Performance modeling

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Recap

- Data networks
- Congestion

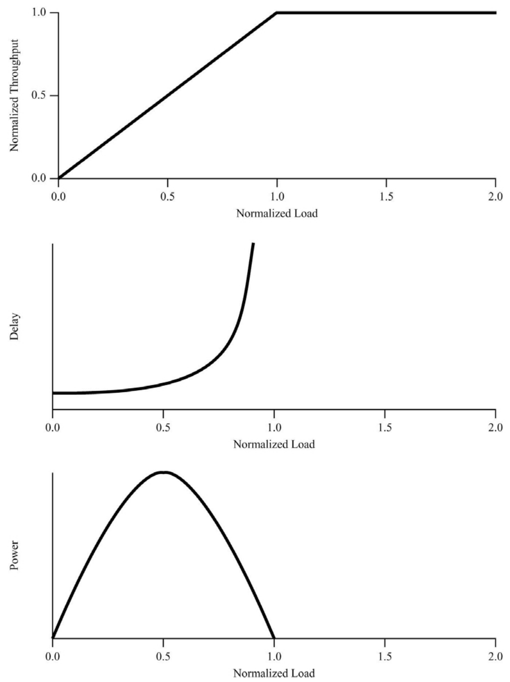
Today's lecture

- Congestion
- Traffic characterization
- Probability
- examples

Congestion

- To see the impact of congestion of network performance, we define:
  - Throughput = delivered packets to dest
  - Offered load = transmitted pkts by src
    - We normalize to max. theoretical throughput
  - Delay
  - Power = ratio of throughput to delay

Ideal case: Infinite buffers



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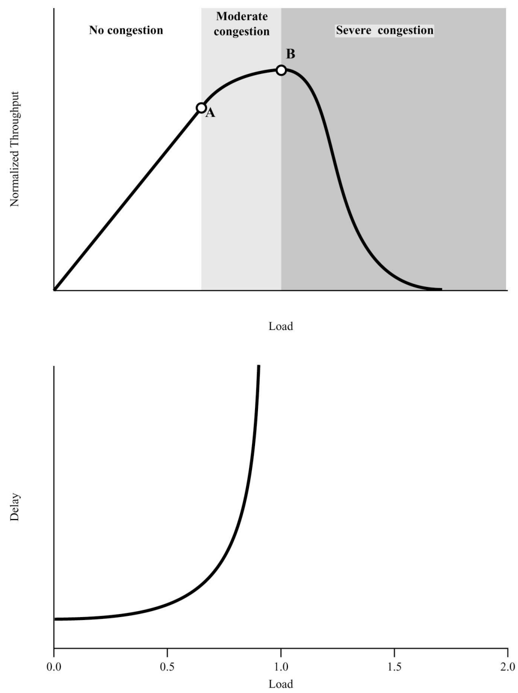
Practical case: finite buffers



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Preliminary

- An important design issue of networking is the ability to model and estimate performance parameters
  - For example, estimate future traffic volumes and characteristics

Why do we need such estimates?

- To study the effect of routing protocols
- To estimate resources needed by reservation protocols
- To study queuing discipline
- To identify buffer sizes needed

Preliminary

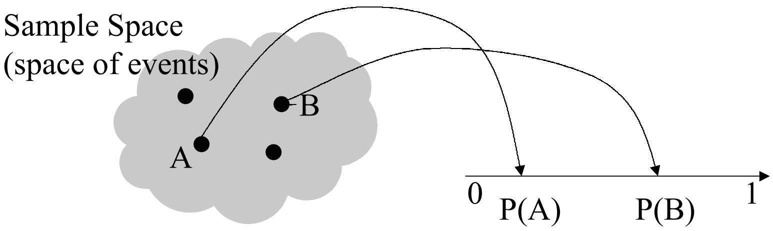
- Parameters used in characterizing data traffic:
  - Throughput characteristics:
    1. Average rate: the load sustained by the source over a time period (resource allocation)
    2. Peak rate: the max. load a source can generate (buffering might be needed for smoothing)
    3. Variability: burstiness of a source

Preliminary

- Delay characteristics:
  1. Transfer delay: delay from source to destination
  2. Delay variation (jitter): variation in transfer delay (impacts real-time applications)

Probability Premier

- Probability P(A) of an event A is a number that corresponds to the likelihood that the event A will occur



Definitions & observations

- 0 P(A) 1
- P(A_i) = 1; A_i is an event in the sample space
- P(A)= N_a/N;
  - N_a= number of outcomes in which A occurred (frequency)
  - N= total number of possible outcome

Definitions & observations

- If two events A & B are mutually exclusive (independent) then:
  - Prob (A or B is to occur) =P(A) + P(B)
  - Prob (A and B to occur) =P(A) * P(B)
  - EX. Out of 2 apples and 3 oranges in a basket, what is the prob. of having 2 oranges when I need to grab three items from the basket?

Definitions & observations

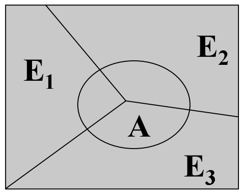
- The conditional prob. of an event A assuming the event B has occurred P(A|B) is (A & B are not independent):
  - P(A|B)=P(AB)/P(B)
  - If A & B are independent:
    - P(A|B)=P(A) & P(A|B)=P(B)

Baye's Theorem

- Given the set of mutual exclusive events $E_1, \ldots, E_n$
  - E_i covers an arbitrary event A
  - $P(A) = \sum_{i=1}^{n} P(A|E_i)P(E_i) = ?$

Then

$P(E_i|A)=P(A|E_i)P(E_i)/P(A)$



Example

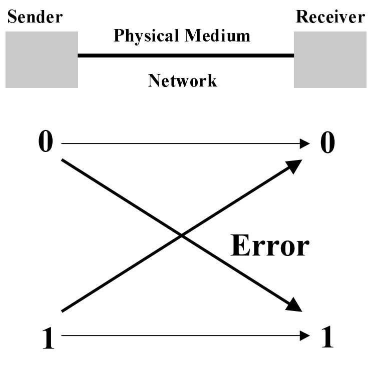
Given,

S_0 = event of sending 0
S_1 = event of sending 1
R_0 = event of receiving 0
R_1 = event of receiving 1

$P(S_0) = p$ $P(S_1) = 1-p$

Also the received data (bits) can be observed

$P(R_0|S_1) = p_a$ & $P(R_1|S_0) = p_b$



Example

- Now to calculate the conditional probability of an error
  - That is a one was sent given that a zero is received

$P(S_1|R_0)= P(R_0|S_1)\ P(S_1) / P(R_0)$

Where $P(R_0) = P(R_0|S_0)\ P(S_0) + P(R_0|S_1)\ P(S_1)$

$P(S_1|R_0)=p_a\, p / [p_a\, p+(1-p_b)(1-p)]$