An Introduction to Interconnection Networks & Xmulator

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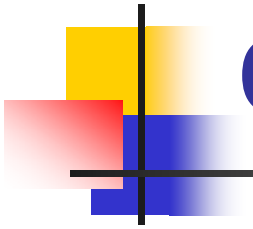


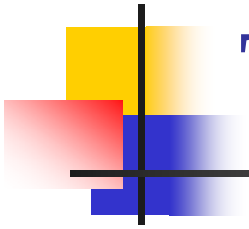
Outline

- Introduction
  - Interconnection networks
  - Topology
  - Switching
  - Routing
- Xmulator
  - Multi-Layer Architecture
  - Listener-Based Integration
- Conclusions and future work

Interconnection Network (IN)

- A set of processors with local memories which communicate through a network

Duato J., Yalamanchili C. and Ni L., Interconnection Networks: An Engineering Approach", IEEE computer society press, 1997.



Terminology

- **Topology:** The way nodes are interconnected
- **Routing Algorithm:** Determines the path from source to destination
- **Switching Method:** Specifies when input channel is connected to the output channel selected by the routing algorithm

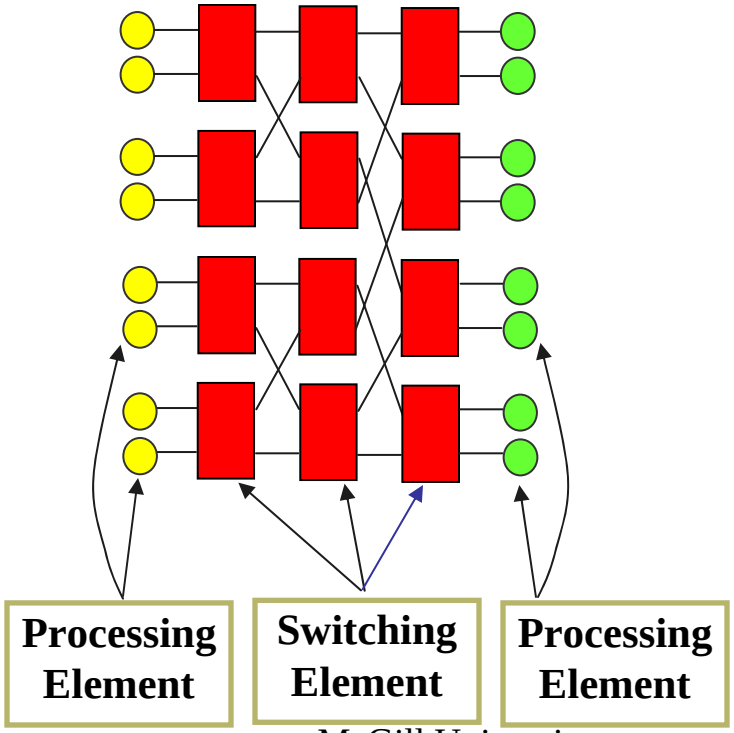
Topology

- **Direct:** Each node directly connects to its neighbor nodes

- **Indirect:** Nodes are connected through a set of switches

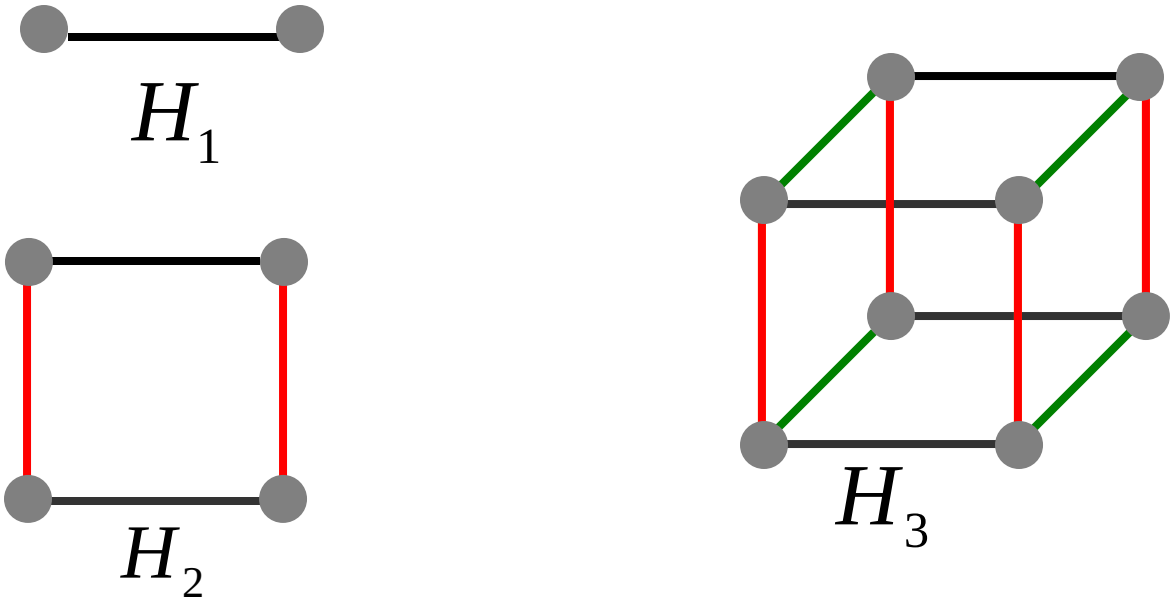
Indirect IN

- Example: A butterfly constructed from 2x2 switches

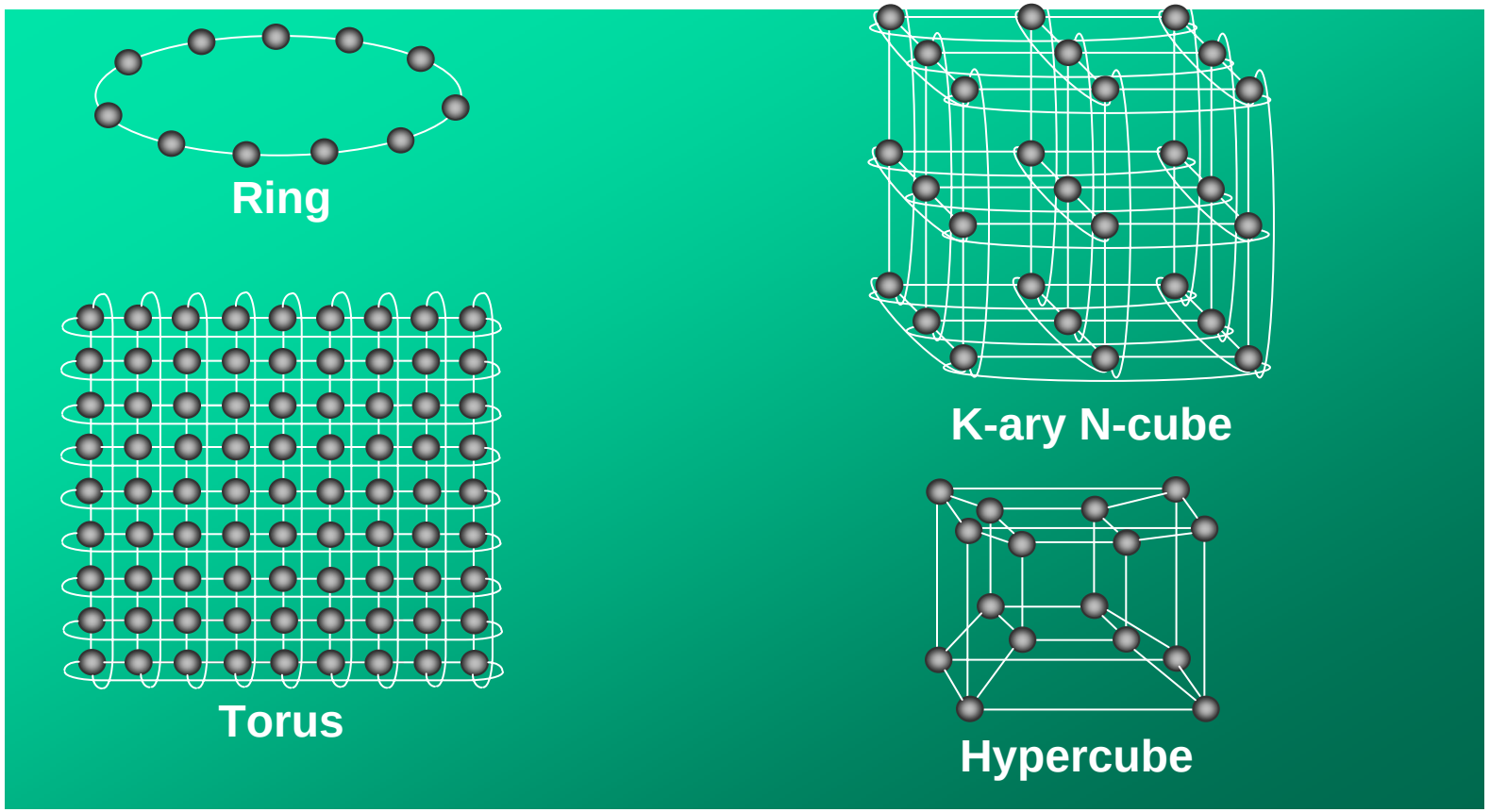


Direct IN

- Example: Hypercube



Topology



Switching Methods

Store & Forward (Packet Switching)

Sending the message after receiving whole of the message

Disadvantages

Large buffer space, Increasing time to transmit a message in network

Wormhole Switching

Messages are divided into flits (= a few bytes)

Each node has buffer for only one flit of a message

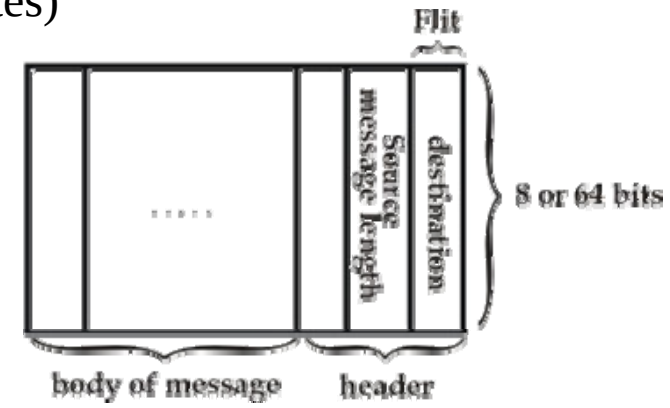
Advantages

Latency is almost insensitive to distance

Fast and simple routers

Disadvantages

Prone to deadlock

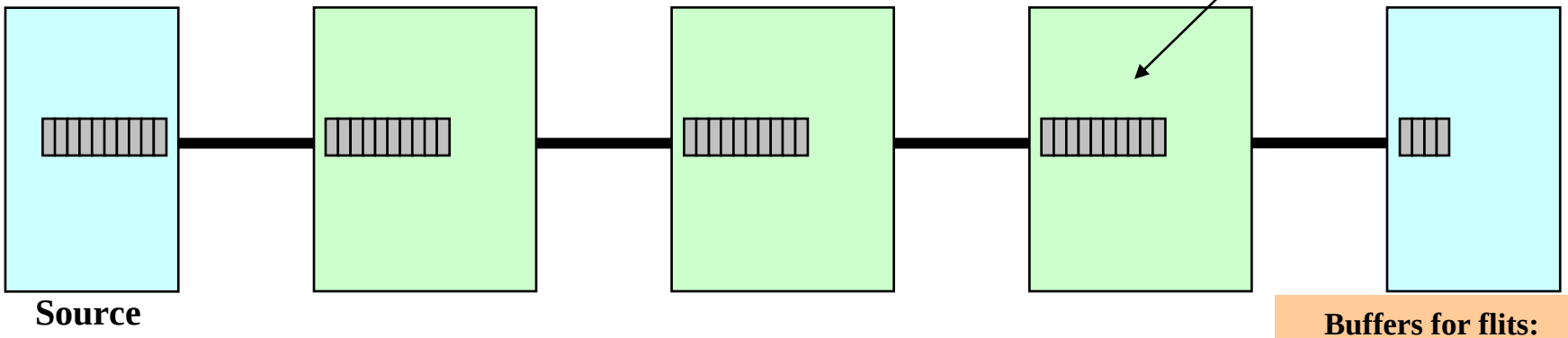


A blocked message remains in the network. Hence, a bottleneck in a single point can increase the traffic of neighboring area

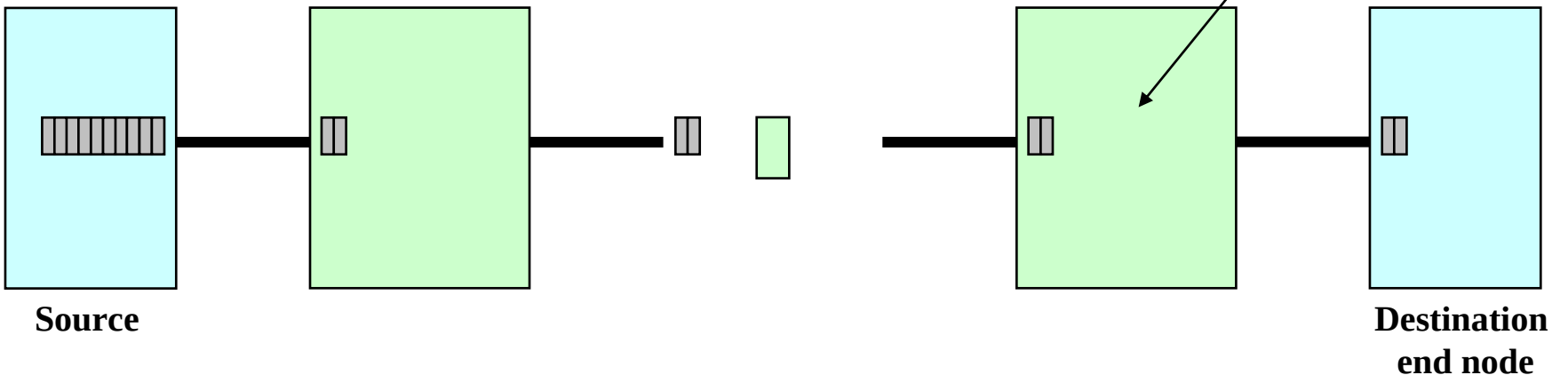
www.wikipedia.org

Switching Methods

- Store & Forward

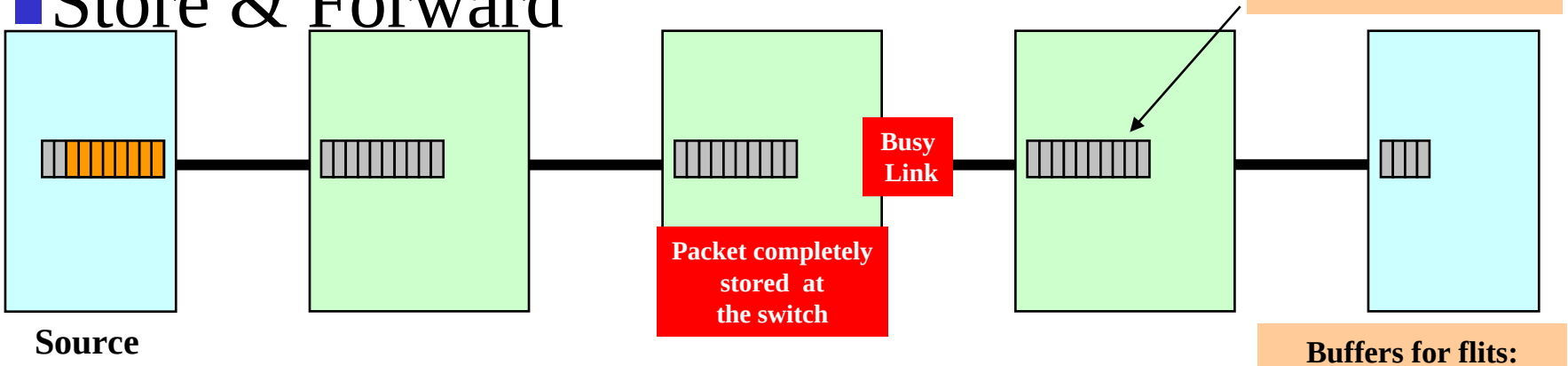


- Wormhole

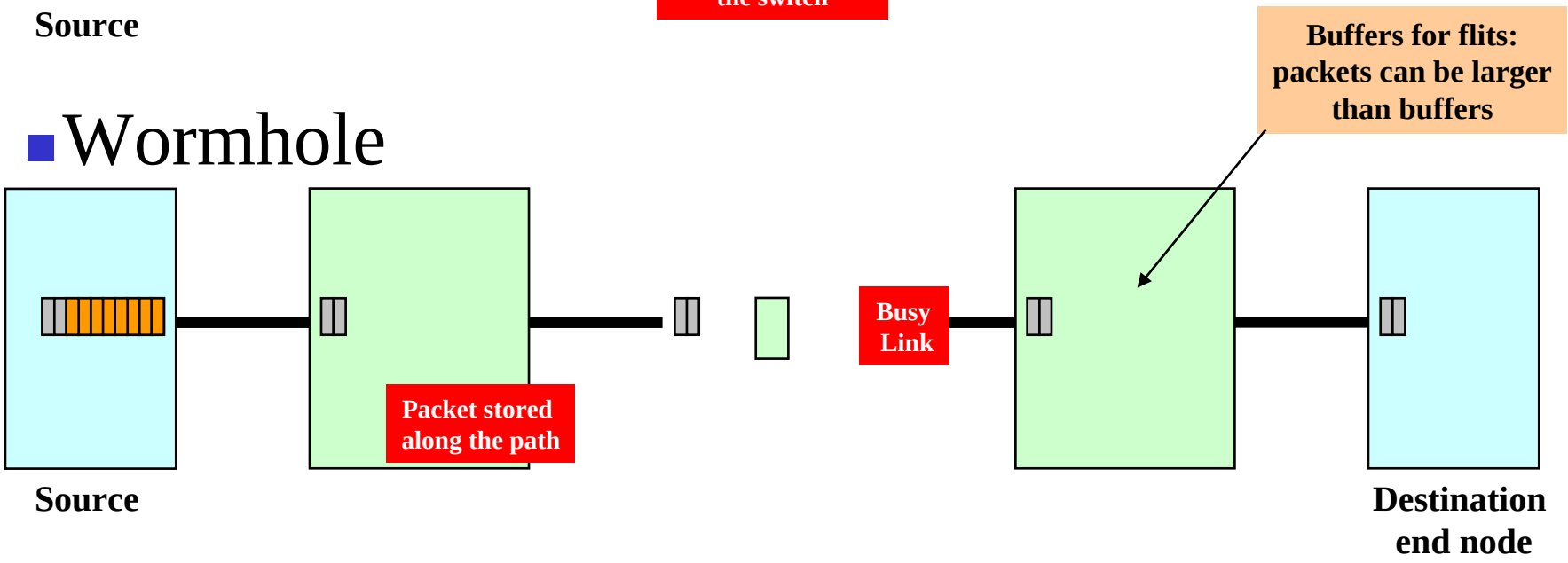


Switching Methods

- Store & Forward



- Wormhole

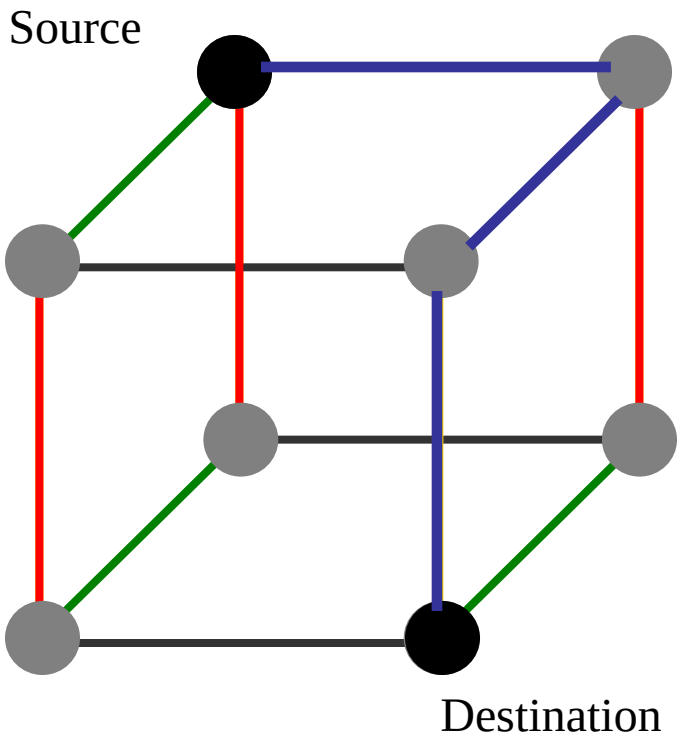


Routing Algorithms

- Topologies are simple and regular
- Very low delay and extra high bandwidth are needed
- Simple routing algorithms are developed for INs (deadlock is an important concern)
- Example: e-cube routing in hypercube networks

  Messages are routed along first dimension, then routing continues in other dimensions.

e-Cube



Xmulator: An Object Oriented Listener-based Network Simulator

- XML + Simulator
- Designed in HPCAN lab. of Sharif University of Technology in 2006

Nayebi A., Meraji S. ,Shamaei A. and Sarbazi-Azad H., Xmulator: A listener-Based Integrated Simulation Platform for Interconnection Networks, Asian Modeling and Simulation (AMS), Pucket, Thailand, 2007

Xmulator: An Object Oriented Listener-based Network Simulator

- Motivations
  - Developing a simulator for simulating **interconnection networks:**
    - Possibility of defining details of hardware and algorithms with performance considerations
    - Applying wormhole, store & forward, and other switching techniques
  - Using new software architecture paradigms (Object Oriented and Multi-Layered Architecture)
  - Using new programming languages (C# , java , XML)
    - Xmulator=XML+Simulator

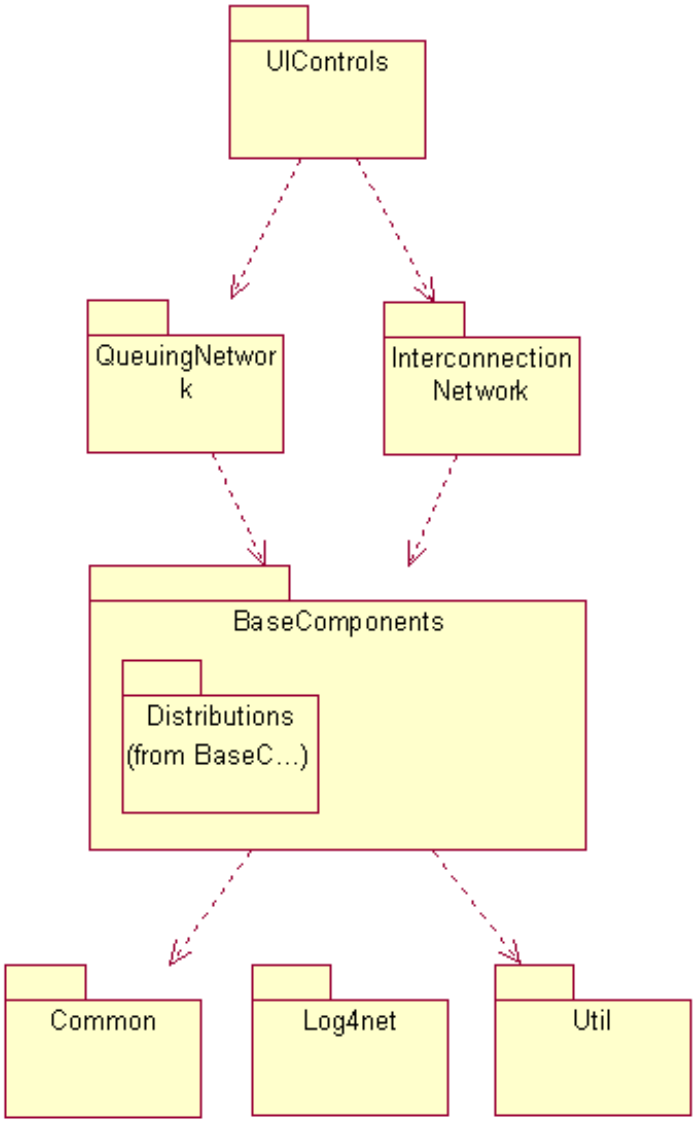
Xmulator: An Object Oriented Listener-based Network Simulator

- Motivations
  - Using XML format for defining topologies, parameters, and outputs
  - No need to learn a new programming or scripting languages and using the previous abilities of users in java and C# languages
  - Ease of developing new packages, new tools for existing packages, or defining routing algorithms
  - Possibility of debugging even into the core of simulator
  - Logging capabilities

Simulator Engine

- Managing the events list:
  - Eliminating the event with less time
  - Call the ProcessXEvent of the component which the event belongs to it
  - The above method can produce other events and register them in simulator engine
- Xmulator use Red-Black tree to keep the concurrent event queues
  - Save the balanced tree during the work
  - Eliminate the smallest element with O(log N)
  - Insert the element with O(log N)

Xmulator Multi-Layer Architecture



Layers

- First Layer: Util – Common – Log4net
- Second Layer: BaseComponents– Distributions
- Third Layer: InterconnectionNetwork - QueuingNetwork
- Forth Layer: Presentation

Listener Based Integrating

- Increase the Extensibility
- Example: Assume a queue and a server
  - The server must know the queue's signature
  - When an element enters the queue, server must serve it
  - Server can't check the queue at all the times
- Solutions
  - Queue knows the server behavior (min extensibility)
  - Simulator's engine keeps track the way (min extensibility)

Listener Based Integrating

- Using the listener: Queue defines an event and server listens to it
  - The listener is called every time a new object is received by queue

Conclusions & Future work

- Design a user interface for Xmulator using AToM^3
- Using model transformation to generate the input XML file for Xmulator
- Developing some routing protocols for interconnection networks
- User can change input parameters to see their effects on performance

References

- Duato J., Yalamanchili C. and Ni L., Interconnection Networks: an engineering approach", IEEE computer society press, 1997.
- Monemizadeh M. and Sarbazi-Azad, H., The necklace-hypercube: a well scalable hypercube-based interconnection network for multiprocessors, ACM SAC 2005, pp.729-733, 2005.
- Nayebi A., Meraji S. ,Shamaei A. and Sarbazi-Azad H., Xmulator: A listener-Based Integrated Simulation Platform for Interconnection Networks, Submitted at Asian Modeling and Simulation (AMS'07).
- Dally W. J., and Seitz C., Deadlock-free message routing in multiprocessor interconnection networks, *IEEE Trans. Computers*, vol. C-36, no. 5, pp. 547-553, 1987.
- http://www.cm.cf.ac.uk/Parallel/Year2/section5.html
- www.wikipedia.org

Questions