

An OMNeT++ Model for the Evaluation of OBS Routing Strategies

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Outline

- Introduction
- Proposed Routing Strategies
- Network Simulation Model
- Performance Results
- Conclusion

Introduction

- Optical Switching Paradigms
 - Optical Circuit Switching (OCS)
 - Optical Packet Switching (OPS)
 - Optical Burst Switching (OBS)

Introduction

Optical Switching Paradigms

- OCS
 - Establishes an end-to-end pipe (wavelength/lightpath)
 - ✓ Mature technology
 - ✓ Good QoS for admitted traffic
 - ✗ Large wavelength granularity
 - ✗ Long reconfiguration delay
 - ✗ Not suitable for bursts or short-lived sessions

Introduction

Optical Switching Paradigms

- OPS
 - Similar to e-packet switching
 - ✓ Familiar architecture
 - ✓ Great flexibility and statistical multiplexing
 - ✗ Per packet processing overhead
 - ✗ Stringent synch & switching requirements
 - ✗ Technological limitation (... no optical RAM!)

Introduction

Optical Switching Paradigms

→ OBS

- *“Leverages the best of electronics and optics ”* *
- ✓ Moderate processing overhead
- ✓ Asynchronous switching
- ✓ Low signaling delay and high statistical multiplexing
- ✗ Lack of optical RAM causes burst dropping
- ✗ Moderate/Fast switching also needed
- ✗ Relatively new, unfamiliar technology

* Chunming Qiao
Int'l Workshop on Future Optical Networks,
March 5, 2006, Anaheim, CA, USA.

Introduction

Optical Switching Paradigms

	Bandwidth utilization	Setup latency	Switching speed	Processing complexity	Traffic adaptivity
OCS	Low	High	Slow	Low	Low
OPS	High	n/a	Fast	High	High
OBS	High	n/a	Medium	Medium	High

A comparison table by:
K.C. Chua, M. Gurusamy, Y. Liu and M.H. Phung
Quality of Service in Optical Burst Switched Networks
Springer, 2007

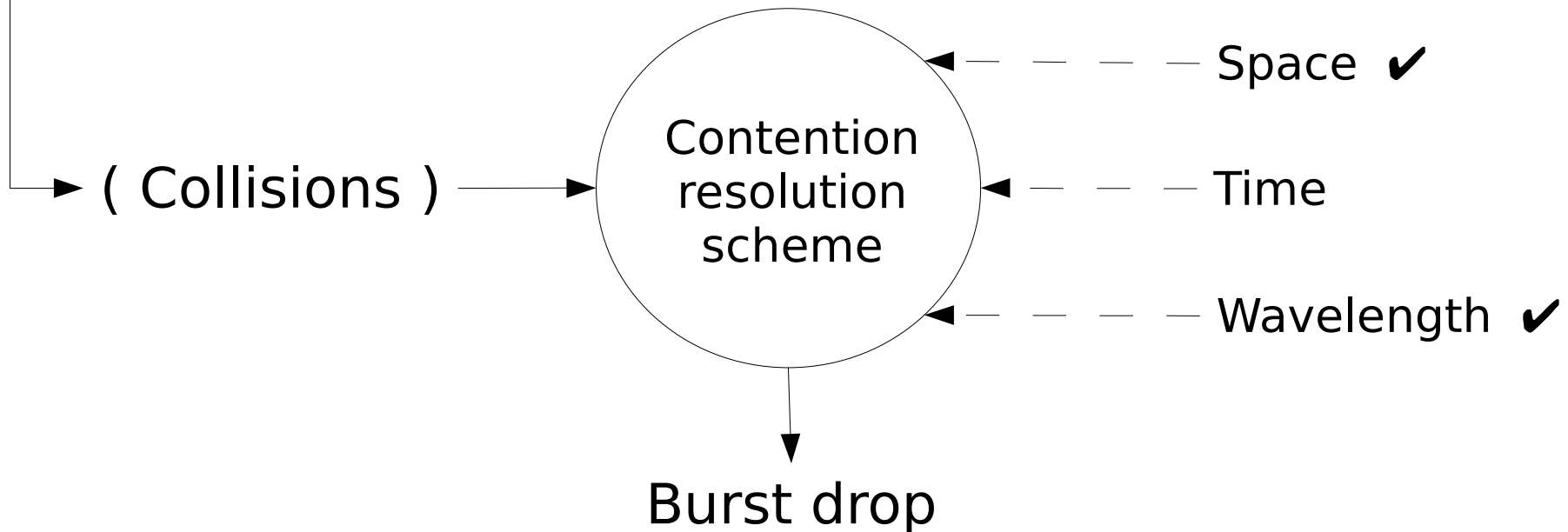
Introduction

OBS reliability issues

"Leverages the best of electronics and optics", but ...

Burst loss:

- One way reservation
- Burst transmission without waiting for permission
- demands > resources



Proposed Routing Strategies

Minimize Maximum Congested Link (MCL)

$$\text{Minimize } \zeta_{MAX} \quad (1)$$

Subject to

$$\sum_{v \in \mathcal{V}_{s,d}} \sigma^v = 1, \quad \forall s, d \in \mathcal{N} \quad (2)$$

$$\sum_{s,d} \sum_{v \in \mathcal{V}_{s,d}} \sigma^v \times p_l^v \times t_{s,d} \leq \zeta_{MAX}, \quad \forall l \in \mathcal{L} \quad (3)$$

$$\sigma^v \in \{0, 1\}; \text{ non-negative integer: } \zeta_{MAX} \quad (4)$$

Proposed Routing Strategies

Minimize Maximum End-to-end Congestion (MEC)

$$\text{Minimize } \varphi_{MAX} \quad (5)$$

Subject to

$$\sum_{v \in \mathcal{V}_{s,d}} \sigma^v = 1, \quad \forall s, d \in \mathcal{N} \quad (6)$$

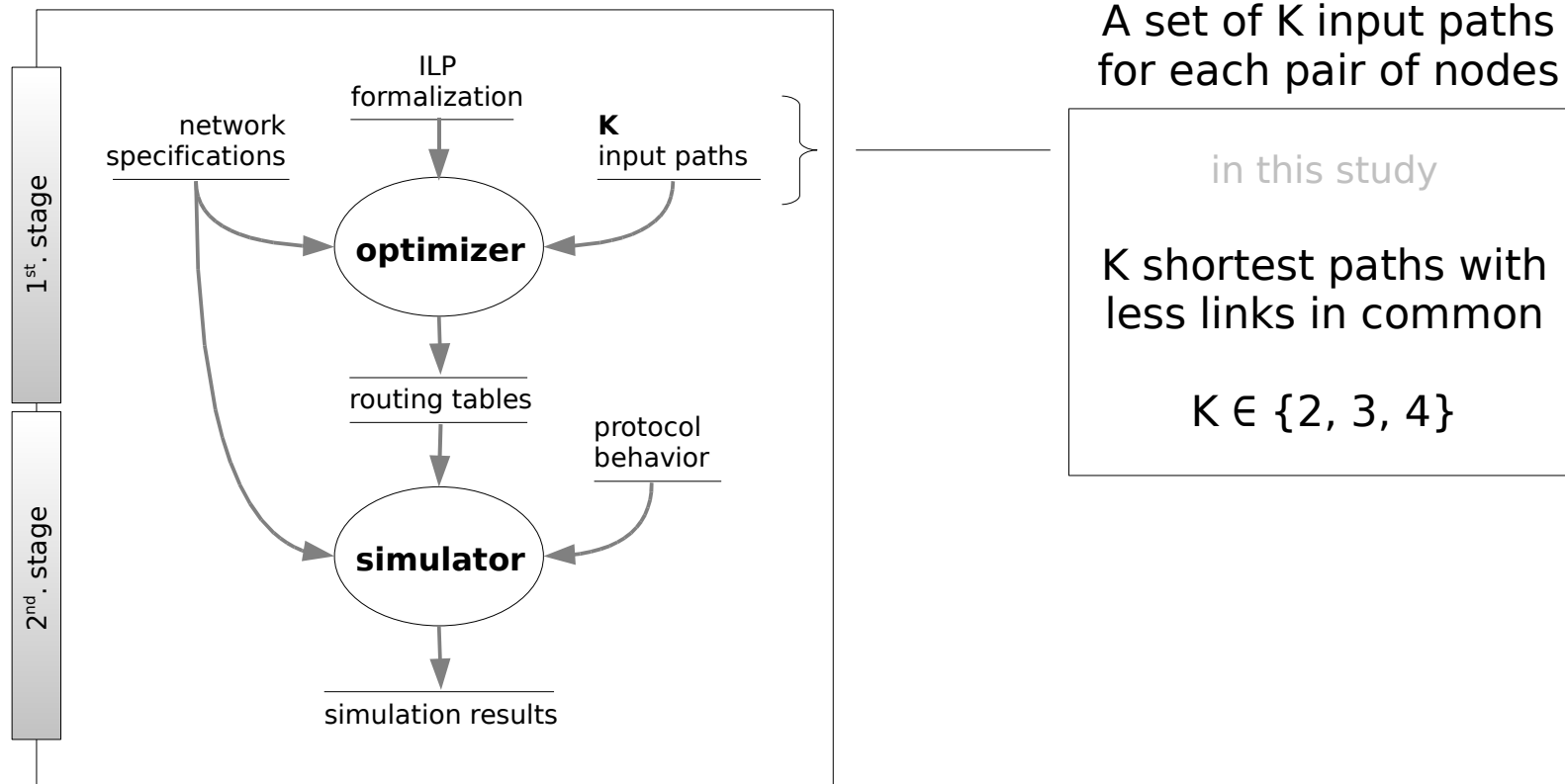
$$\eta^{v,v'} \geq (\sigma^v + \sigma^{v'} - 1) \times q^{v,v'}, \quad \forall v \in \mathcal{V}, \forall v' \in \mathcal{V} \setminus \mathcal{V}_{s(v),d(v)} \quad (7)$$

$$t_{s,d} + \sum_{v \in \mathcal{V}_{s,d}} \sum_{v' \in \mathcal{V} \setminus \mathcal{V}_{s,d}} \eta^{v,v'} \times t_{s(v'),d(v')} \leq \varphi_{MAX}, \quad \forall s, d \in \mathcal{N} \quad (8)$$

$$\sigma^v, \eta^{v,v'} \in \{0, 1\}; \text{ non-negative integer: } \varphi_{MAX} \quad (9)$$

Simulation Model

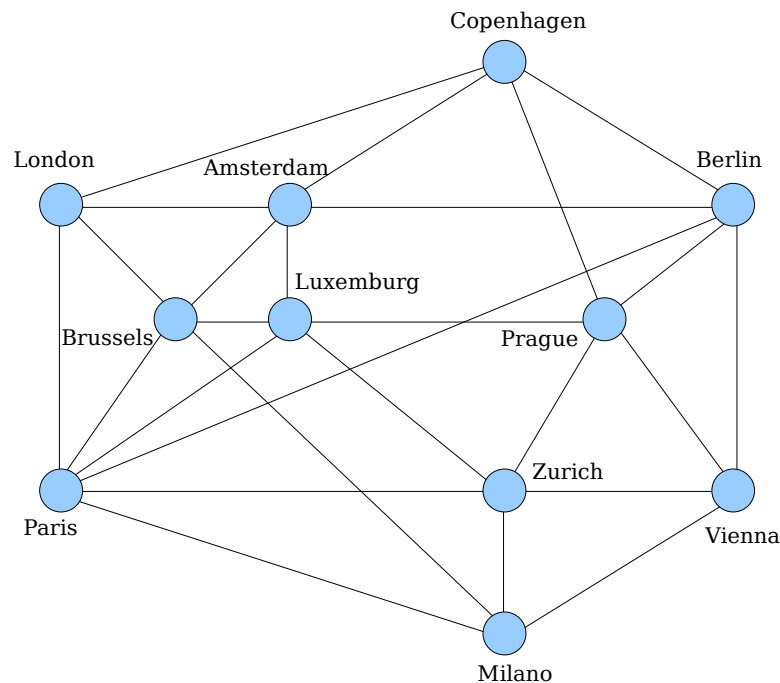
A conceptual view



Simulation Model

The OBS network global characteristics

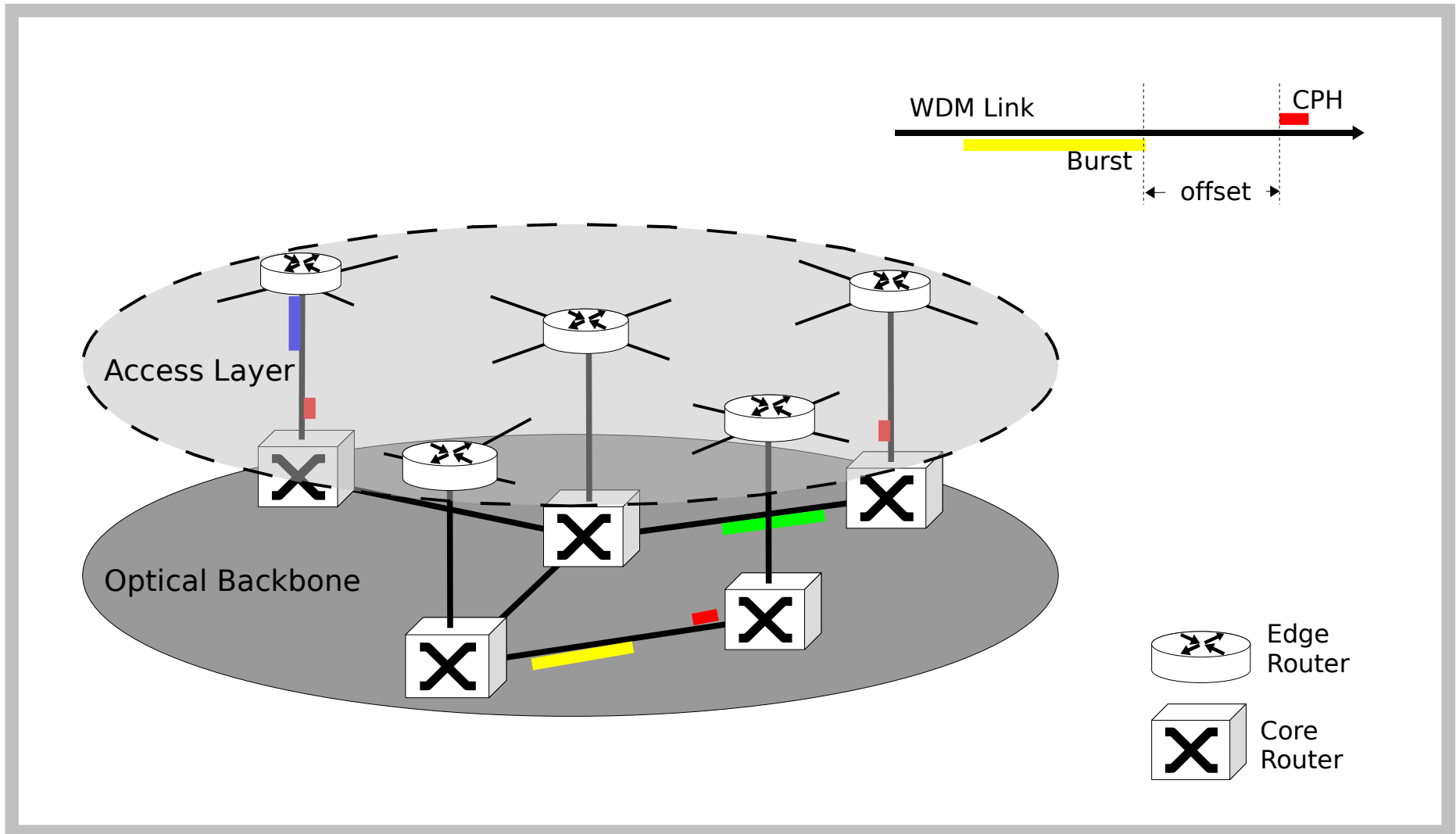
The COST 239 topology



- $W=16 \lambda s$ / link
- 10 Gbit / channel
- Poisson pattern traffic
- Threshold-based bursts (100 KB)
- Symmetric traffic matrix
- JET signaling scheme
- Source routing decision (MCL / MEC)
- Full wavelength conversion

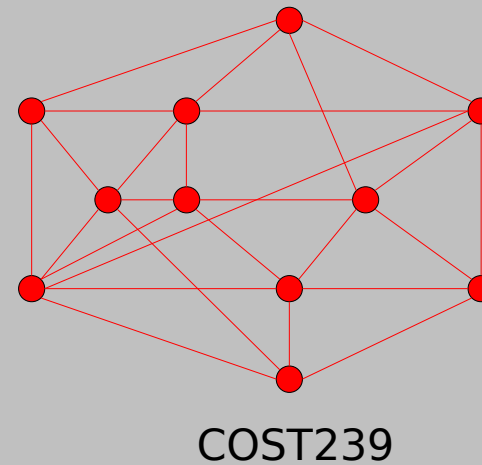
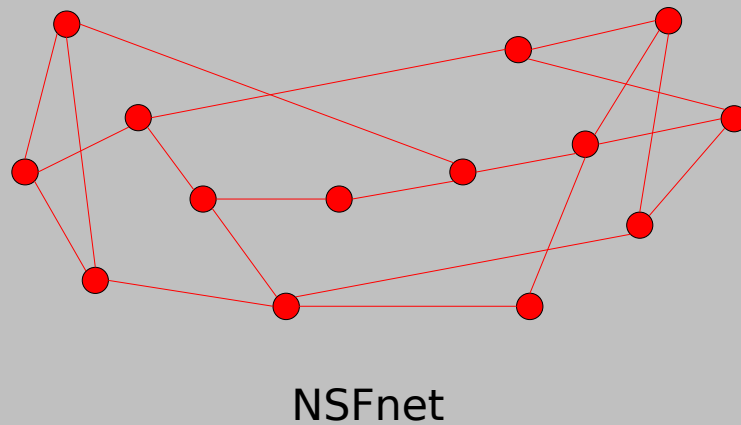
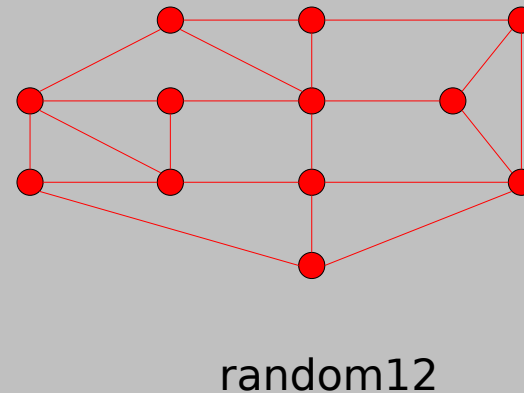
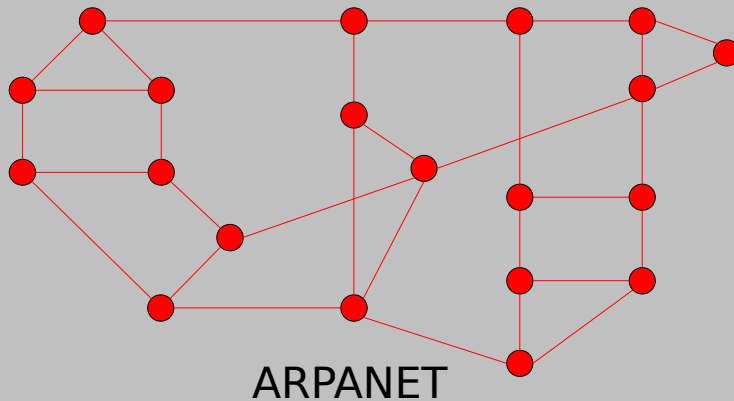
Simulation Model

The adopted OBS architecture



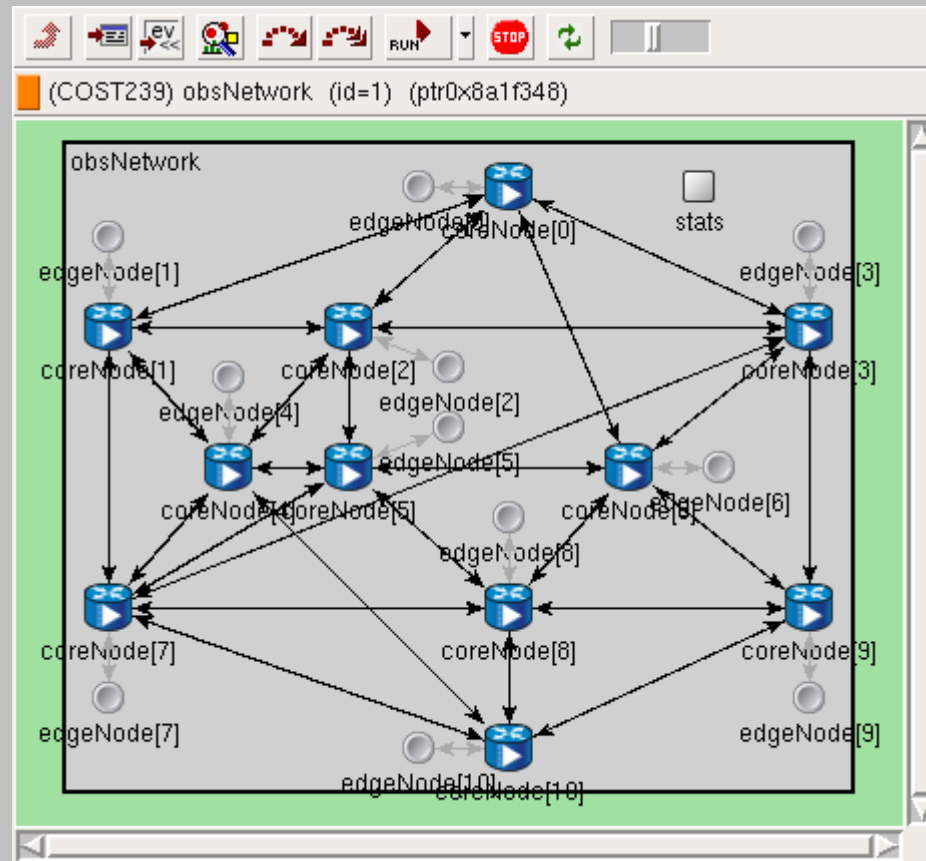
Simulation Model

Network topologies under study



Simulation Model

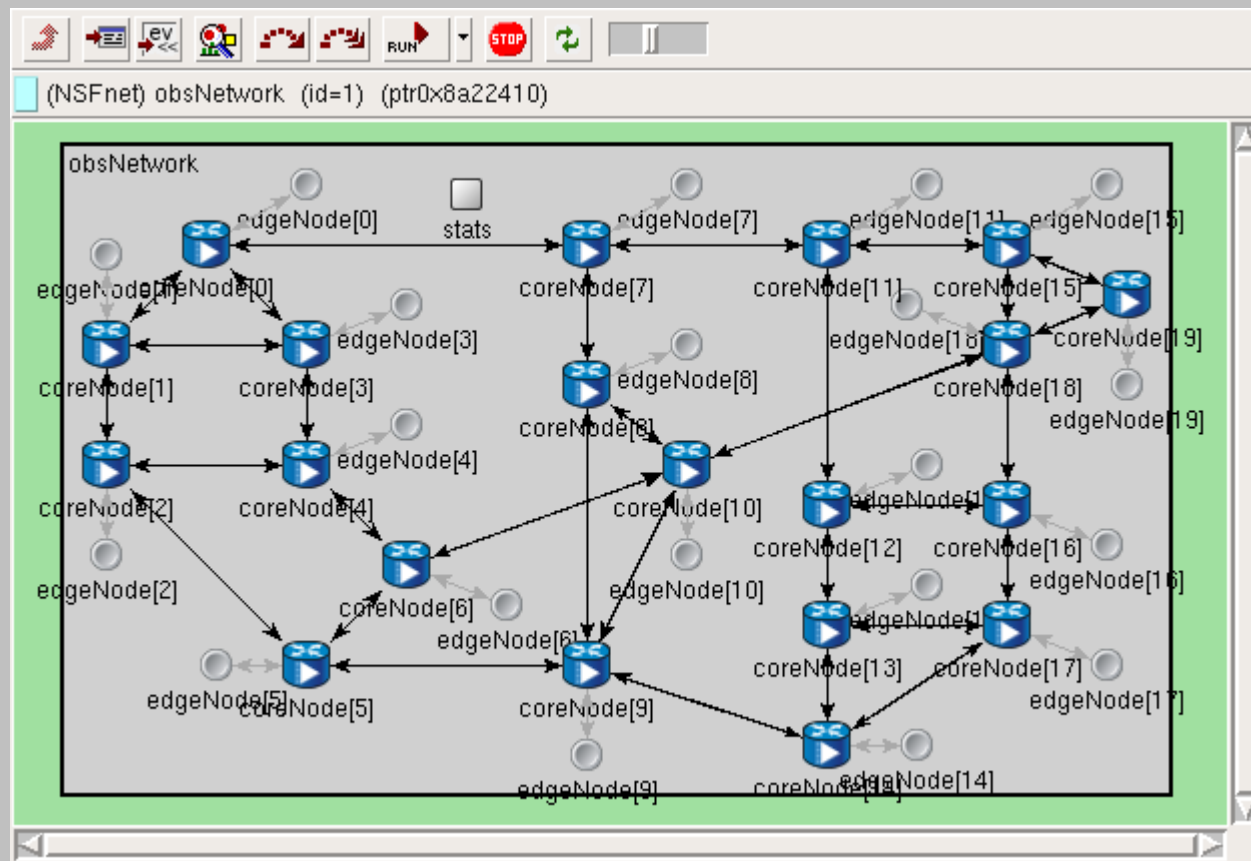
Snapshot of COST239 *



* in OMNeT++

Simulation Model

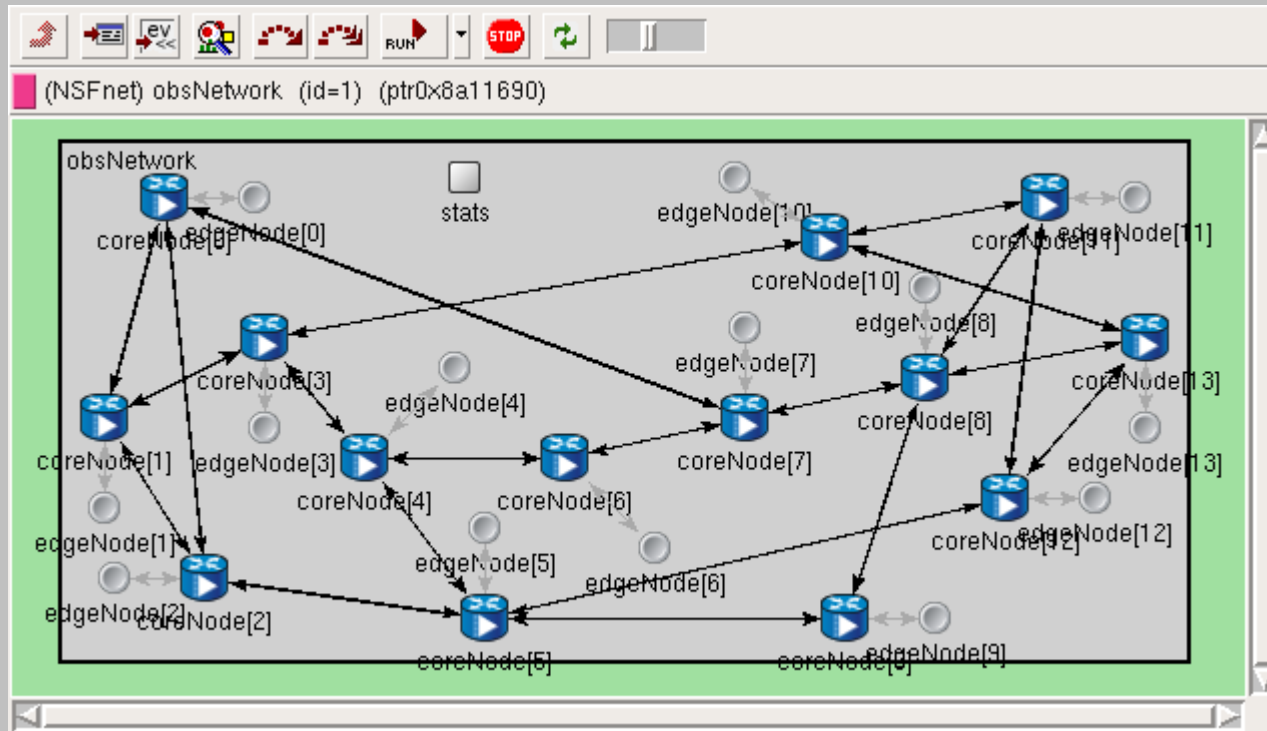
Snapshot of ARPANET *



* in OMNeT++

Simulation Model

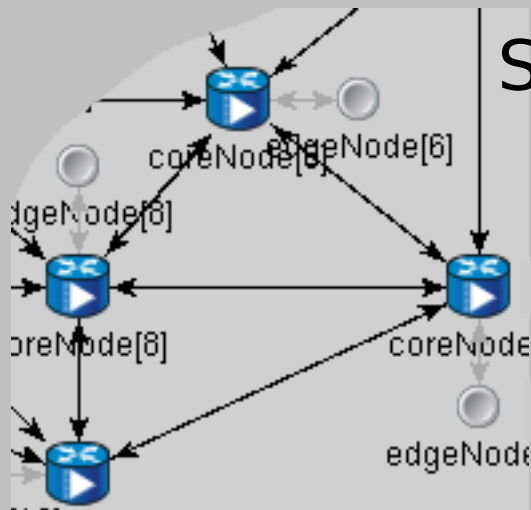
Snapshot of NSFnet *



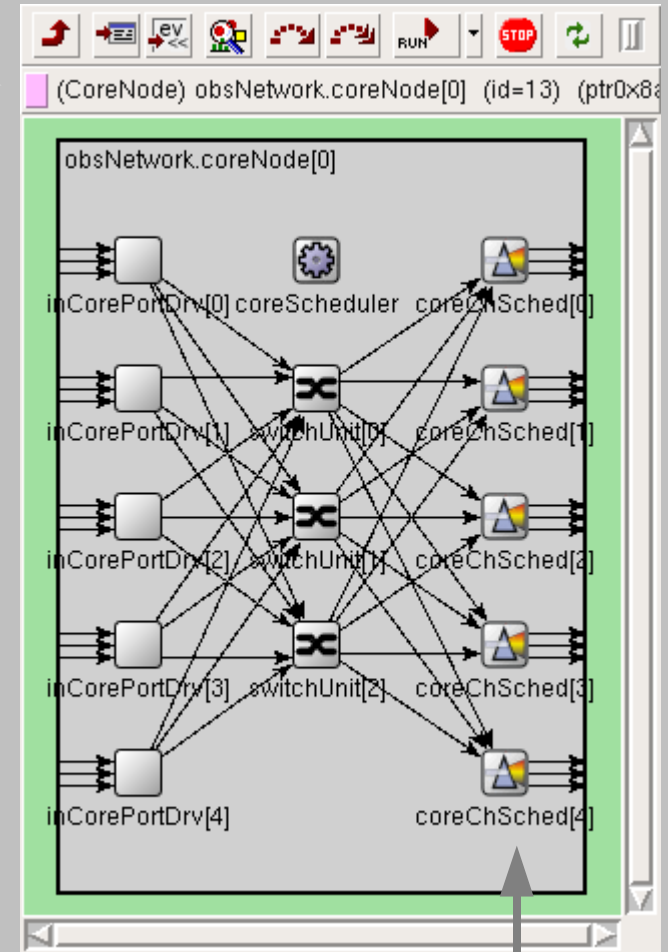
* in OMNeT++

Simulation Model

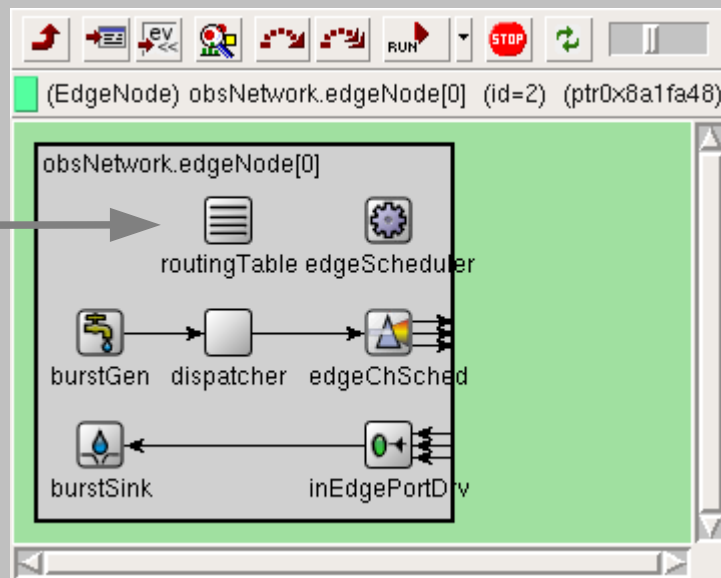
Snapshots of submodules *



coreNode



edgeNode



actions in
space
dimension

actions in
wavelength
dimension

* in OMNeT++

Simulation Model

Structure of the RoutingTable @ edgeNode

```
abarra@ceotserver:~/cost239$ cat cost239_sp_s9.rte
```

```
9 0 1 9 6 0
9 1 1 9 3 0 1
9 2 1 9 3 2
9 3 1 9 3
9 4 1 9 10 4
9 5 1 9 8 5
9 6 1 9 6
9 7 1 9 3 7
9 8 1 9 8
9 9 1 9 9
9 10 1 9 10
```

```
abarra@ceotserver:~/cost239$
```

routingTable.h

```
class RoutingTable : public cSimpleModule
{
    private:
        struct RouteEntry {
            std::vector<int> route;
            int numOfHops;
            bool accessed;
        };

        // container for Routing Table
        std::vector<RouteEntry> routingTable;

    public:
        // ...

    protected:
        // ...
}
```

source routing
is used

Simulation Model

Behavior of the coreChSched @ coreNode

handleMessage

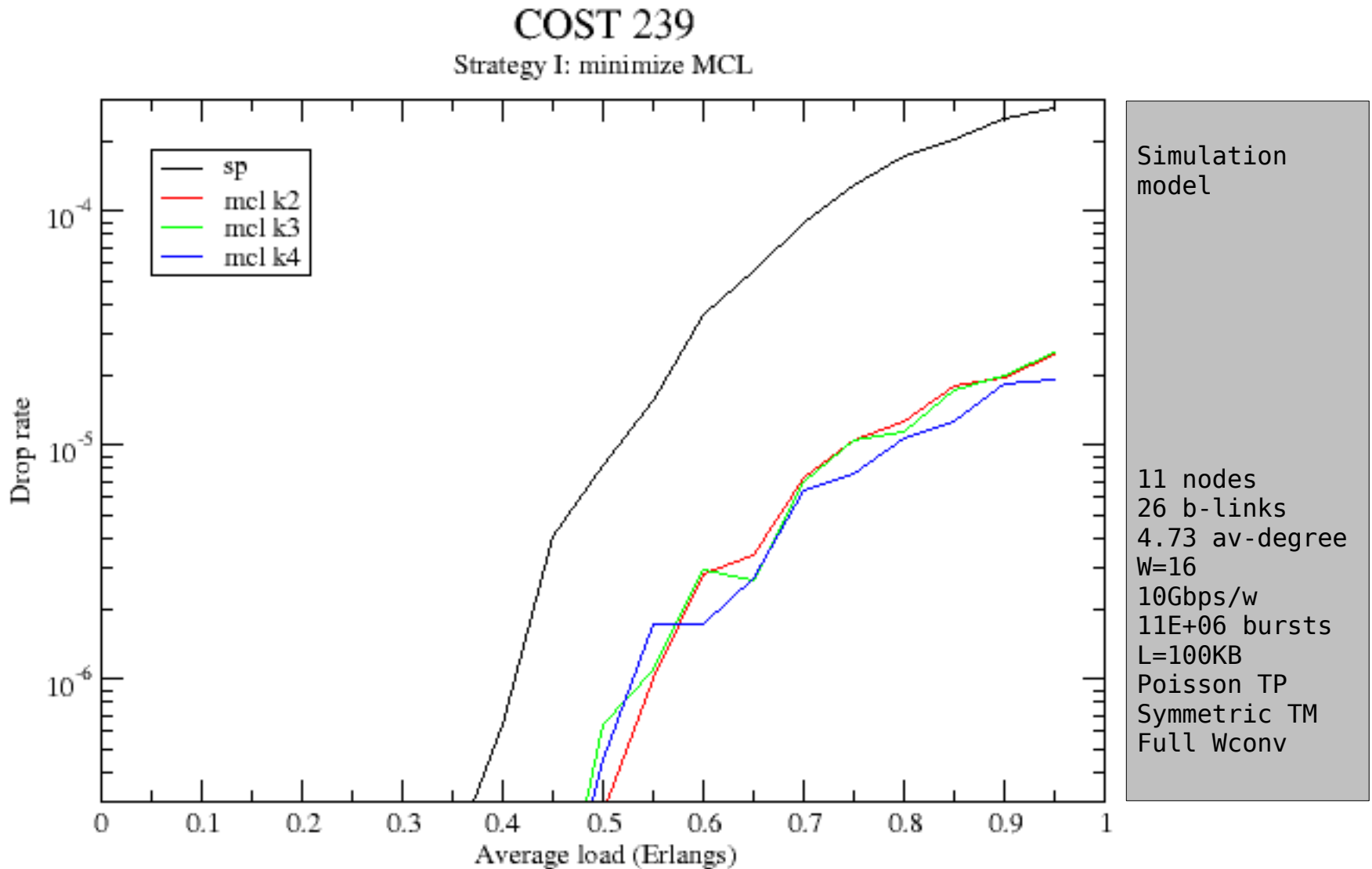
// Function called for each event

if msg is a Control Packet Header
processCph

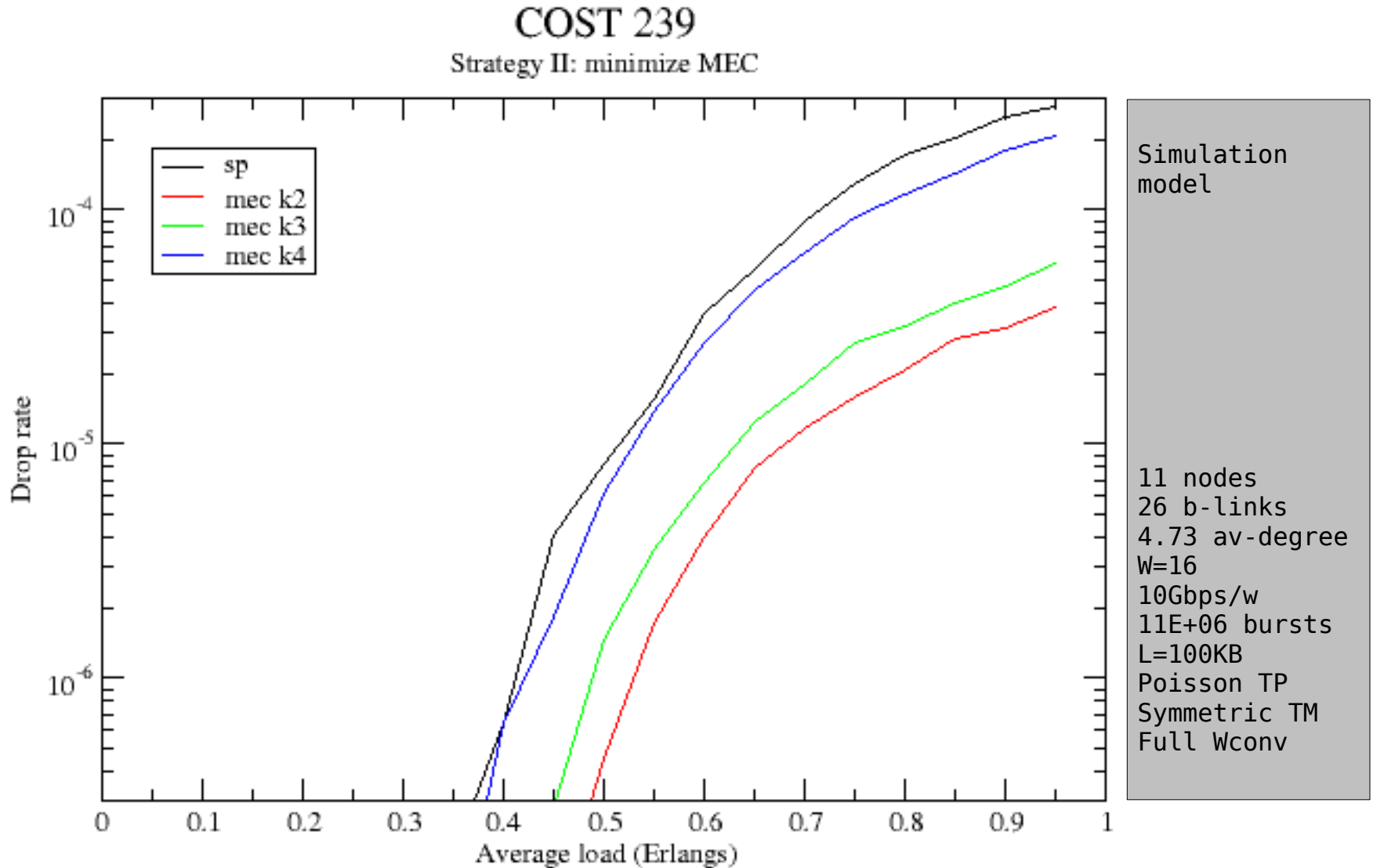
else if msg is an Optical Burst
processBurst

else, it is a selfmessage
processHoldingTimer

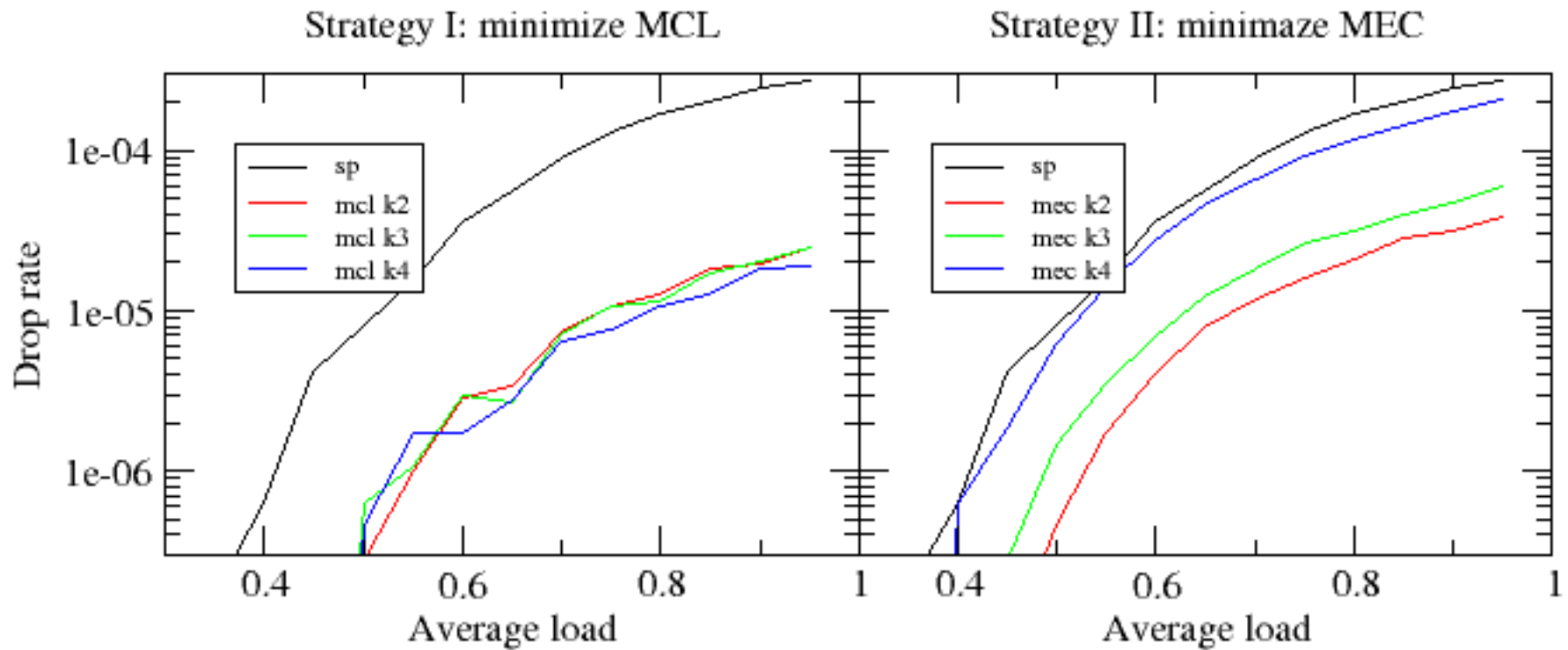
Performance Evaluation



Performance Evaluation



Performance Evaluation



Conclusion

- Both routing strategies (MCL and MEC) behave better than the shortest path approach.

Ending

- An OMNeT++ simulation model was created for routing path evaluation in OBS networks.
- Two routing strategies for OBS networks are presented and evaluated
- It is possible to reduce burst loss taking preventive actions on the space domain.
- (Performance results may also depend on the network connectivity..., *further research is needed*).
- Network simulation model is being prepared for future work.

Acknowledgments:



Thank you