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Network Simulation

1st year Academic Master

Networks and Technologies of Information and Communication

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Network modeling

Network modeling Introduction

- Network modeling is the process of developing abstract models of a network, with each model presenting a different view or perspective of that network.
- Network modeling can use some kind of graphical notation, like in the Unified Modeling Language (UML), Graphs, Petri nets and so on.
- Network modelling helps with understanding the behavior of the network protocols and components.
- (Modeling a network = representing it in a simpler way).

Network modeling Introduction

- With modeling, network parameters can be modified, tested and analysed.
- If well managed, modelling process can reduce network development costs.
- To model a network, certain simplified assumptions are often necessary.
 - A very abstracted model is simple to carry out but it can lead to inaccurate representation of the network !
 - Very detailed model might be difficult to manage !

Network modeling approaches

There are two approaches:

1) Analytical modelling: The general concept of analytical modeling is first of all to find a way to describe the system mathematically using applied mathematics and tools such as queues and probabilistic theorems

- Markov Chains are a mathematical concept that describes a sequence of possible events in which the probability of each event depends only on the state attained in the previous event. They are widely used in various fields, including probability theory, statistics, physics, computer science, and economics.

Network modeling approaches

There are two approaches:

- 2) Modeling through simulation:** Simulation is widely used in network modeling. Compared to analytical modeling, simulation generally requires less abstraction in the model (e.g., fewer assumptions) and almost all possible details about the system specifications can be put into the simulation model to better describe the current system.
- When the system is quite large and complex, a simple mathematical formulation may not be possible; in this case, the simulation approach is generally preferred to the analytical approach.

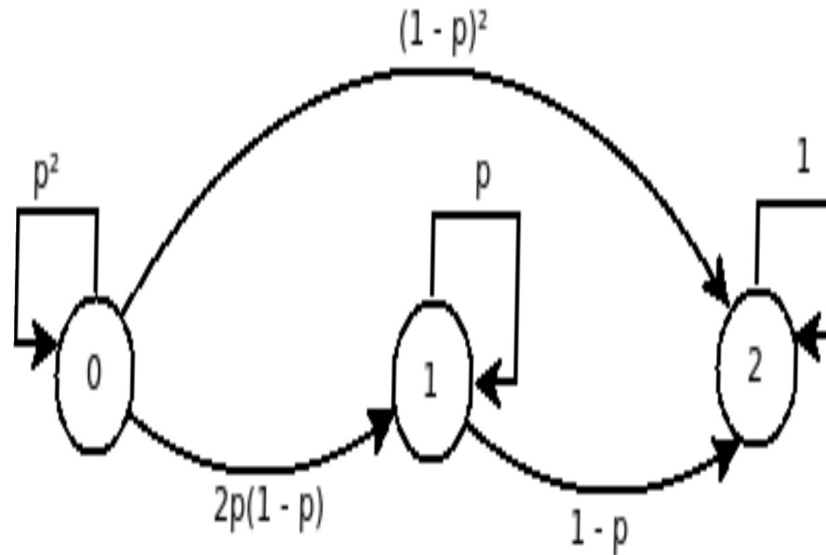
Network modeling approaches

Example of analytical modelling :

- We consider a wireless LAN with two stations (source and destination). The source station wants to transmit three packets to the destination station. Each packet to be transmitted has a signal strength that depends on the distance between the two stations. This means that the probability of a packet being lost is $(1-p)$. Initially, the two stations exchange packets without loss of information.
- The process will be in state 0, 1 or 2 depending on whether there are 0, 1 or 2 lost packets.

Network modeling approaches

- The various transitions (and their probabilities) are represented by the following graph:



Network modeling approaches

- The following transition matrix is associated with this graph:

$$P = \begin{pmatrix} P_{0,0} & P_{0,1} & P_{0,2} \\ P_{1,0} & P_{1,1} & P_{1,2} \\ P_{2,0} & P_{2,1} & P_{2,2} \end{pmatrix} = \begin{pmatrix} P^2 & 2p(1-p) & (1-p)^2 \\ 0 & p & 1-p \\ 0 & 0 & 1 \end{pmatrix}$$

Classes of network simulators

Classes of Network simulators

There are many classes of network simulators:

- Open-source vs private
- Time driven vs Event-driven (discrete event simulation)
- Generic vs Platform-dependent

Classes of Network simulators

Open-source network simulators

- Open-source simulators like NS-2/3 often have vibrant communities. This means that we can find extensive documentation, tutorials, and user forums where we can seek help and collaborate with others.
- Open-source simulators typically offer high levels of flexibility and customization. We can modify the code to tailor the simulator to our specific requirements, making it ideal for research, experimentation, and academic purposes.
- Open source simulators can be extended with new network-specific mechanisms and features.
- Open-source simulators are usually free to use.

Classes of Network simulators

Private network simulators

- Private network simulators, such as Opnet or Cisco's Packet Tracer often come with dedicated commercial support. This can be beneficial for prompt assistance, training or consultancy services.
- The simulator cannot be extended and the code can't be changed or improved.
- Private simulators often prioritize user-friendliness and ease of use, with intuitive graphical interfaces and predefined templates. This can be advantageous for beginners or those who prioritize convenience over customization.

Classes of Network simulators

Time-driven network simulators

- In time-driven simulators, the simulation progresses in discrete time steps. At each time step, the simulator advances the simulation time by a fixed increment, regardless of whether any events occur.
- Time-driven simulators typically update the state of the network components (nodes, links, etc.) at each time step, regardless of whether there are changes or events to process.
- Time-driven simulators are often suitable for scenarios where events occur regularly or at predictable intervals, such as periodic data transmissions or network maintenance activities. They are less suited for modeling scenarios with irregular or unpredictable event occurrences.

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Event-driven network simulators

- In event-driven simulators, the simulation progresses by responding to events that occur in the network. Events can include packet arrivals, link failures, routing updates, etc. The simulator maintains a priority queue of events and processes them in chronological order.
- Event-driven simulators exhibit asynchronous behavior, where events are processed as they occur, rather than being synchronized to a global simulation clock. This allows for more flexible and dynamic simulation behavior.
- Event-driven simulators can be more efficient than time-driven simulators. The simulator only needs to process events as they occur, rather than at every time step.

Classes of Network simulators

Generic network simulators

- **Cross-Platform Compatibility:** Generic network simulators support the simulation of different types of network infrastructures and protocols.
- **Flexibility:** Generic network simulators often provide a high degree of flexibility, allowing users to model diverse network architectures, protocols, and scenarios. They are suitable for academic research, prototyping, and experimentation across a wide range of networking domains.
- **Community Support:** Many generic network simulators have active communities of users and developers who contribute to documentation, tutorials, and extensions.

Classes of Network simulators

Platform-dependent network simulators

- Platform-dependent network simulators are dedicated to the simulation of a particular type of networks like Tossim and Cooja that are IoT simulators.
- They can be developed by network equipment vendors (e.g., Cisco) and are tailored to their specific hardware and software platforms.
- Integration: Platform-dependent simulators provide models that integrate seamlessly with the real-world networks they are simulating. This tight integration can simplify network design, configuration, and troubleshooting tasks.

Classes of Network simulators

How to choose the right network simulator ?

- According to the thematic.
- According to the network type.
- According to the skills of the developer.
- According to the availability of the protocols to simulate.
- According to the existence of the community and potential forums to seek help whenever needed.