Note: most of this lecture has been removed due to copyright restrictions.

1.204 Lecture 24

Approximate queuing analysis

Queuing theory

- **It's hard to solve real problems with classical queuing theory**
  - **Exact solutions to real problems rarely exist**
  - **We either make heroic assumptions or simulate to solve**
  - **Both approaches tend to produce the wrong answer**
- **Real queues tend to be <u>non</u> steady state, time-dependent queues**
  - **This is how real queues form and dissolve**
  - **They can best be solved approximately**
  - **There are no exact solutions**

Approximation techniques

- **Three major forms of approximation**
  - **Graphical approximation**
  - **Fluid approximation**
  - **Diffusion approximation**
- **Two major system types**
  - **Steady flow: rush hour traffic on road or at airport**
  - **Pulsed flow: traffic signals, buses/trains**
- **Two major conditions to find approximate solutions:**
  - **Heavy traffic**
  - **Light traffic**
  - **These bound medium traffic, often well enough**
- **All of these have feasible mathematics but require skill and ingenuity to apply**

Foundations of queuing theory

- **Queuing theory analyzes the flow of objects through a network**
- **Conservation principles apply:**
  - **Objects do not disappear**
  - **Objects do not change identity**
    - **But we sometimes disregard their identity**
  - **An object that cannot pass a restriction is stored in a reservoir**
  - **If there are objects in a reservoir, the facility will pass them as quickly as the restriction will permit**
  - **Different objects take different amounts of time to pass a restriction (e.g., long jobs and short jobs on a machine)**
  - **Delays to different objects are worth different amounts of money (e.g., commercial aircraft versus private plane)**

Examples of queues

- **Examples**
  - **Highway congestion**
  - **Waiting/bunching of buses**
  - **Traffic signals**
  - **Airports: runways, baggage, ground side**
  - **Hospitals: patient admission, treatment, discharge**
  - **Buildings: flows of people or goods**
  - **Inventory management: storage, use of materials**
  - **Water system management: dams, reservoirs**
  - **Financial flows and investments**
- **All have random elements:**
  - **Market movement, random rainfall, stochastic demand, …**
- **All have systematic elements**

Summary

- **Newell's text has a series of approximations for nonstationary queues that model real systems in many cases**
  - **Graphical techniques: cumulative and parametric curves**
  - **Analytic, calculus-based methods to estimate queues and waits**
  - **Graphical and analytic methods to analyze varied service rates, pulsed service, tandem queues**
  - **Statistical methods to estimate queue behavior over long periods, based on central limit theorem**
- **These are a very useful addition to the queuing literature for systems engineers**

1.204 Computer Algorithms in Systems Engineering

Spring 2010