Network Simulation

Internet Technologies and Applications

Aim and Contents

- Aim:
  - Motivate the need for simulation tools for network performance analysis
  - Familiarise students with a popular analysis tool, OPNET

- Contents:
  - Basics of network simulation
  - Introduction to OPNET (demonstration, handouts provided separately)

Performance Questions

- How does the current network/applications perform?
  - What is the current utilisation of a link/server?
  - Which link/devices contribute the largest delay?
  - Where are packets being dropped in the network?
  - What is the amount of traffic sent/received by P2P applications?
  - *Used for evaluating effectiveness and diagnosing problems*

- 'What if' scenarios?
  - What if the number of users on our Ethernet LAN doubles?
  - How many voice calls can be supported on our current network?
  - How will web page response time reduce if we introduce a cache server?
  - How will throughput/delay change if switch from ADSL link to Wireless LAN link?
  - *Used for planning network changes/upgrades*

Answering Performance Questions

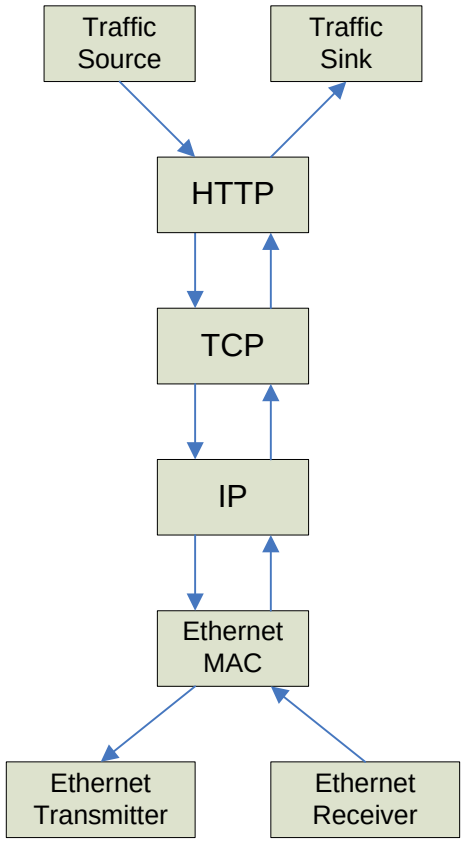
- Questions about current network
  - Answered using measurement
    - Most network devices (switches, routers, hosts, modems) measure statistics about their usage
      - Packets sent per second (instantaneous, average across minute/hour/day)
    - Special software can be used to perform measurements
      - Wireshark, …
- ‘What if’ scenarios
  - Build the scenario and perform measurements
    - Difficult and expensive; disrupts current network
  - Analyse using mathematical techniques
    - Very difficult to get accurate results; need mathematical background
  - Simulate the scenario using software
    - A good alternative; accuracy of results depends on
      - Accuracy of simulation model
      - Accuracy of input data

Network Simulation

- Use software to create a model of a network
  - Model of devices, links and users
  - Many simulation software packages provide you with models of common devices, links and applications
- Specify a scenario to analyse
  - Topology: how are the devices connected together?
  - Traffic: what do the users do to generate traffic?
  - Mobility (optional): how do the devices move?
- Specify statistics to collect
  - Select performance statistics for devices, links, applications or entire network
- Simulate the scenario
  - The scenario is simulated in software, and statistics collected as it runs
  - Referred to as *discrete event simulation*

Modelling Devices

- Modelling a device such as PC, router, switch, modem, server, …
  - Implement software that simulates the behaviour of the device
  - Simulation models often follow same layered structure as the real devices
    - Use software to implement the transmitter or receiver (instead of hardware)
    - Simulation models of protocols often only implement basic features; not all the functionality that a real protocol implements
  - Once a model of a device is created, that device can be re-used in any scenario



Modelling Traffic

- Many common Internet applications can be modelled as a request/response application
  - Client sends requests to Server
    - Request inter-arrival time, *ia*. Number of requests per second = 1/*i*.
    - Size of request, *req* (in bits).
  - When receiving a request, Server responds
    - Size of response, *resp* (in bits)
- With real applications, *ia*, *req* and *resp* vary over time
  - Use probability distributions to model changing parameters
    - For each request/response, choose a random number from some range to determine the value
  - Example:
    - Request size is random with interval 100 bytes to 200 bytes
    - Average request size is therefore 150 bytes (but each individual request may be different size)
  - Different applications will have different ranges/distributions

Scenario Parameters

- To simulate a real-world network, you need to specify all necessary parameter values for your model
  - Protocol parameters: wireless LAN data rate, retry limits, timeout values, …
  - Environment parameters: simulation duration, random seed, statistic collection methods, …

Discrete Event Simulation

- Simulation software treats everything as events at some discrete time
  - Time 1.035: Node 1 - traffic source sends data to TCP
  - Time 1.036: Node 2 - traffic source sends data to UDP
  - Time 1.037: Node 4 - IP receives frame from MAC
  - Time 1.038: Node 1 - TCP sends segment to IP
  - …
- Simulation software keeps a timer of current simulation time, and a list of all scheduled events in the future
  - As the simulation time progresses, actions are taken based on the scheduled events

Analysing Results

- The very basic results is a record of each event and the time it occurred
  - Time 1.035: Node 1 - traffic source sends data to TCP
  - Time 1.036: Node 2 - traffic source sends data to UDP
  - Time 1.037: Node 4 - IP receives frame from MAC
  - Time 1.038: Node 1 - TCP sends segment to IP
  - …
- At the end of the simulation, from this record of events it is possible to calculate statistics such as:
  - Throughput, delay, traffic sent, window size, …
- Many simulation software packages provided tools to make the analysis of the results easier
  - Producing summary reports
  - Plotting results

Network Simulation Software

- Many different software applications can be used for network simulation
  - Differ based on: existing models supported; types of networks (wired or wireless, small or large); layers (physical layer only, applications only, all layers); cost/licensing; usability (command line, GUI, programming); …
- Software developed by network companies
  - Cisco, HP, IBM, Juniper, …
- Generic network simulation software
  - OPNET, ns2, GlomoSim/Qualnet, OMNET++, BoNes, …
- Generic simulation/analysis software
  - Matlab, Scilab, Simula, GPSS, …