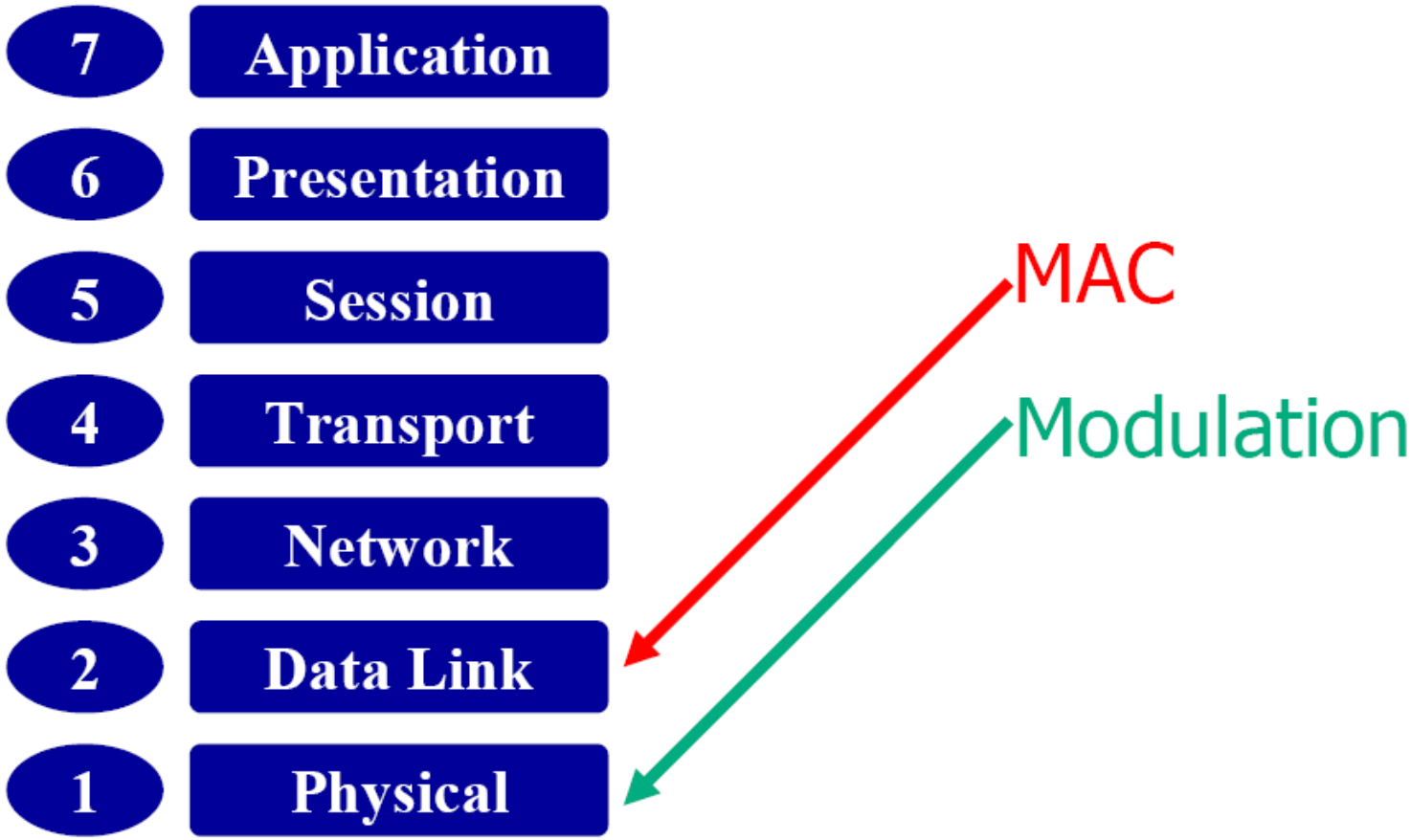
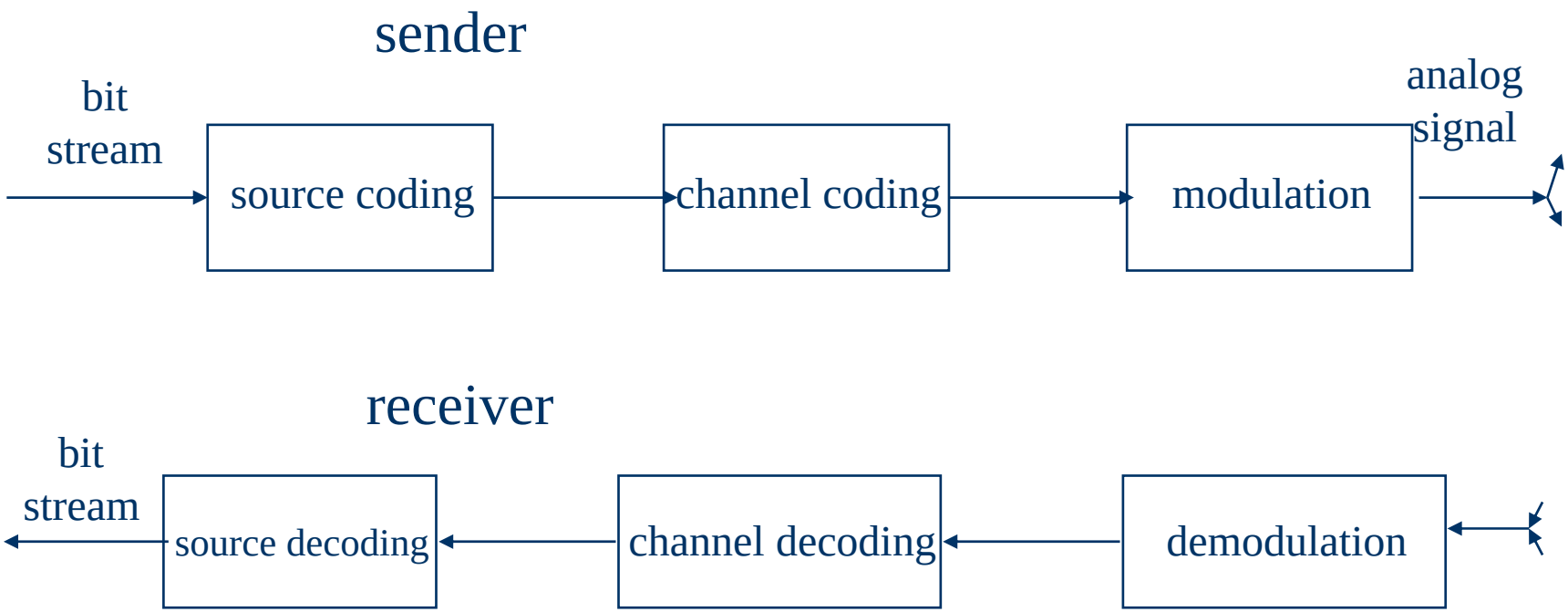
Computer Networks

Computer Network Overview

OSI Model & Wireless LAN



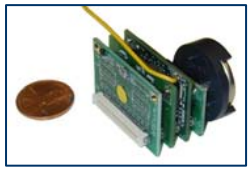
Overview of Wireless Transmissions



Heterogeneous Devices

Laptop
- fully functional
- standard applications
- battery; 802.11

PDA
- data
- simpler graphical displays
- 802.11



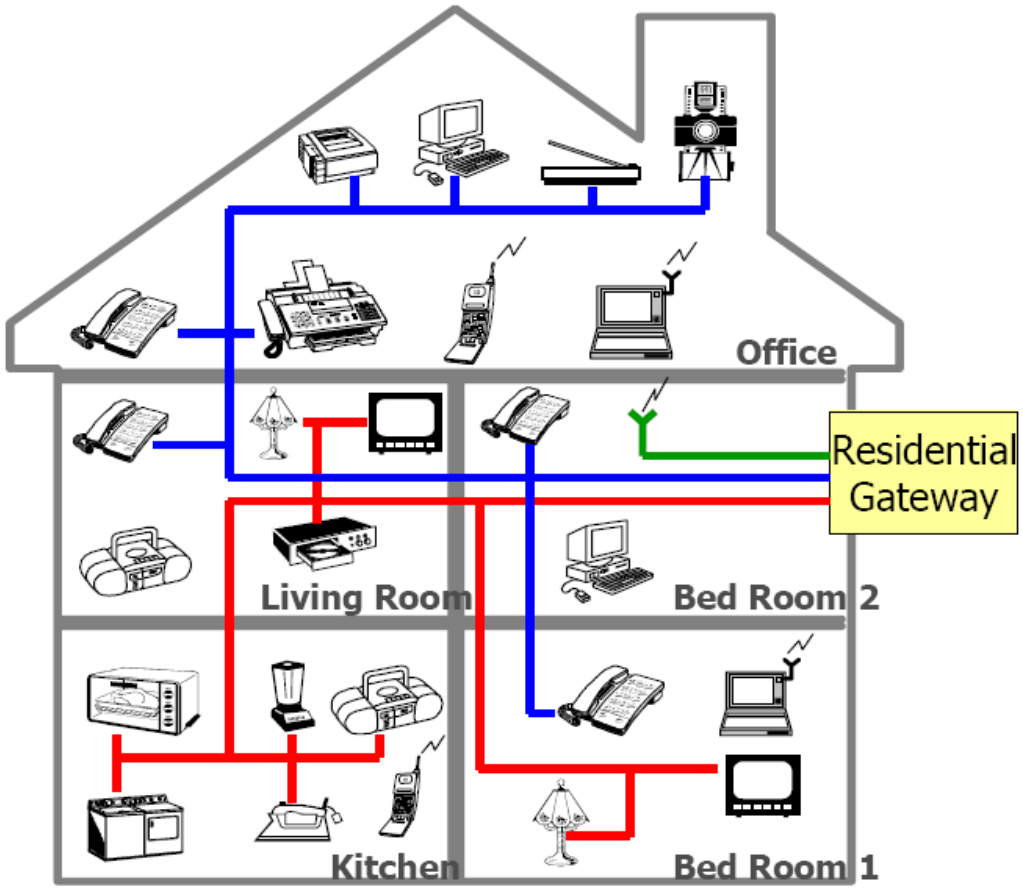
Mobile phones
- voice, data
- simple graphical displays
- GSM

Sensors, embedded controllers

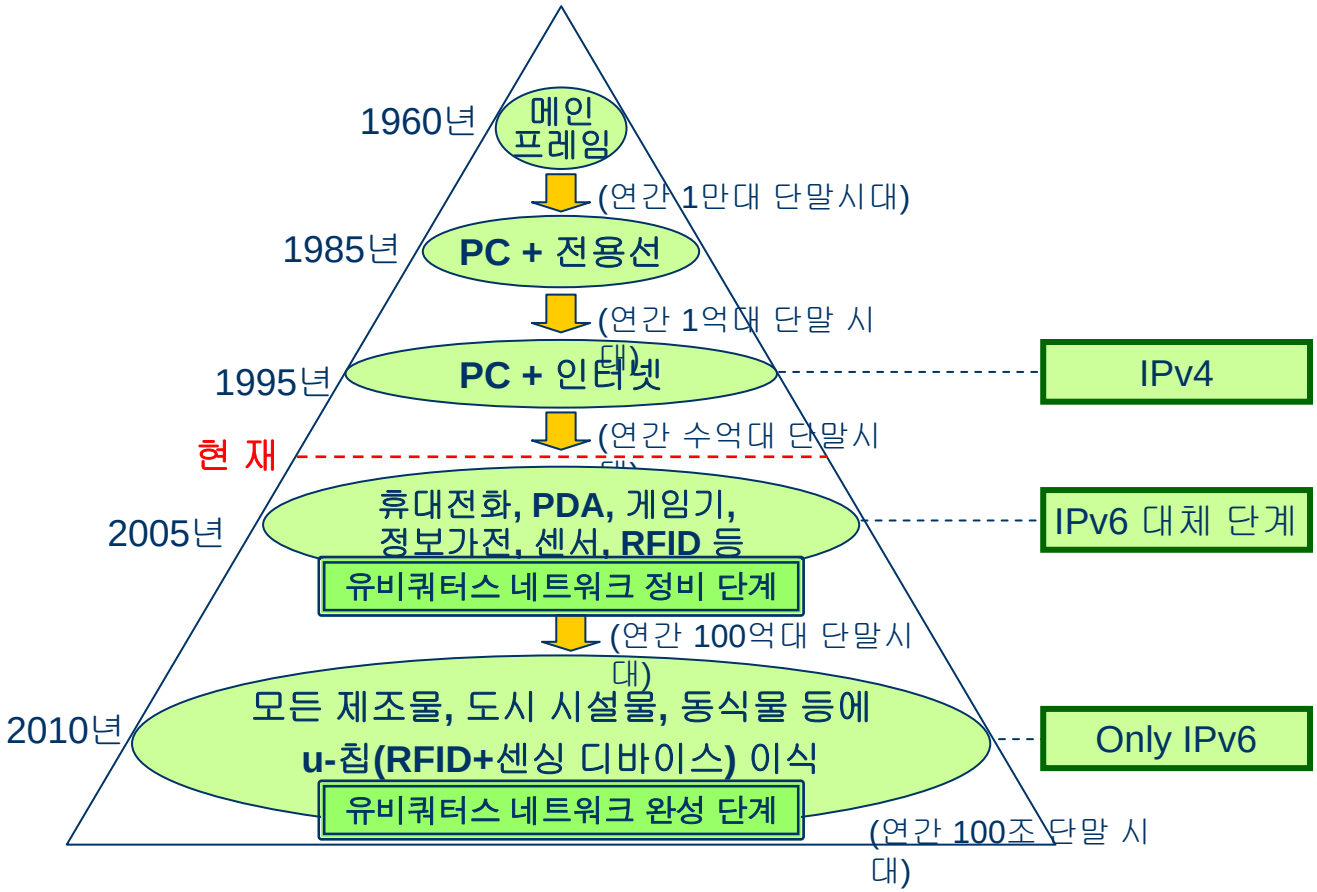
Desktop
- fully functional
- standard applications
- unlimited power supp.
- Gbps Ethernet

Performance/Weight/Power Consumption

Home Network



유비쿼터스 네트워크로의 전개 구도



PART I

Introduction

Topic And Scope

Computer networks and internets: an overview of concepts, terminology, and technologies that form the basis for digital communication in private corporate networks and the global Internet

You Will Learn

Terminology

Communication basics

- Media and signals
- Asynchronous and synchronous communication
- Relationships among bandwidth, throughput, and noise
- Frequency-division and time-division multiplexing

You Will Learn (continued)

Networking and network technologies
- Packet switching
- Framing, parity, and error detection
- Local and wide area technologies
- Network addressing
- Connection and extension (repeaters, bridges, hubs, switches)
- Topologies and wiring (star, ring, bus)
- Next-hop forwarding
- Shortest path computation
- Measures of delay and throughput
- Protocol layers

You Will Learn (continued)

Internets and Internetworking

- Motivation and concept
- Internet Protocol (IP) datagram format and addressing
- Internet routers and routing
- Address binding (ARP)
- Internet control messages (ICMP)
- User Datagram Protocol (UDP)
- Transmission Control Protocol (TCP)
- Protocol ports and demultiplexing

You Will Learn (continued)

Network applications

- Client-server paradigm
- Domain name system (DNS)
- File transfer (FTP)
- Mail transfer (SMTP)
- IP Telephony
- Remote login (TELNET)
- Web technologies and protocols (HTTP, CGI)
- Network security

What You Will Not Learn

Commercial aspects

- Products
- Vendors
- Prices
- Network operating systems

How to purchase/configure/operate

How to design/implement protocol software

Background Required

Ability to program in C

Knowledge of low-level programming constructs

- Pointers
- Bit fields in structures
- Printf

Familiarity with basic tools

- Text editor
- Compiler/linker/loader

Background Required (continued)

Basic knowledge of operating systems

- Terminology
- Functionality
- Processes and concurrent processing

Desire to learn

Schedule Of Topics (in USA)

Signals, media, bandwidth, throughput, and multiplexing(~1 weeks)

Networking: concepts, technologies (~4 weeks)

Internetworking fundamentals (~5 weeks)

Internet applications (~5 weeks)

Motivation For Networking

- Information access
- Interaction among cooperative application programs
- Resource sharing

Practical Results

- E-mail
- File transfer/access
- Web browsing
- Remote login/execution
- IP Telephony
- The Internet

What A Network Includes

- Transmission hardware
- Special-purpose hardware devices
  - Interconnect transmission media
  - Control transmission
  - Run protocol software
- Protocol software
  - Encodes and formats data
  - Detects and corrects problems

What A Network Does

- Provides communication that is
  - Reliable
  - Fair
  - Efficient
  - Secure
  - From one application to another

What A Network Does (continued)

- Automatically detects and corrects
  - Data corruption
  - Data loss
  - Duplication
  - Out-of-order delivery
- Automatically finds optimal path from source to destination

Network Programming

- Network allows arbitrary applications to communicate
- Programmer does not need to understand network technologies
- Network facilities accessed through an *Application Program Interface*

Basic Paradigm For Internet Communication

- Establish contact
- Exchange data (bi-directional)
- Terminate contact

Establishing Contact

- Performed by pair of applications
- One application starts and waits for contact (called *server*)
- Other application initiates contact (called *client*)

Representations And Translations

- Humans use names such as
  - *www.netbook.cs.purdue.edu* (computer)
  - *ftp* (application)
- Network protocols require binary values
- Library routines exist to translate from names to numbers

PART II

Signals, Media, and Data Transmission

Transmission Of Information

- Well-understood basics
- From physics
  - Energy
  - Electromagnetic wave propagation
- From mathematics
  - Coding theory

Transmission Media

- Copper wire
  - Need two wires
  - Possibilities
  * Twisted pair
  * Coaxial cable
- Optical fiber
  - Flexible
  - Light “stays in”
- Air/space
  - Used for electromagnetic transmission

Forms Of Energy Used To Transmit Data

- Electric current
- Audible sounds
- Omni-directional electromagnetic waves
  - Radio Frequency (RF)
  - Infrared

Forms Of Energy Used To Transmit Data (continued)

Directional electromagnetic waves

- Point-to-point satellite channel
- Limited broadcast (spot beam)
- Microwave
- Laser beam

Types Of Satellites

- Geosynchronous Earth Orbit (GEO)
- Low Earth Orbit (LEO)
  - Array needed

Two Important Physical Limits Of A Transmission System

- *Propagation delay*
  - Time required for signal to travel across media
  - Example: electromagnetic radiation travels through space at the speed of light (*C*=3´108 meters per second)
- *Bandwidth*
  - Maximum times per second the signal can change

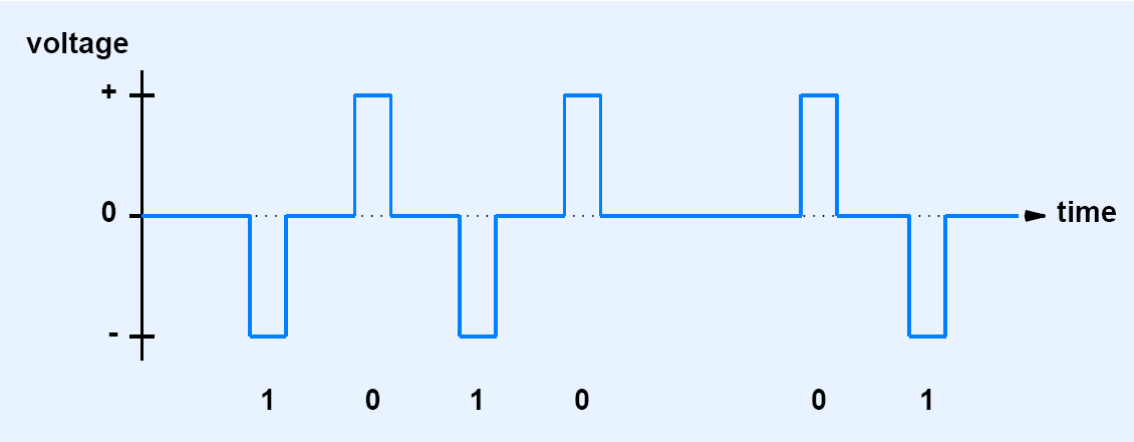
Transmission Of Data

- Network hardware encodes information for transmission
- Two types of encoding
  - Analog (amount of energy proportional to value of item sent)
  - Digital (two forms of energy to encode *0* and *1*)
- Computer networks use the latter

Example Digital Encoding

- Medium
  - Copper wire
- Energy form
  - Electric current
- Encoding
  - Negative voltage encodes *1*
  - Positive voltage encodes *0*

Illustration Of Digital Encoding



- Known as *waveform diagram*
- X-axis corresponds to time
- Y-axis corresponds to voltage

Encoding Details

- All details specified by a *standard*
- Several organizations produce networking standards
  - IEEE
  - ITU
  - EIA
- Hardware that adheres to standard interoperable

The RS-232C Standard

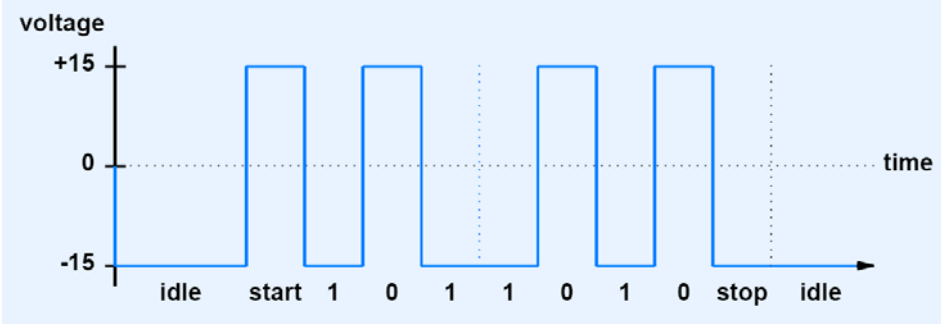
- Example use
  - Connection to keyboard/mouse
  - Serial port on PC
- Specified by *EIA*
- Voltage is +15 or −15
- Cable limited to ~50 feet
- Newer EIA standard is RS-422 (ITU standard is V.24)
- Uses *asynchronous* communication

Asynchronous Communication

- Sender and receiver must agree on
- – Number of bits per character
- – Duration of each bit
- Receiver
- – Does not know when a character will arrive
- – May wait forever
- To ensure meaningful exchange send
- – Start bit before character
- – One or more stop bits after character

Illustration Of RS-232

- Start bit
  - Same as *0*
  - Not part of data
- Stop bit
  - Same as *1*
  - Follows data



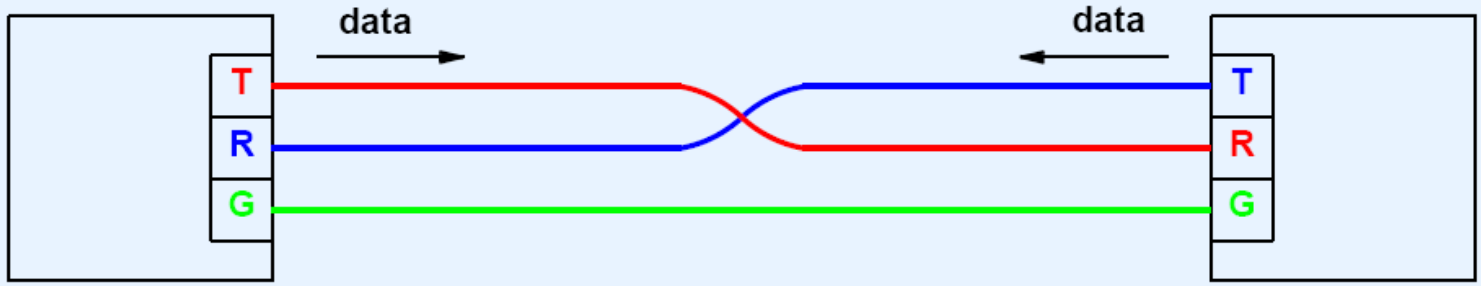
Duration Of A Bit In RS-232C

- Determined by *baud rate*
  - Example baud rates: 9.6 Kbaud, 28.8 Kbaud, 33.6 Kbaud
  - Duration of bit is 1/baud_rate
- Sender and receiver must agree *a priori*
- Receiver samples signal
- Disagreement results in *framing error*

Two-Way Communication

- Desirable in practice
- Requires each side to have transmitter and receiver
- Called *full duplex*

Illustration Of Full-Duplex Communication



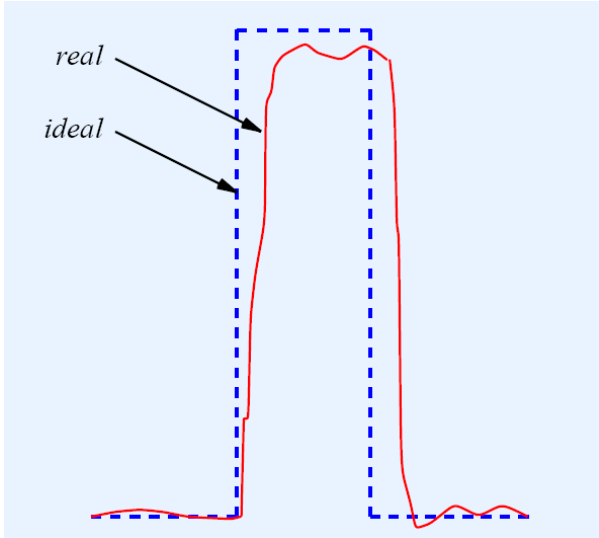
- Transmitter on one side connected to receiver on other
- Separate wires needed to carry current in each direction
- Common *ground wire*
- DB-9, DB-15, or DB-25 connector used
  - Pin *2* is transmit
  - Pin *3* is receive

Electrical Transmission (The Bad News)

- It's an ugly world
  - Electrical energy dissipates as it travels along
  - Wires have resistance, capacitance, and inductance which distort signals
  - Magnetic or electrical interference distorts signals
  - Distortion can result in loss or misinterpretation

Illustration Of Distorted Signal For A Single Bit

- In practice
  - Distortion can be much worse than illustrated



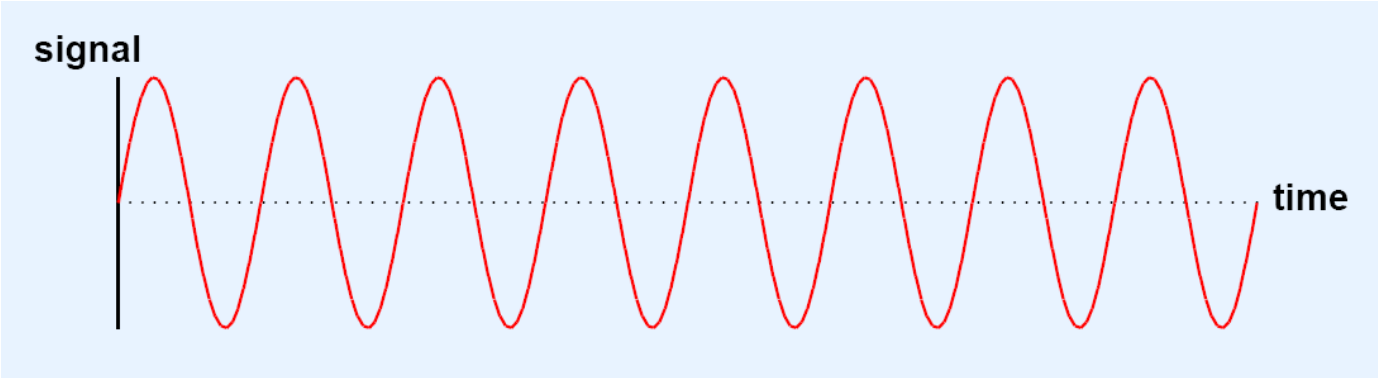
Consequences

- RS-232 hardware must handle minor distortions
  - Take multiple samples per bit
  - Tolerate less than full voltage
- Cannot use electrical current for long-distance transmission

Long-Distance Communication

- Important fact: an oscillating signal travels farther than direct current
- For long-distance communication
  - Send a sine wave (called a *carrier wave*)
  - Change (*modulate*) the carrier to encode data
- Note: modulated carrier technique used for radio and television

Illustration Of A Carrier

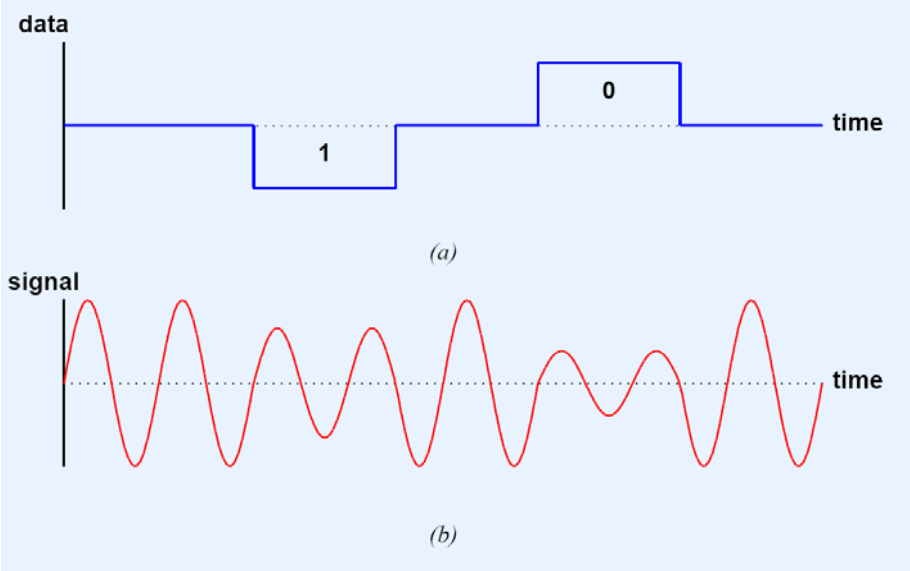


- Carrier
  - Usually a sine wave
  - Oscillates continuously
- Frequency of carrier fixed

Types Of Modulation

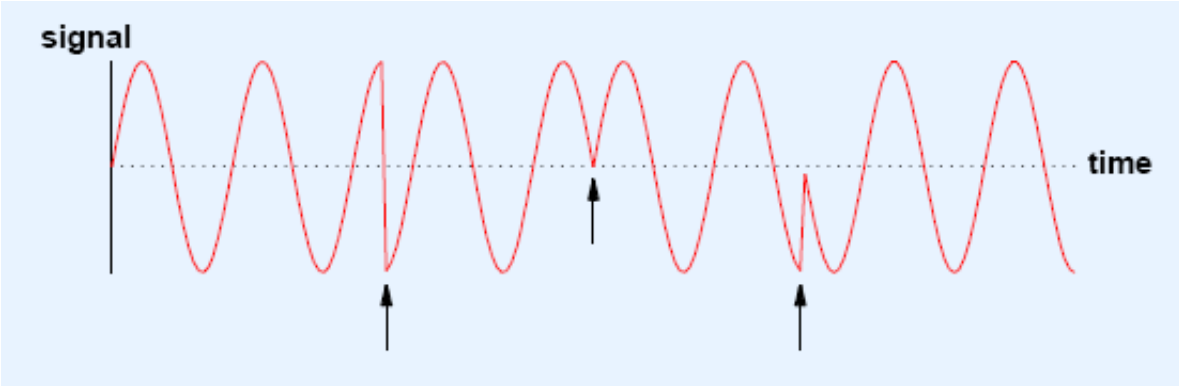
- Amplitude modulation (used in AM radio)
- Frequency modulation (used in FM radio)
- Phase shift modulation (used for data)

Illustration Of Amplitude Modulation



- Strength of signal encodes *0* or *1*
- One cycle of wave needed for each bit
- Data rate limited by carrier bandwidth

Illustration Of Phase-Shift Modulation



- Change in phase encodes *K* bits
- Data rate higher than carrier bandwidth