Simulation of Computer Networks

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Computer Networks

- *A distributed environment*
  - *Millions of nodes are connected to each other*
- *Why its successful?*
  - *Simplicity*
  - *It is a multilayered system*
- *Open System Interconnection Network (OSI) model*
  - *Each layer provide certain services and guarantees to layer above*

Computer Networks

- An application or protocol at particular layer communicates directly with corresponding layer
- Different layers encapsulate different levels of communication abstraction

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OSI Model

- Physical Layer
- Data Link Layer
- Network Layer
- Transport Layer
- Session Layer
- Presentation Layer
- Application Layer

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Physical Layer

- Bit steam signals
- Fiber Optic, Wireless, Bus

Data Link Layer

- Error detection
- Frame based
- Access control (Simulation can be used!)
  - Tradeoffs between access control & techniques
  - A time shared medium

Network Layer

- Packet based
- Routing across subnets
- IP protocol (global addressing)
  - Source/destination addressing
  - Type of data being arrived
- Routers work in this layer
- Simulation is frequently used to study algorithms that manage devices (routers) that implement network layer

Transport Layer

- Message based (segment to packets and vice Vera)
- The assurance of received packets
- Transmission Control Protocol (TCP)
- Detect packet loss
- Flow control algorithms
  - Try to utilize the available bandwidth fully

Traffic modeling

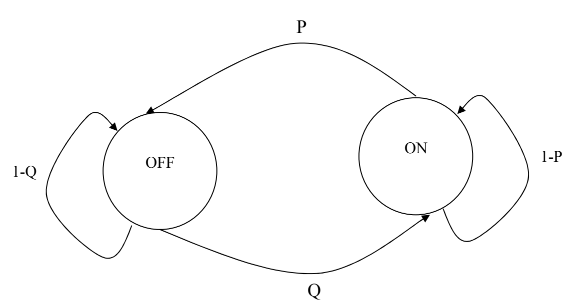
- Bernoulli Traffic

$$E[X] = \lambda_{Bernoulli} = p$$

- Bursty Traffic

Bursty Traffic

- Two states Markov Chains (P,Q,B are inputs)



Bursty Traffic

- The probability of staying n cycles in ON

$$\Pr(T_{on}=n)=P(1-P)^{n-1}, n\geq 1$$

$$\overline{T_{on}}=\sum_{n=1}^{\infty} n\Pr(T_{on}=n)$$

$$=\sum_{n=1}^{\infty} nP(1-P)^{n-1}=P\sum_{n=1}^{\infty} n(1-P)^{n-1}=-P\frac{d}{dP}\left\{\sum_{n=0}^{\infty}(1-P)^{n}\right\}$$

$$=-P\frac{d}{dP}\left\{\frac{1}{1-(1-P)}\right\}=-P\frac{-1}{P^{2}}=\frac{1}{P}=b=E[B]$$

Bursty Traffic

- The probability of staying n cycles in OFF

$$\overline{T_{off}}=\sum_{n=0}^{\infty} n\Pr(I=n)=\sum_{n=0}^{\infty} nQ(1-Q)^{n}=$$

$$(1-Q)\left\{Q\sum_{n=1}^{\infty} n(1-Q)^{n-1}\right\}=(1-Q)\frac{1}{Q}=\frac{1-Q}{Q}$$

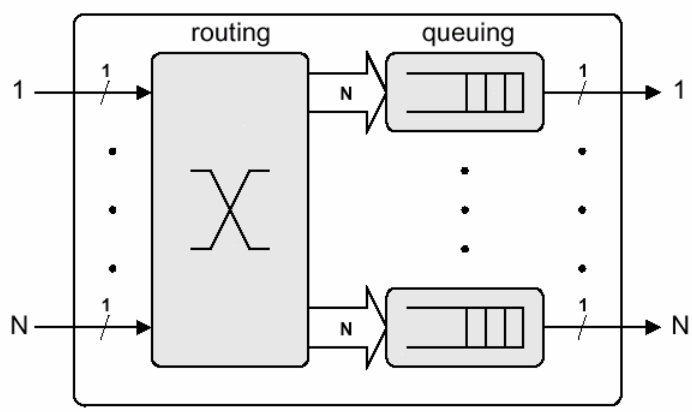
$$E[I]=\frac{1-Q}{Q}$$

Bursty Traffic

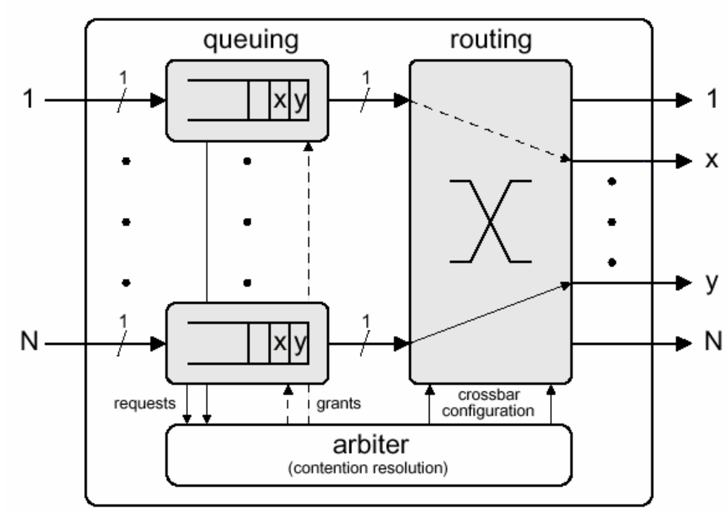
$$\lambda = \frac{E[B]}{E[B]+E[I]} = \frac{Q}{P+Q-PQ}$$

- B=> P
- P, λ=>Q
- Now we can generate Bursty packets

Switch Simulation (Output queue)



Switch Simulation (Input queue)



Switch Simulation

- Which mechanism is better?
  - Throughput
  - Complexity

Computation Throughput in FIFO input Queues

- B^i_m :number of reminded cells for output i in cycle m^{th}
- B^i :Steady state
- A^i_m :number of cells for output i moved to head of queues
- A^i :Steady state

$$B^i_m = \max(0, B^i_{m-1} + A^i_m - 1).$$

Computation Throughput in FIFO input Queues

- The probability of each arrived cell in hedd of queue to output I is 1/N
- So A^i_m has Binomial Distribution

$$\Pr[A^i_m = k] = \binom{F_{m-1}}{k}\left(\frac{1}{N}\right)^k \left(1-\frac{1}{N}\right)^{F_{m-1}-k}, k = 0,1,\ldots,F_{m-1}$$

$$F_{m-1} \cong N - \sum_{i=1}^{N} B^i_{m-1}$$

$$F_{m-1} = \sum_{i=1}^{N} A^i_m$$

Computation Throughput

- When N->∞ , A^i_m has poison process with $\rho^i_m = \frac{F_{m-1}}{N}$

$$\rho_o = \frac{\overline{F}}{N}$$

- B^i is markov process , in steady state we have

$$\overline{B}_i = \frac{\rho_o^2}{2(1-\rho_o)}$$

Computation Throughput in FIFO input Queues

- In steady state :

$$\overline{F} = N - \sum_{i=1}^{N} \overline{B}^i$$

$$\overline{B}^i = \frac{1}{N}\sum_{i=1}^{N} \overline{B}^i = 1 - \frac{\overline{F}}{N} = 1 - \rho_o$$

$$\rho_o = 2 - \sqrt{2} = 0.586$$