School of Business
Eastern Illinois University

Fundamentals of Data & Signals

(September 26, 2016)

Learning Objectives

- Distinguish between Data and Signals
- Understand transmission speed
- Distinguish between Bit Rate and Baud Rate

Data and Signals

- Ingredients of computer networks
  - Computers
  - Transmission media
  - Hubs/Switches
  - Routers, bridges
  - Etc.
- Other ingredients
  - Software
  - Data
  - Signals

Data

4

- Data = Entities that convey meaning within a computer system
- Examples of data (captured and stored on storage devices)
  - Files on a hard drive
  - Movie on a DVD
  - Music on a CD
- For transmission, Data (static entities) need to be converted into signals (dynamic entities)

Signals

5

- Signal = Electric or electromagnetic encoding of data for transmission
  - Using a physical transmission medium
  - Using airwaves
- Examples of signals (situations)
  - Telephone conversation over a telephone line
  - Live television news interview from Europe
  - Web page download over your telephone line via the Internet

Data and Signals

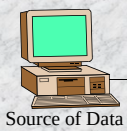
6

- Both Data (sources of data) and Signals can be
  - either analog
  - or digital
- Four combinations
  - Transmitting digital data using digital signals
  - Transmitting digital data using analog signals
  - Transmitting analog data using analog signals
  - Transmitting analog data using digital signals
- Need Translation devices

Translation Devices

7

- Source of Data versus Line ☆☆☆



Translator — Transmission Line

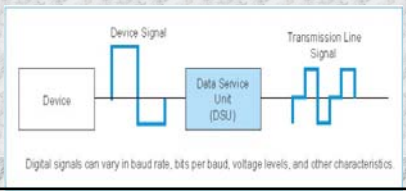
Source of Data

	Analog Line	Digital Line
Analog Device (e.g. Tel)		Codec
Digital Device (e.g. Computer)	Modem	DSU

DSU (Data Service Unit)

8

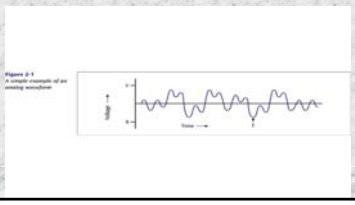
- DSU translates between different digital formats
  - Device and line are both digital, but still might need translator because
    - Different bit rates
    - Different number of possible states
    - Different voltage levels for the states
    - Different ways to represent ones and zeros ☆



Analog signals ☆

9

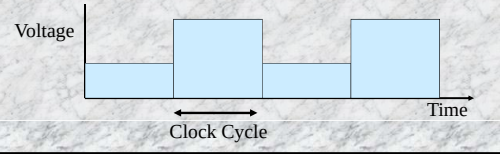
- Represented as continuous waveforms
- In *analog transmission,* the state of the signal (voltage level, etc.) varies continuously and smoothly among an infinite number of states
  - States could be signal strength, voltage level, or other measurable conditions



Digital signals

10

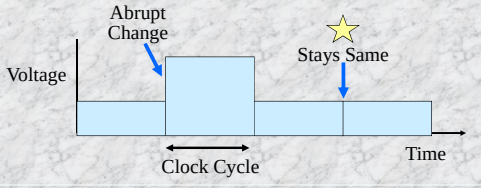
- Represented as discrete (non-continuous) waveform
- In *digital transmission*, time is divided into periods of fixed length called *clock cycles*
- The state of the signal (voltage level, etc.) remain constant during each clock cycle.
  - Typically, there are between two and 64 possible states.
  - Here, only two states are shown



Digital Signals

11

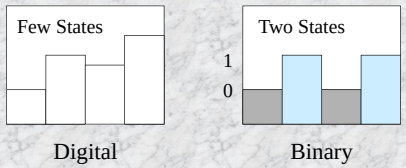
- At the end of each clock cycle, the state *may* change abruptly to another of the few possible states
  - Can also stay the same



Digital Versus Binary Transmission

12

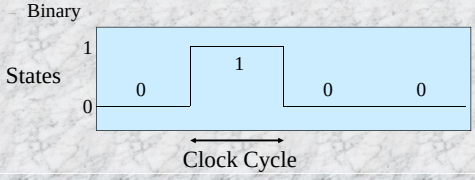
- ***Digital transmission***: *a few* states
- ***Binary transmission***: *exactly two* states (1 and 0)
  - Binary is a special case of digital



States and Bits

13

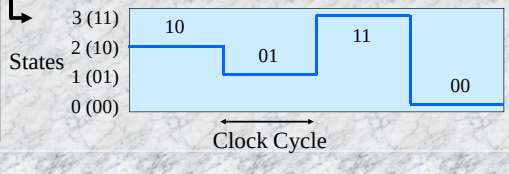
- $2^{\text{Bits per clock cycle}}$=Number of states
  - For 1 bit per clock cycle,
  - 2 states are required (One for 1, one for 0)
  - $2^1=2$
  - Binary



States and Bits

14

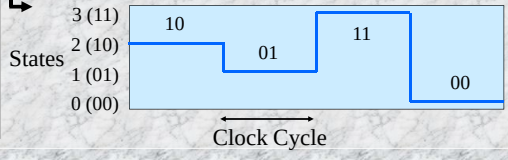
- $2^{\text{Bits/clock cycle}}$=States
  - For 2 bits per clock cycle, 4 states are required ($2^2=4$)
  - For 3 bits per clock cycle, 8 states are needed ($2^3=8$)
  - For 4 bits per clock cycle, 16 states are needed ($2^4=16$)



States and Bits

15

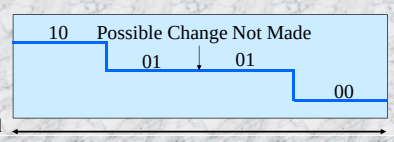
- $2^{\text{Bits per clock cycle}}$=States
  - With 4 states, send two bits per clock cycle ($2^2=4$)
  - With 8 states, send 3 bits per clock cycle ($2^3=8$)
  - With 16 states, send 4 bits per clock cycle ($2^4=16$)



Bits and Baud

16

- Baud Rate = Number of clock cycles/sec
  - In this example, 4 baud (not 4 bauds/second)
  - Note: Number of clock cycles, not actual line changes
- Bit Rate = Number of bits/second
  - In this example, 8 bits/second
- Bit Rate = Baud Rate * Bits per clock cycle



Equations

17

- # of states
  - $2^{\text{Bits per clock cycle}}$ = Number of possible states (Eq. 1)
- Bit rate
  - Bit rate = Baud Rate * Bits per clock cycle (Eq. 2)
- Exercise
  - (See next slide)

Exercise

18

A) If a transmission line has a Baud rate of 10 000 baud, and if there are eight possible line states, what is the Bit rate?

B) If you wish to send two bits per clock cycle, how many possible states must you have?

Summary Questions

19

1. Distinguish between digital and analog signals	9-10
2. Distinguish between digital and binary transmission	12
3. What is the difference between the bit rate and the baud rate?	16