



A Model-Driven Multi-Paradigm Integrated Simulation Framework For Analysis of Communication Networks

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Outline



- Difficulties with current approach
- Network Modeling and Description Language
- SeMA framework
- SeMA hybrid systems simulator
- SeMA benefits
- Concluding Remarks



Difficulties in analysis of communication networks (1/3)



- A number of tools exist
 - event based models (ns-2)
 - most accurate
 - models steady-state and transient behavior
 - not scalable, complexity increases as the number of packets
 - fluid models
 - fast, steady-state analysis of network
 - can not model transient behavior



Difficulties in analysis of communication networks (2/3)



- A single 'solve-it-all' tool is not present
- Combination of a number of tools used for network analysis
 - *event-based* tools for transient behavior study
 - *fluid* models for steady state study



Difficulties in analysis of communication networks (3/3)



- Describing the communication network model
 - ns-2 uses tcl/tk scripts
 - FSN uses GML files
- Describing a specific topology means learning the tool-specific modeling language
- Changes in the topology (physical or behavioral) involves tedious and error prone changes
- Need for a platform independent modeling language



Network Modeling & Description Language



- Three main views to any communication network modeling & description language-

Structure – describes topology of the network (how routers are connected, through what port etc.)

Behavior – describes occurrences of events and their timing information (start and end times of various flows, link failure etc.)

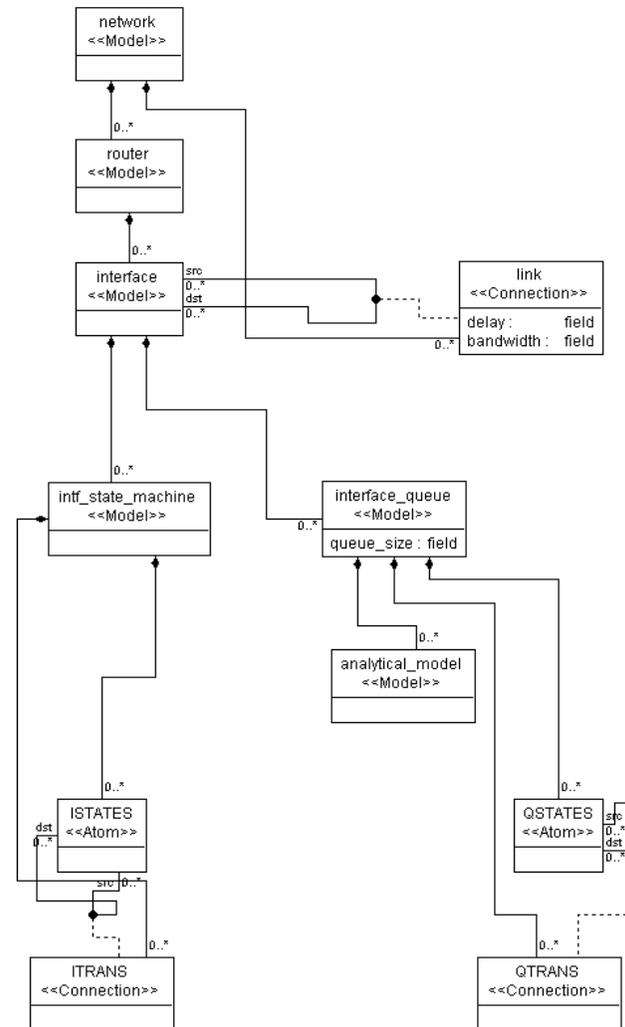
Flows – describes flow information (flow *bps*, *source* and *destination* routers, whether *tcp/udp* etc.)



SeMA: A Model-driven Network Simulation Framework



- SeMA has three aspects *topology_description*, *event_description* and *flows_description* as views of a specific network topology.
- Network elements representations are hierarchical.





SeMA: Structural Description (1/2)



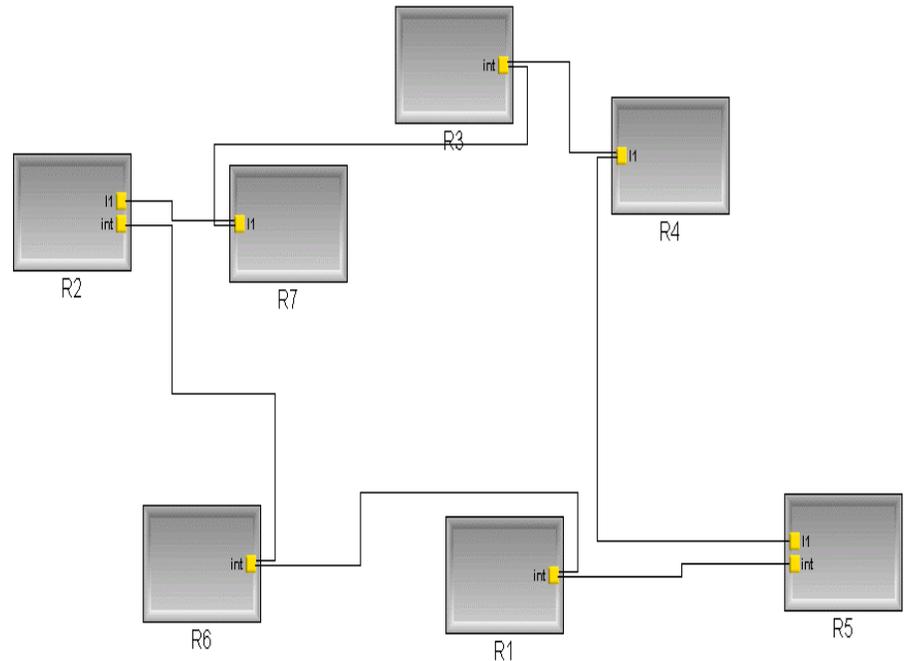
- *Interfaces* of routers are implemented as *ports*.
- *Physical links* expressed as *connections* between routers (through interfaces).
- Each interface defines associated buffer/queue and state machine.
- Buffers have been implemented as *drop-tail* or *RED*.
- State machine only used for hybrid model.



SeMA: Structural Description (2/2)



- OSPF implemented for shortest path between a *source-destination* pair.
- *Delay* expressed as sum of all link-delays in flow optimal path.

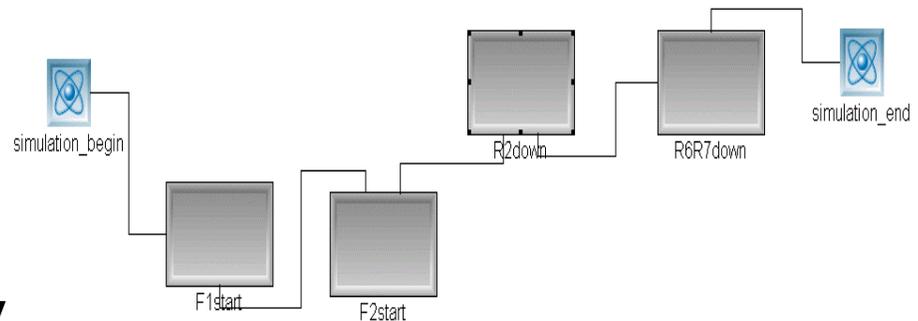




SeMA: Behavioral Description (1/2)



- Defines the discrete events occurring in the network using *events_description*.
- The start of the simulation defined by a start block (with time info) and end by an end block. All events occur between these two.

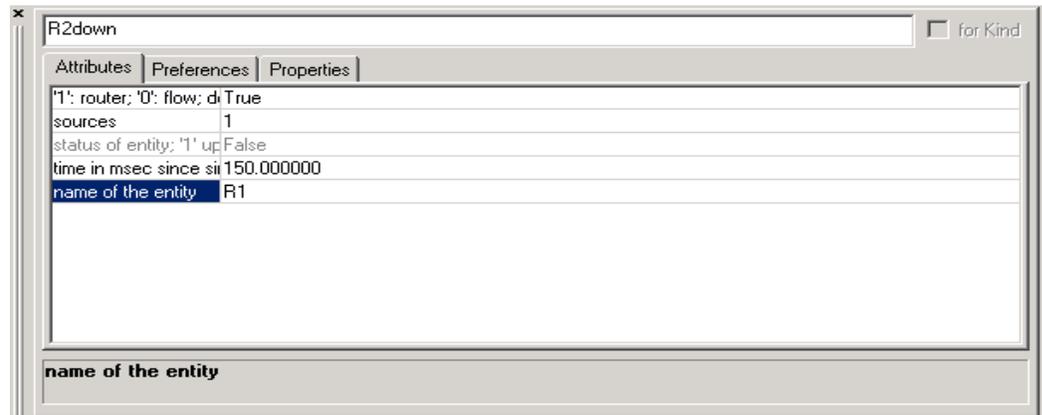




SeMA: Behavioral Description (2/2)



- Events are:
 1. Flow events
 2. Router events
 3. Link events





SeMA: Flows Description



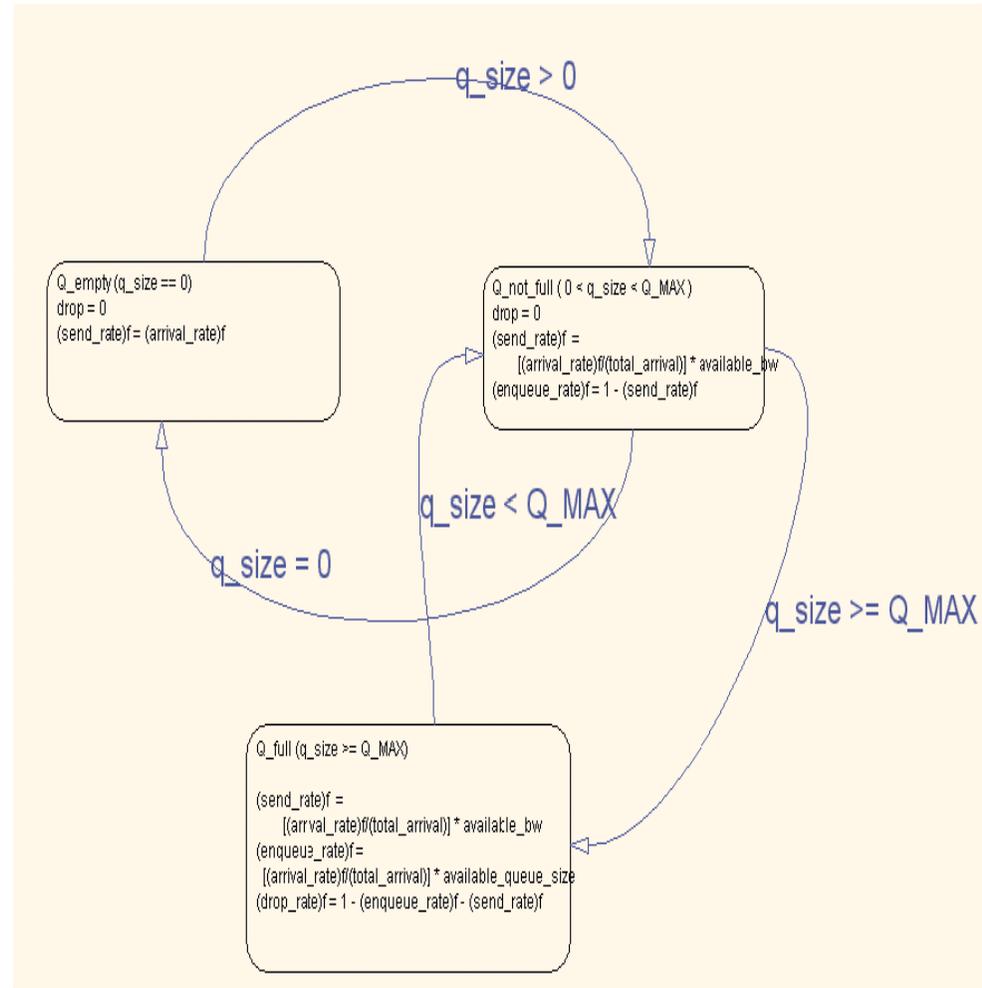
- Describes the flows in the network.
- For each flow –
 1. flow type (TCP/UDP)
 2. rate in *Mbps*
 3. source and destination routers
 5. number of flowsare defined.
- The number of flows is a flow aggregation feature used only for hybrid model.



SeMA: Hybrid Simulator



- Complexity of tracking individual packets is $O(n)$ (no. of packets), instead tracks discrete events.
- Each queue represented by a state machine (with 2/3 states).
- Rates governed by current state of the queue.
- TCP source continuously evolves sending rate (and not discretely only when an ACK is received.)





SeMA: Benefits



- Model-Driven approach allows service providers to write simple, platform independent Network Description models.
- Changes in the topology are easy to incorporate.
- Can be used for a variety of platforms – ns-2, modelica etc.
- Faster than event-driven (ns-2) simulator since complexity is $O(f)$ (number of flows, subflows).
- Accuracy comparable to ns-2 for sufficiently small stepping intervals.
- Able to model steady-state as well as transient behavior.



SeMA: Concluding Remarks



- Network elements description language: Describes how elements (TCP source – Reno, NewReno, Sack etc., queue policies) behave. This includes state machines and DEs (if the system is hybrid).
- Environment generation: generation of platform specific environment. For example, for Modelica generation of environment which implements network elements behavior.