CMPEN362 — Formulas

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Chapter 1

#supported users

R: link capacity, p: fraction of active time, r: transmission rate, τ: maximum congestion probability.
Circuit switching: $\lfloor R/r \rfloor$
Packet switching: $\max N$ s.t. $\sum_{n=\lfloor R/r \rfloor+1}^{N} \binom{N}{n} p^n (1-p)^{N-n} \leq \tau$

Delay calculation

M: message size, h: #hops, R_i: capacity of i-th link, d_i: propagation delay at i-th link, P: #packets
E2e delay without segmentation: $\sum_{i=1}^{h} (\frac{M}{R_i} + d_i)$
E2e delay with segmentation: $\sum_{i=1}^{h} (\frac{M}{PR_i} + d_i) + \frac{M/P}{\min_{i \in \{1,\ldots,h\}} R_i}(P-1)$

Chapter 2

HTTP response time

s_h: size of base HTML, s_o: size per object, n: #objects, R: e2e throughput, t: RTT
Non-persistent HTTP with c parallel connections: $2t + \frac{s_h}{R} + \lceil \frac{n}{c} \rceil \cdot (2t + \frac{s_o}{R})$
Persistent HTTP without pipelining: $2t + \frac{s_h}{R} + n(t + \frac{s_o}{R})$
Persistent HTTP with pipelining: $2t + \frac{s_h}{R} + t + \frac{n \cdot s_o}{R}$

Single object downloading time

T: Internet delay, s_o: object size, λ: request rate, p: cache hit probability, R_a: access link capacity, R_l: LAN capacity

$$(1-p)(T+\frac{1}{\frac{R_a}{s_o}-\lambda(1-p)}+\frac{s_o}{R_l})+p\cdot\frac{s_o}{R_l}$$

File distribution time

x: file size, R_s: server upload capacity, R_i^u: user i's upload capacity, R_i^d: user i's download capacity, K: #users
Client-server: $\max(\frac{K\cdot x}{R_s},\ \frac{x}{\min_{i=1,\dots,K} R_i^d})$
P2p: $\max(\frac{x}{R_s},\ \frac{x}{\min_{i=1,\dots,K} R_i^d},\ \frac{K\cdot x}{R_s+\sum_{i=1}^{K} R_i^u})$

Chapter 3

TCP throughput

Throughput = (total #bits per period)/(#rounds per period $\cdot$ RTT)
Formula related to computing the total #bits:
Arithmetic series: $\sum_{i=1}^{n}(a_0+(i-1)d)=\frac{n}{2}(2a_0+(n-1)d)$
Geometric series: $\sum_{i=1}^{n} a_0 r^{i-1}=\frac{a_0(1-r^n)}{1-r}$

Chapter 6

Efficiency of random access protocols

N: number of nodes, p: transmission probability
slotted ALOHA: efficiency = $Np(1-p)^{N-1}$
unslotted ALOHA: efficiency = $Np(1-p)^{2(N-1)}$

Physical Layer

#received harmonics over a bandwidth-limited link

b: data rate (bps), s: #bits per signal, f_c: cutoff frequency (Hz)
#received harmonics = $\lfloor\frac{f_c s}{b}\rfloor$