WORLD VIEW OF INTERNET MODELING

(ACCORDING TO KULKARNI)

AN ABSTRACT MODEL OF THE INTERNET

- Internet is a NETWORK: It has a set of nodes (computers, switches, routers, etc.) and a set of arcs (twisted pairs, coaxial cables, fiber optic cables, microwave links, etc.) that connect the nodes.
- Traffic may originate at any node and terminate at any node.
- The traffic between any (origin, destination) pair is routed by setting up a session (a virtual path following a physical path) between the two nodes.
- The traffic on a session is managed by network protocols (TCP/IP, UDP, etc.) operating at all the nodes on the physical path of the session.
- Traffic on a session is packetized. Packets may get fragmented/defragmented at the nodes.
- A link between two nodes may carry traffic belonging to multiple sessions.
- The multiplexing (interleaving of packets) is controlled by the network protocols and the traffic priorities.

A SIMPLE EXAMPLE.

- There are N computer stations on the campus connected to a server via a router (or a switch).
- Traffic flows between each station and the server via the router.
- There are multiple sessions between each station an the server.
- The link between the server and the router carries the traffic from all the stations.

THE SYSTEM DESCRIPTORS.

DESIGN VARIABLES.

- Network topology: Should we use two routers instead of one?
- Buffer capacities at the nodes.
- Link speeds.
- Traffic protocols.

TRAFFIC VARIABLES.

- Traffic demand at each station.

PERFORMANCE VARIABLES.

- Congestion, delay, response time for each user.
- Packet loss probabilities.
- Reliability, recovery times, etc.
- Cost/benefit ratio.

OBJECTIVE.

Design and operate the network so that the performance variables stay in acceptable ranges.

METHODS OF ANALYSIS.

1. Physically create the system (network) and run it under various traffic conditions in field tests. This provides the most accurate data, but is expensive in terms of time and money. Using this data develop rules of thumbs about the design parameters as a funtion of usage.

2. Simulate the network. Needs two sets of inputs:

   - Network parameters. This includes the topology, buffer sizes, link capacities, protocols, etc.
   - Traffic Parameters. This needs a user behavior model.

   With these two components we can perform what if experiments.

USER BEHAVIOR MODEL.

- A Detailed Model:
  - Users arrive from outside to the computers, and use them if available.
  - Each user starts by downloading a single web page of random size from the server.
  - Each web page consists of a random number of embedded pages (each of random size).
  - The user waits until all the web pages are loaded. (May not be true.)
  - The user spends a random time in read/think mode and then either leaves or initiates the downloading of a new web page.
- The above model requires estimates of the user arrival rates, web page structures and sizes, think times, etc.
- A Coarse model:
  - Demands for web pages arrive at each computer according to a batch arrival process.
- This requires estimates of the arrival rates, size of each batch, and web page sizes.
- The simulation will generate sample paths of traffic over links which will lead to estimates of delays, packet losses, etc.
- Conduct what if experiments by changing network parameters, user behavior parameters, etc.

AN ABSTRACT FORMULATION.

- G = network parameters.
- T = traffic parameters.
- Y = performance measure (vector) of the network.
- $Y = f(G,T)$
  where f denotes the black box "network transformation" operator.
- We need to study G and T to get Y.
- Paradoxically, observing Y is easier than observing G or T.
- Can we use Y to estimate T (and G)?
- Having a good model of Y will be of limited help in doing extensive what if analysis.
- Having a good model of T will be of great help in design and operation of the network – which is our main objective.