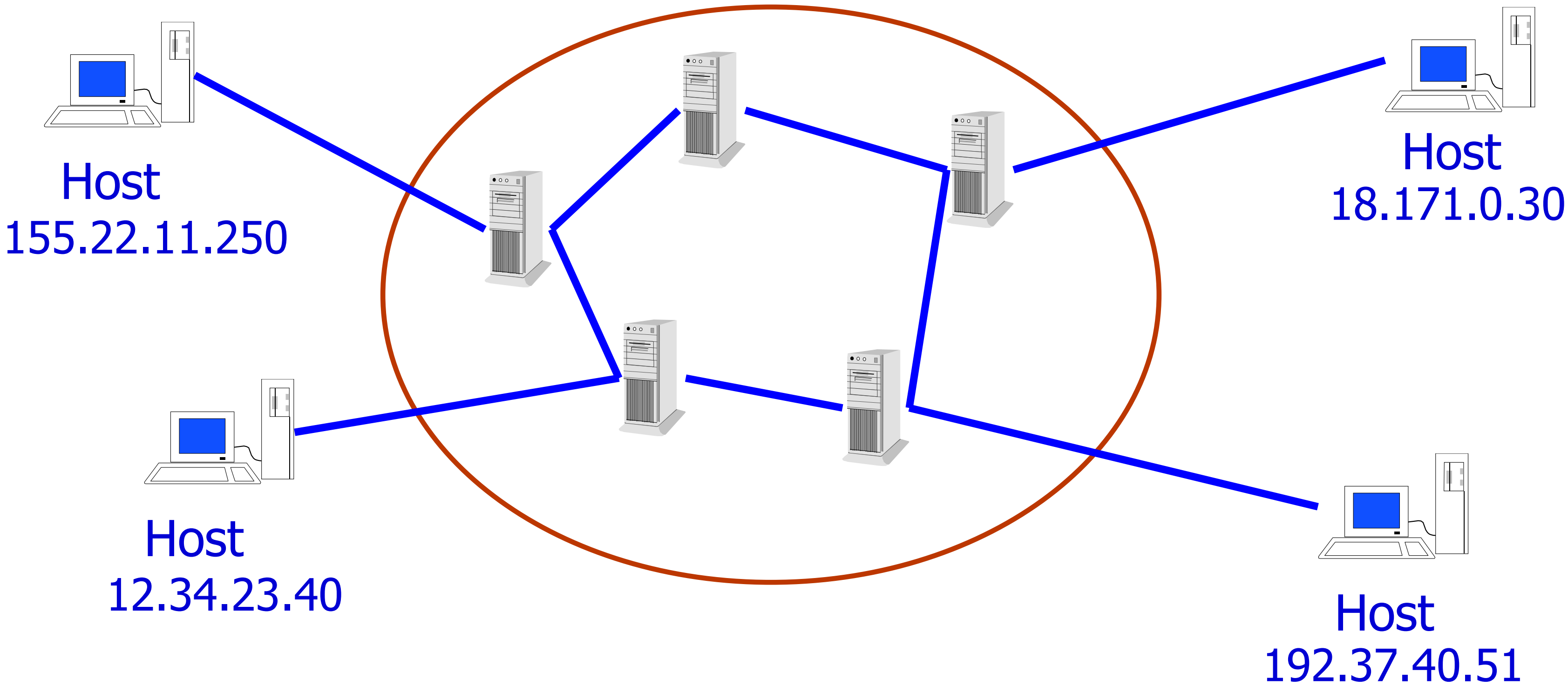
Hierarchy of networks



SM

For further info, see: navigators.com/isp.html

Internet Addresses (IP addresses)



Understanding Internet Addresses

- 18.154.0.27
  - uniquely assigned to a specific Internet connection point
  - 32-bit address
  - each number between dots is the decimal representation of 8 bits in the address
  - In this case:
    - » 18 specifies MIT (MIT owns all addresses 18.xxx.yyy.zzz)
    - » 154 specifies the subnet corresponding to building E56
    - » 0.27 is host number within the subnet
  - Every internet address can optionally have a descriptive host name (e.g.LASAGNA.MIT.EDU)

Who controls the Internet?