Reliable Multicast Sessions Provisioning in Sparse Light-Splitting DWDM Networks using P-Cycles

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Introduction

- DWDM networks allow hundreds of wavelengths to be multiplexed into one single fiber.
  - A Node or Link failure could disrupt several communications.

DWDM networks survivability is very important.

- In Multicast traffic:
  - One single node or link may carry the traffic to multiple destinations.

Survivability is a crucial task for multicast traffic.

Problem Statement

- Problem:
  - **Node** and **link** failure recovery for dynamic **multicast** traffic in **sparse light-splitting** DWDM networks.

- Challenges:
  - **Sparse light-splitting** constraints:
    - Avoiding **Multicast Incapable** (MI) nodes.
    - Ensuring **wavelength continuity**.
  - **Efficient** use of the network capacity.
  - **Fast** restoration time.

→ **P-Cycles (pre-configured protection cycles) protection approach.**

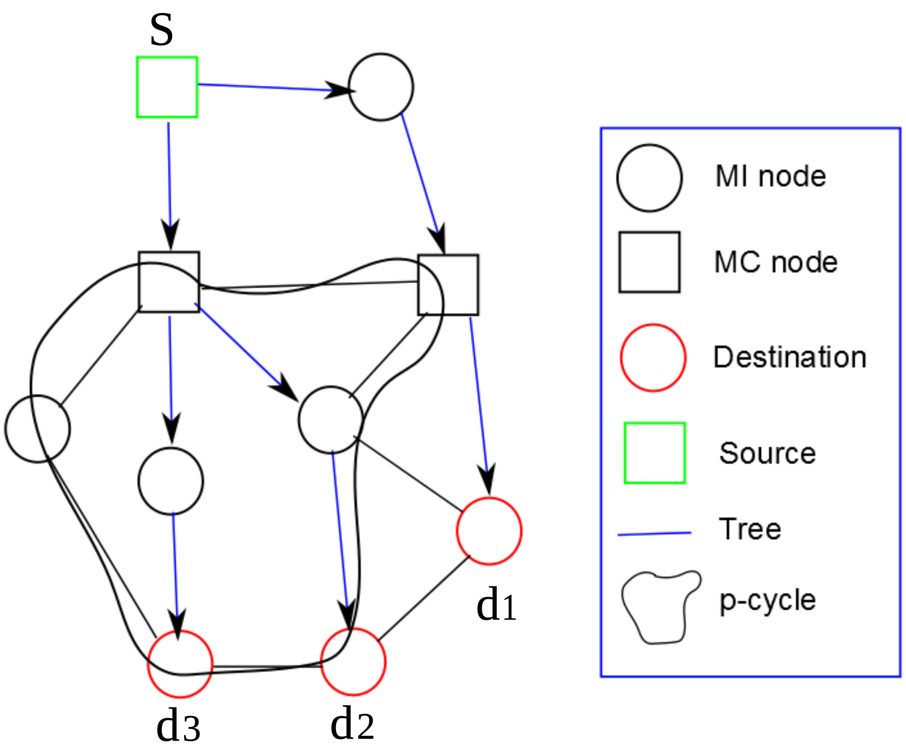
P-Cycle Protection Approach

➢A p-cycle:

- **Pre-configured** closed path
- **Reserved** capacity

➢Network protection strategy:

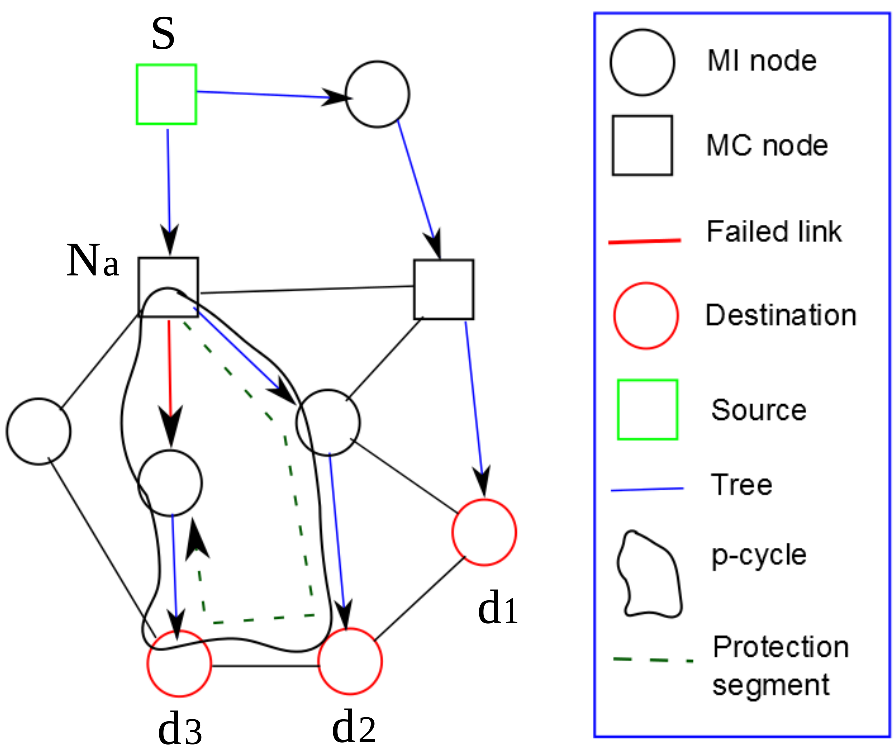
- **Links**
- **Nodes**



Link Protection Mechanism

➢On-cycle link:

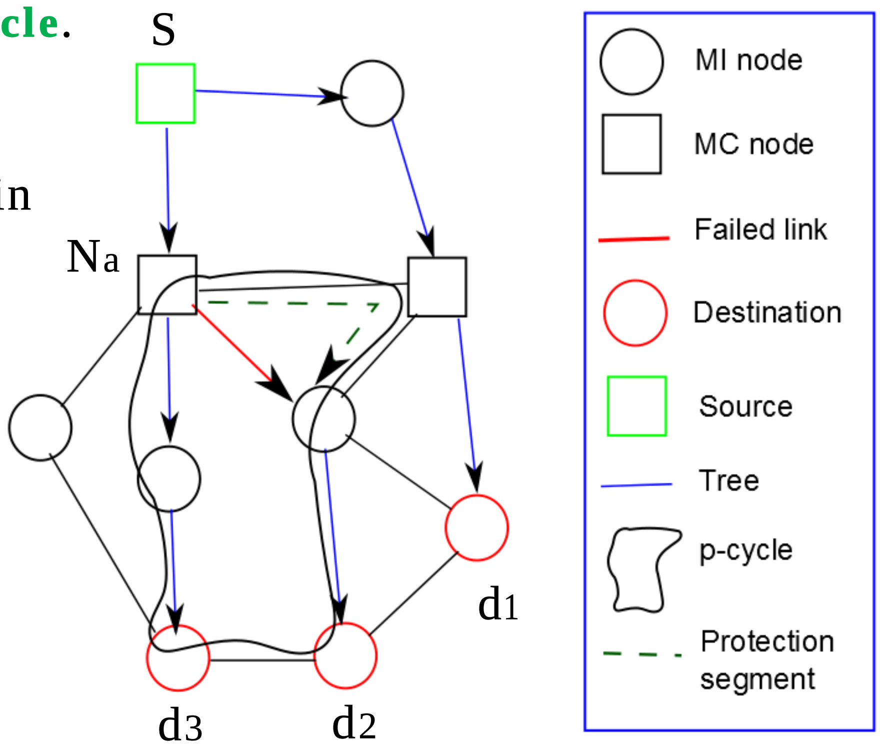
- The **failed** link is **on the p-cycle**
- Na **injects** the input light **signal** in **the p-cycle**.



Link Protection Mechanism

➢Straddling link:

- Link's end nodes are **on the p-cycle**.
- Link is **not used** by the p-cycle.
- N_a **injects** the input light **signal** in **the p-cycle**.

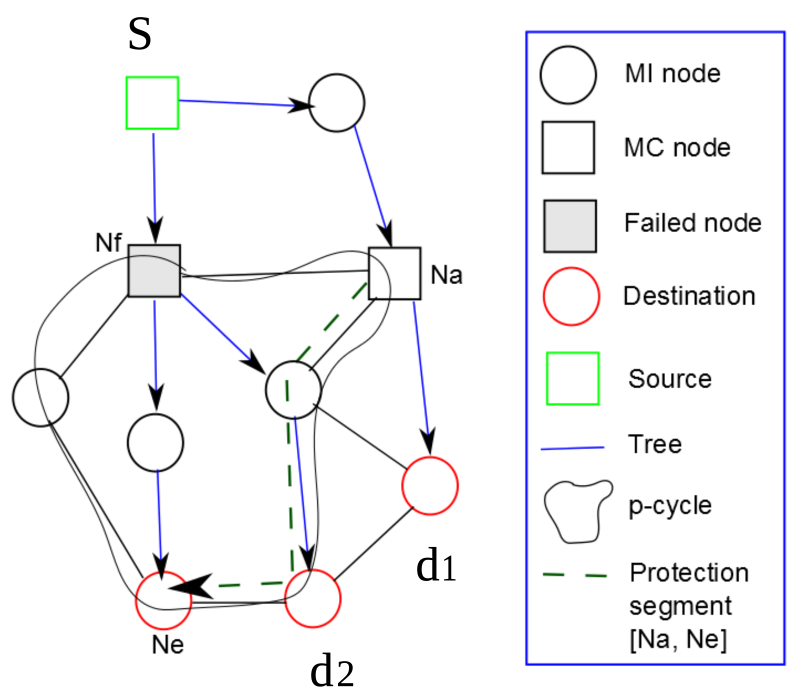


Node Protection Concept

- Let ***D*** be the **set** of **destination affected** by a failure on a node **N_f**.
- A p-cycle can **protect** N_f:
  - If it contains a **protection segment** [N_a, N_e] such that:
    - ✓ N_a **activates** the p-cycle whenever **N_f fails**.
    - ✓ Every destination in ***D*** is **covered** by [N_a, N_e].
    - ✓ N_f **does not belong** to [N_a, N_e].

Node Protection Concept

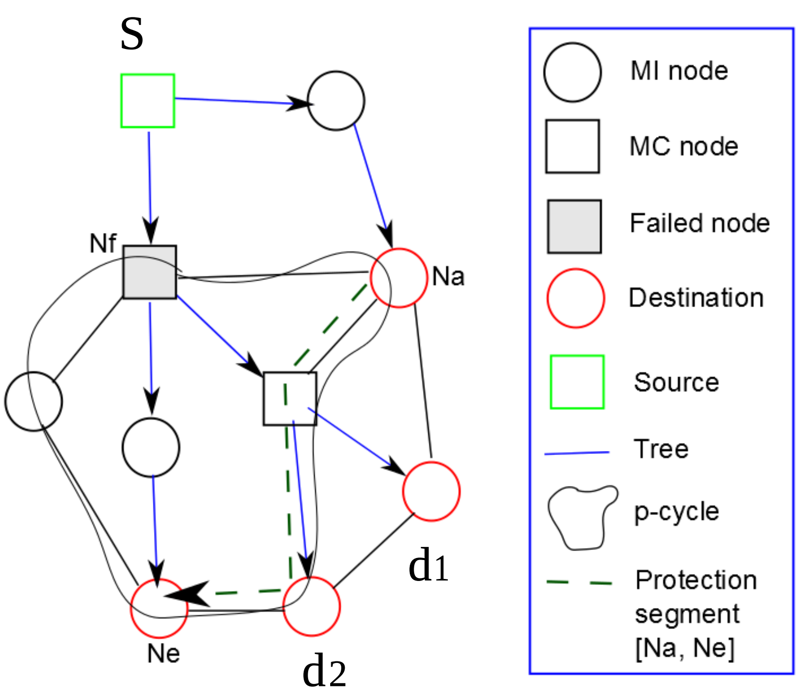
- N_a is a **Multicast Capable** (MC) node
- N_a **splits** the input light signal into **two signals**:
  - The **first** is injected in the **p-cycle**.
  - The **second** is injected in the down streaming node of the **light tree**.



Node Protection Concept

➢Na is a **leaf destination** node:

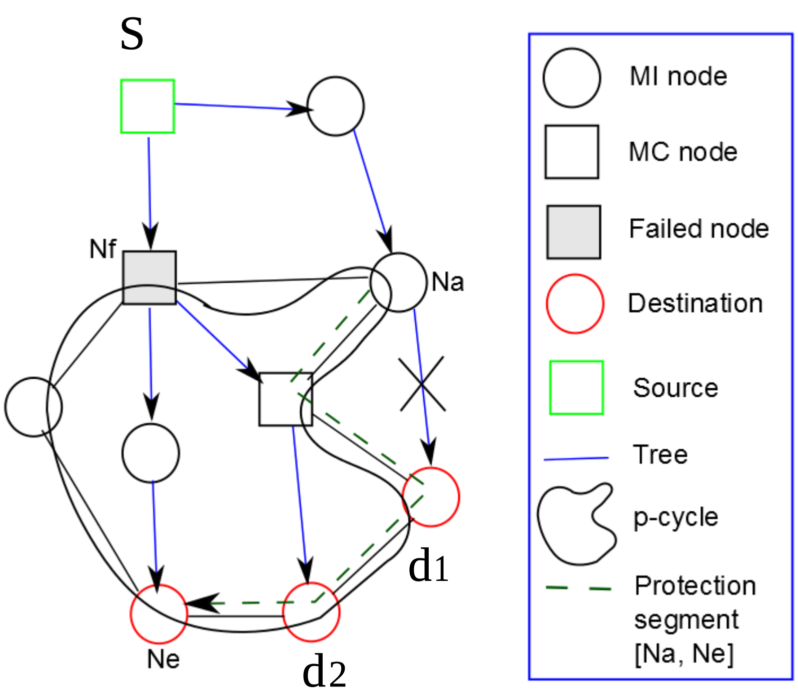
- Na **injects** the input light **signal** in the **p-cycle**.



Node Protection Concept

➢ Na is a **Multicast Incapable** (MI) node:

- It **reroutes** the multicast **traffic** trough **the p-cycle**.
- Downsteaming **destination** of Na is **covered** by the p-cycle.



Existing Algorithm for Dynamic Multicast Traffic

- The **ESHN** algorithm:
  - **Dynamic** multicast traffic
  - **P-cycle** protection approach
  - The most **efficient** algorithm in the literature in terms of :
    - ✓ **Bandwidth** saving
    - ✓ **Acceptance rate** of the request
  - **High computational time!**
  - **Not adapted for sparse light-splitting constraints!**

The Proposed Algorithms

- An improved version of ESHN:
  - Takes into consideration the **sparse light-splitting** constraints.
- The **NPCC-SSC** algorithm:
  - Uses our proposed **concept** for **node protection** with sparse light-splitting constraints.
  - Uses a **candidate cycle set** to maintain a **low computational time**.

Candidate Cycles Selection

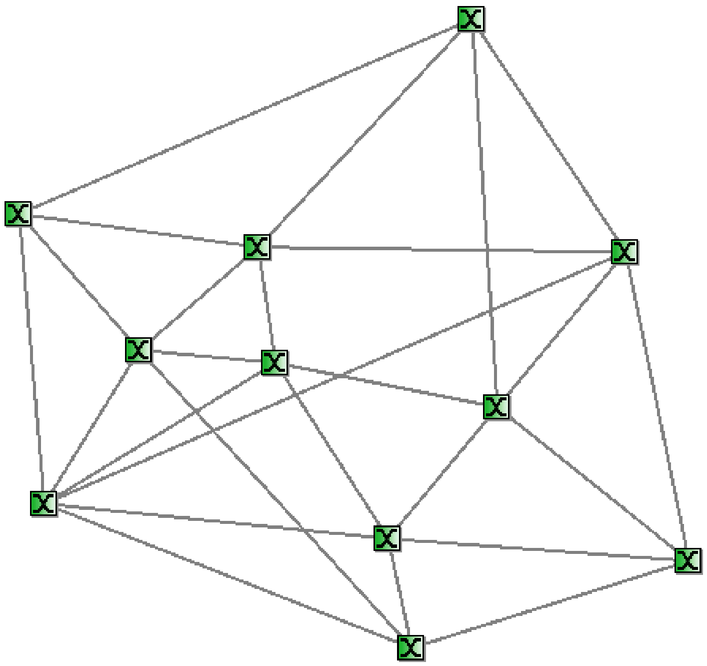
- **NPCC-SSC** selects the candidate cycles in advance based on the protection capacity score ***PC*.**

$$PC(Cj) = \frac{LCj}{|Cj|}$$

- ***LCj*** : The amount of **link capacity** in the network that ***Cj*** can protect.
- $|Cj|$: The sum of **spare capacity** required by ***Cj*.**

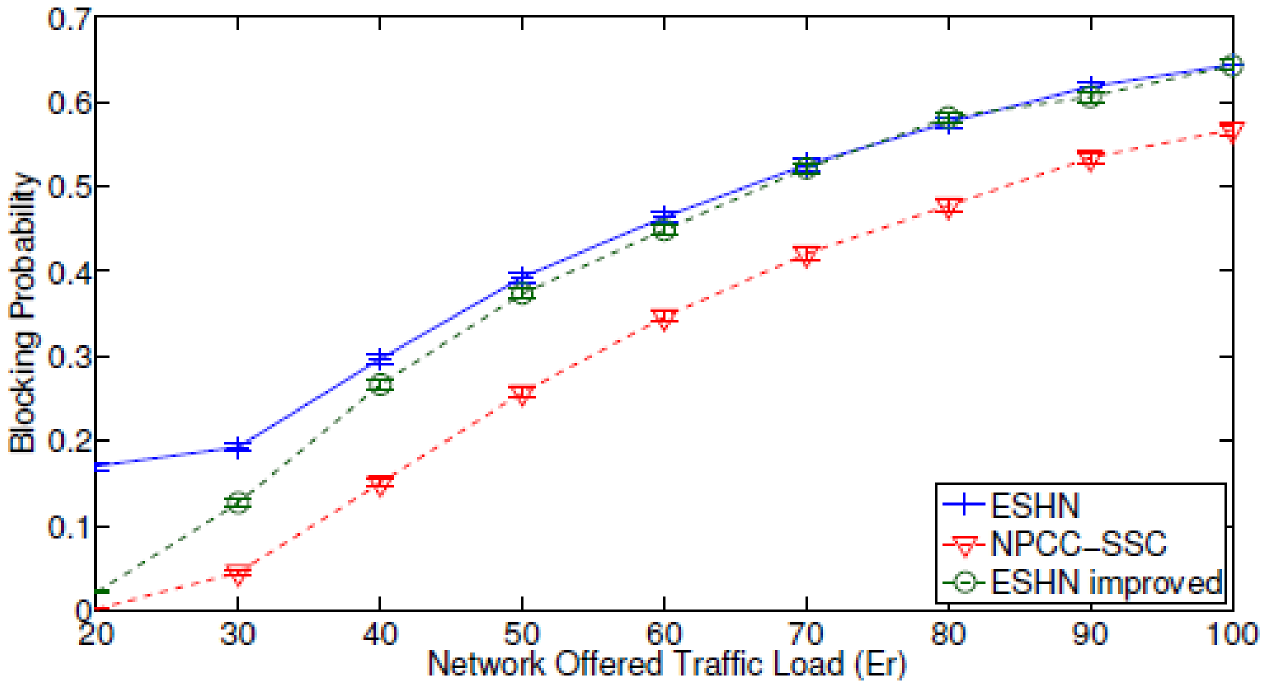
Performance Evaluation

- Dynamic Multicast traffic:
  - **2.500.000** requests for each traffic load value.
  - **Five** destinations in each multicast request.
- **50%** of nodes are **MI**.



Topology: **COST239** Network

Blocking Probability ***(BP)***



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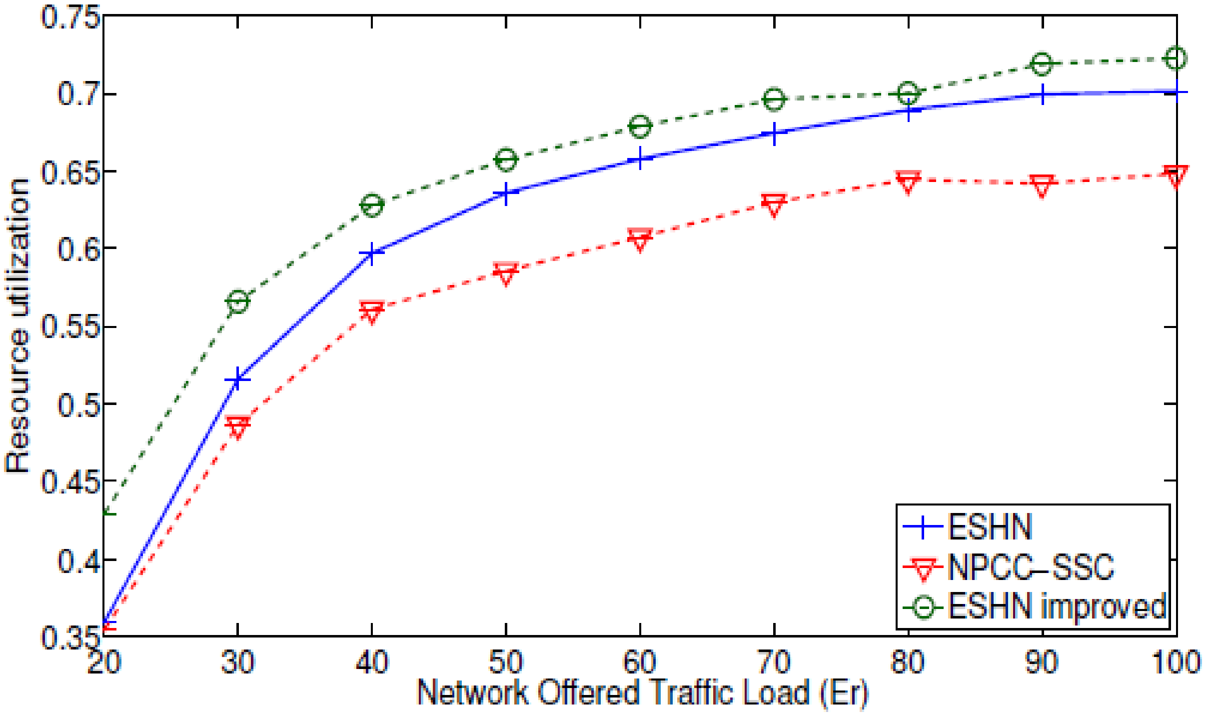
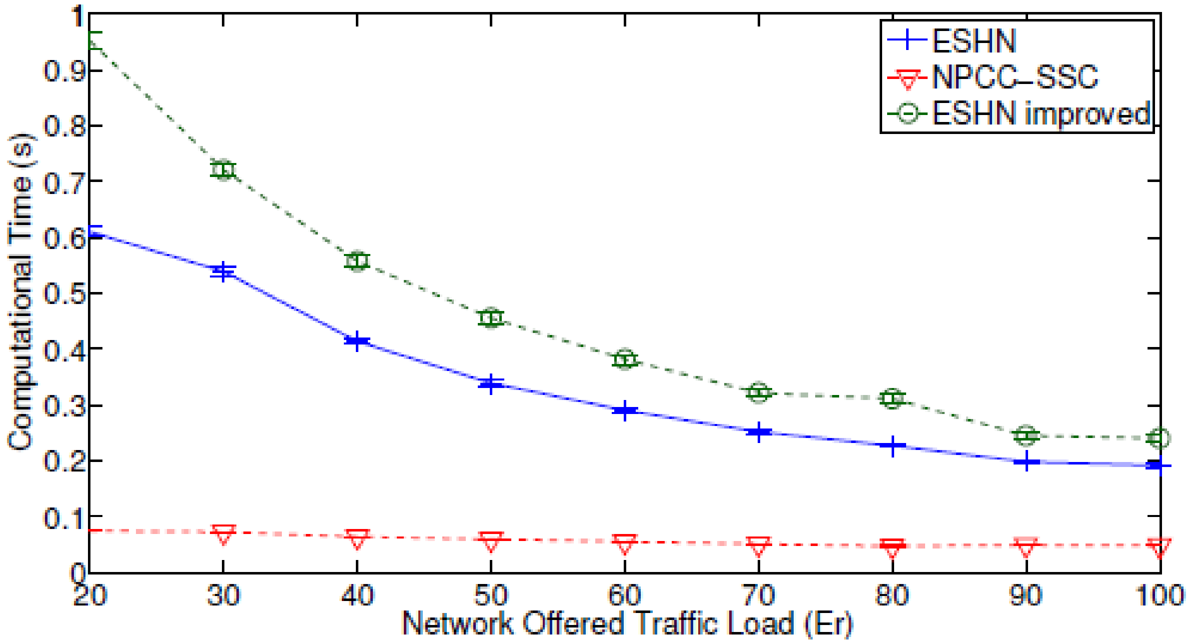
Resource Utilization ***(RU)***



Average Computational Time *(CT)*



Conclusion

	ESHN	*ESHN improved*	*NPCC-SSC*
Blocking Probability (*BP*)	The Highest one	High	The Lowest one
Resource Utilization (*RU*)	High	The Highest one	The Lowest one
Computational Time (*CT*)	Hight	The Highest one	The Lowest one

Thank you for your attention

Conclusion

- Problem:
  - **Node** and **link** failure recovery for dynamic **multicast** traffic in **sparse light-splitting** DWDM networks.
- Propositions:
  - Extending the **p-cycle** approach to support **node** protection with sparse light-splitting constraints.
  - Two novel algorithms:
    - ✓ **ESHN improved**
    - ✓ **NPCC-SSC**

Performance Evaluation

- Performance criteria:
  - The Blocking Probability ***(BP)***
    - Percentage of requests that **cannot be** routed or protected among the total number of requests.
  - Average Computational Time ***(CT)***
    - Required for **routing** and **protecting** a traffic request.
  - Resource Utilization ***(RU)***
    - Percentage of **reserved wavelengths** in the network among the total number of wavelengths.

The ESHN Algorithm

- P-cycles are **selected** based on the Efficiency Score (***ES***).
  - The p-cycle with the **highest *ES*** is selected and configured.

$$ES\,(C_j) = \frac{W_{j,L} + W_{j,N}}{|C_j|}$$

- ***Cj*** : A protection p-cycle.
- ***|Cj|*** : The sum of **spare capacity** required by ***Cj***.
- ***Wj,L***: The amount of **working link** capacity protected by ***Cj***.
- ***Wj,N*** : The number of **transit nodes** protected by ***Cj***.

Flow chart of NPCC-SSC