ITS 323 –CHEAT SHEET

The following contains some important concepts and equations that we have learnt in ITS 323 during the first half of semester. **This is not everything** – there are other important topics that are covered in lectures but not included in this handout.

1 Basic Maths

1.1 Logarithms

$a = \log_n(b)$

$n^a = b$

$\log(xy) = \log(x) + \log(y)$

$\log(x/y) = \log(x) - \log(y)$

$10^x \times 10^y = 10^{(x+y)}$

$10^x / 10^y = 10^{(x-y)}$

$$\log_2(x) = \frac{\log_{10}(x)}{\log_{10}(2)}$$

1.2 Units

G: 1,000,000,000 or 10^9
M: 1,000,000 or 10^6
K (or k): 1,000 or 10^3
m: 0.001 or 10^{-3}
µ: 0.000001 or 10^{-6}
n: 0.000000001 or 10^{-9}
b: bit
B: byte = 8 bits

1.3 Power and Decibels

Decibel gain, $G_{dB} = 10 \log_{10}(P_{out}/P_{in})$
$Power_{dBW} = 10 \log(Power_W / 1W)$
$Power_{dBm} = 10 \log(Power_{mW} / 1mW)$

2 Protocol Architectures

2.1 Layered Models

OSI (7)	*Internet (5)*
Application	Application
Presentation	--
Session	--
Transport	Transport
Network	Network
Data Link	Data Link
Physical	Physical

2.2 Address Types

Application (or user-specific), e.g. www.google.com
Transport or ports, e.g. 80 for web servers
Network (or logical or IP), e.g. 192.168.1.3
Physical (or MAC or Data link or Hardware, e.g. 07:01:02:01:2C:4B

2.3 Performance

Throughput: rate at which receiver receives real (or useful) data
Delay:
Propagation = Distance [m] / Velocity [m/s]
Transmission = DataSize [b] / DataRate [b/s]
Queuing: time spent in queues at computers
Processing: time computers spend processing data
Speed of light: 3 x 10^8 m/s

3 Data Transmission and Media

3.1 Signals

$s(t) = A\sin(2\pi ft + \phi)$

$T = 1/f$

$\lambda = v/f$

Spectrum is range of frequencies in a signal (or system)
Bandwidth is difference between maximum frequency component and minimum frequency component (sometimes practical limits)

3.2 Capacity

Nyquist bandwidth: $C = 2B\log_2(M)$
Shannon capacity: $C = B\log_2(1+SNR)$
SNR = SignalPower/NoisePower
$SNR_{dB} = 10 \log_{10}(SNR)$

3.3 Propagation

Antenna gain: $G = \frac{4\pi A}{\lambda^2}$

Free-space propagation:

$$\frac{P_t}{P_r} = \frac{(4\pi d)^2}{G_t G_r \lambda^2}$$

4 Signal Encoding Techniques

4.1 Digital Data on Digital Signals

Non-Return to Zero Level (NRZ-L)
0 = high level
1 = low level
Non-Return to Zero Invert on Ones (NRZI)
0 = no transition at beginning of bit interval
1 = transition at beginning of bit interval
Other schemes

See the lecture notes and make sure you understand them!

4.2 Digital Data on Analog Signals

Vary the Amplitude, Frequency or Phase of the waveform to represent different sequences of bits.

- Amplitude Shift Keying (ASK)
- Frequency Shift Keying (FSK)
- Phase Shift Keying (PSK)

Can use two levels (e.g. Binary FSK) or multiple levels. Can also combine the three to create multiple levels. Each level represents a sequence of bits.

4.3 Analog Data on Digital Signals

Convert the Analog Data into Digital Data, and then send on Digital Signal using encoding schemes like NRZ, …

Sampling theorem: must sample at a rate two times the highest signal frequency

Analog to Digital data conversion using Pulse Code Modulation (PCM)

- Measure the signal at each time instant (according to sampling rate)
- Map the measured value into an integer value
- Map the integer value into a binary value
- The resulting binary sequence is the digital data

4.4 Analog Data on Analog Signals

Often want to send the analog signal at different frequency to analog data. Therefore modulation the analog data using Amplitude, Frequency or Phase Modulation.

5 Digital Data Communications

5.1 Error Detection

Add extra information to data – called the error detecting code.

Receiver uses the error detecting code to try to detect errors.

Single bit odd parity check: transmitter adds 1-bit to the front of data so that total bits has odd number of 1's. Receiver counts number of 1's – if odd, then assume no error. If even, then assume error.

Single bit even parity check: transmitter adds 1-bit to the front of data so that total bits has even number of 1's. Receiver counts number of 1's – if even, then assume no error. If odd, then assume error.

CRC: see lecture notes.

5.2 Error Correction

Also called forward error correction (FEC)

Transmitter sends redundant information; receiver uses it to try to detect and correct errors.

Hamming Distance: number of bits that differ in two sequences of bits.

Example error correction code using Hamming – see lecture notes.

6 Data Link Control Protocols

6.1 Flow Control

Aim: prevent sender from sending too fast for receiver.

Stop and Wait Flow Control: sender can only send next frame, once it has received ACK for previous frame.

Efficiency depends on propagation and transmission time: in general, if propagation is larger than transmission, then inefficient.

Sliding Window Flow Control: sender can send W frames before waiting for ACK.

- Each frame has sequence number: 0 to 2^k
- Maximum size of W is 2^k -1
- k is the number of bits available in the frame to store the sequence number

6.2 Error Control

An alternative/complementary techniques to those in Digital Data Communications.

Automatic Repeat Request (ARQ): retransmit data if don't receive an acknowledgement that it was successfully received.

Stop and Wait ARQ: Same as Stop and Wait Flow Control, but also retransmissions and timeouts.

Go-Back-N: Same as Sliding window, but retransmit all N frames if error indicated by received

Selective-Reject: Same as Go-Back-N, except only retransmit 1 error frame

7 Multiplexing

Concept: allow data from multiple users to be sent over a single link

Frequency Division Multiplexing (FDM): send input signals at different frequencies

Time Division Multiplexing (TDM): send input data at different times