# Lecture 1 Notes

Exercise 1: For each of the following digital communication services identify the source, sink and the channel(s) involved: the Ethernet connection between a computer and a router; a cell phone call; watching a YouTube video at home.

computer ──────── router

↑ source

ethernet cable (channel)

↑ sink

sound

free space

person

Y.Tube server

laptop

internet
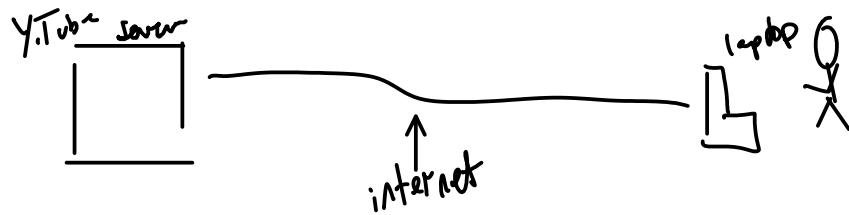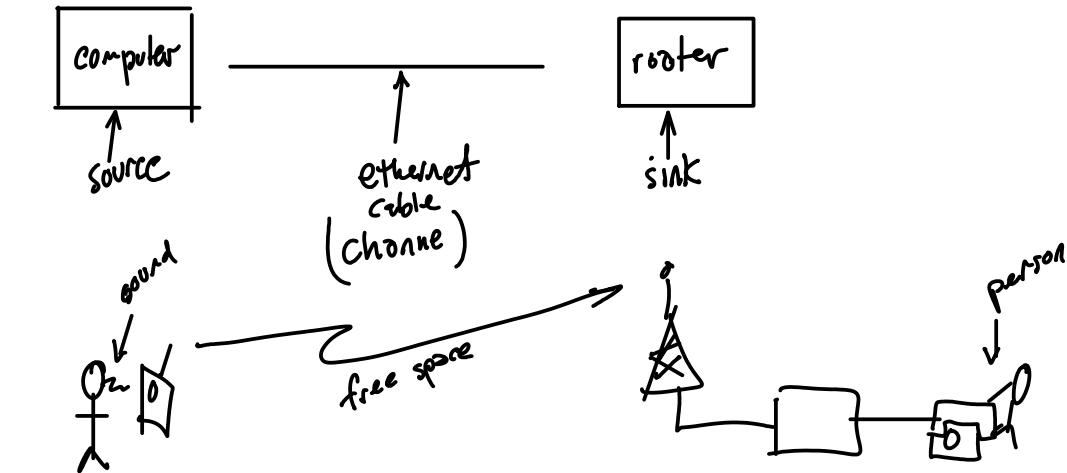
	for humans	for machines
tolerant of undetected errors	Y	N
tolerant of delay	N	Y

Exercise 2: What units would be used to specify error rate, delay, and delay variability? For each of the following data sources/sinks identify the relative data rate variability and the tolerance it is likely to have to errors, to the absolute delay and to the delay variability: a phone call between two people, downloading a computer program, streaming a video over a computer network. Try to estimate typical values.

$$\frac{\text{error free s.}}{\text{total s.}} \left\} \begin{array}{l}\text{alternative}\\\text{error}\\\text{rate}\\\text{measure}\end{array}\right.$$

$$\frac{b}{S} = \frac{\text{bits}}{\text{second}}$$

error rate : $\left\{ \dfrac{\text{bits in error}}{\text{total bits}} \right\}$ $\rightarrow$ useful for random (not bursty) error

< 1 max.
$< \frac{1}{2}$ typically

unitless: $\left\{ \begin{array}{l} \% \\ p.u \\ 10^{-6} \end{array} \right.$

delay: time $\left(\begin{array}{l} S \\ MS \\ \mu S \end{array} \right.$

delay variability:
- maximum deviation
- average deviation
- standard deviation
- variance

$\left. \right\}$ statistics

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tolerance to

	errors	delay	delay variability
phone call	H (reasonably low error rates)	L $\ll$ 1s	—— (L)
down loading	L	H	H
streaming	L	H	—— (H)

buffering converts variability to delay

O

1

T_{symbol}

$f_{symbol} = \dfrac{1}{T_{symbol}}$

1

0

$$f = \dfrac{1}{T} \leftarrow \text{period}$$

frequency

1
2
4
8
16
32
64
128
256
512
1024 — 2^{10}
2048 — 2^{11}
4096

Ex. 3
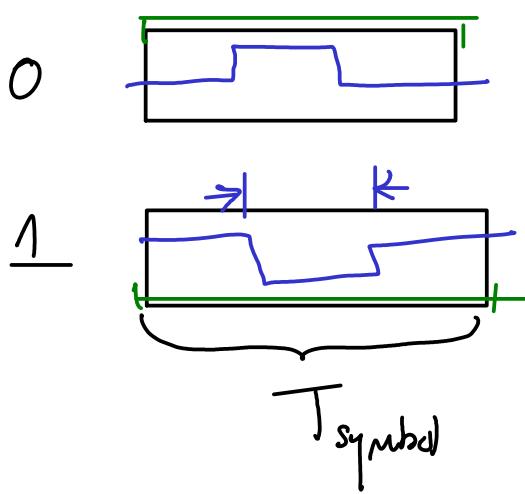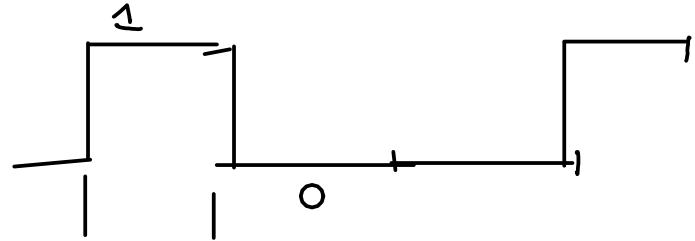
```
3525
2048   2^11
─────
1477
1024   2^10
─────
 453
 256   2^8
─────
 197
 128   2^7
─────
  69
  64   2^6
─────
   5
   4   2^2
─────
   1   2^0
```

big endian or
"network" order

12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	1	0	1	1	1	0	0	0	1	0	1

0   P   C   S

little endian order

1010   0011   1011   0000
 A   3   B   0

0xA3B0 ← 'c' syntax

$A3B0 ← Motorola syntax

A a ä
─────────
  glyphs

Ex.4   3 5 2 5   4 characters (not a number)

0x33   0x35   0x32   0x35

0011 0011   0011 0101   0011 0010   0011 0101   ← binary, Msbit first

$\underbrace{\underline{0011} \ \underline{0011}}_{'3'}$

1 100 1100   1010 1100

V_+

V_-

V_{diff}

V_{CM}

0

V_{diff}

0   0

0