

Coordinated Network Management and Control System for Reservation and Real-Time Optical-Path Provisioning

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Outline

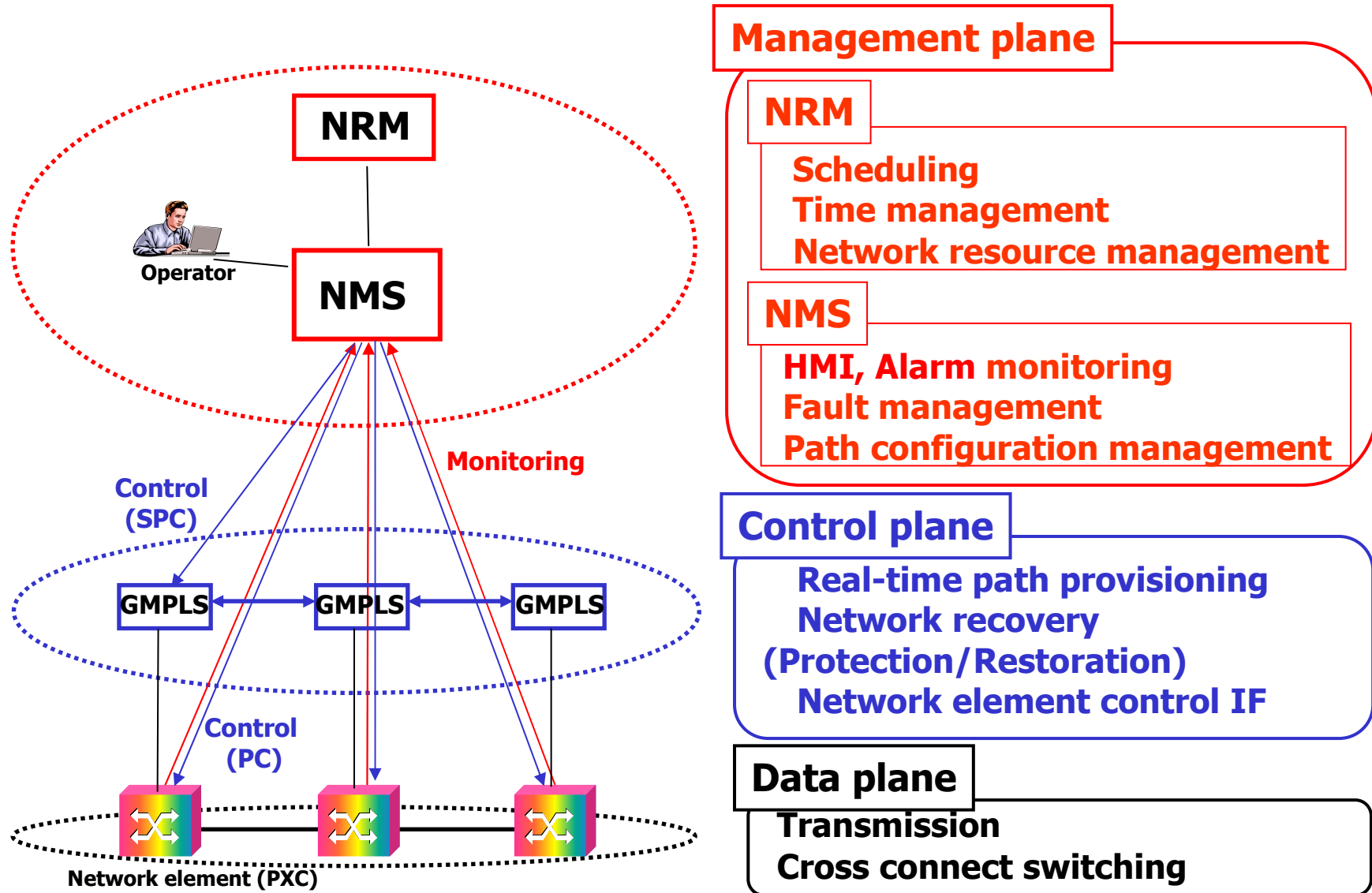
- **“Time-aware” service**
 - ▶ **Function allocation**
- **Synchronization of network resources**
 - ▶ **Synchronization of NRM and data plane**
 - ▶ **Re-design reserved path**
- **Path configuration management**
 - ▶ **Compare and restore control plane and data plane using management plane**
- **Implementation of prototype system**
 - ▶ **System construction**
 - ▶ **Experimental results**
- **Conclusion**

Time-Aware Service

- **Optical path service on photonic transport networks**
 - ▶ **Real-time optical path service**
 - ✓ **GMPLS**
 - ➡ **Real-time optical path provisioning**
 - ▶ **Scheduled optical path service**
 - ✓ **Network Resource Manager (NRM)**
 - ➡ **Reserved path management**
- **“Time-aware” service**
 - ▶ **Provides real-time and reserved optical path on same network platform**
 - ✓ **GMPLS: Control plane**
 - ✓ **NRM: Management plane**

Must coordinate Control and Management planes

Function Allocation for Time-Aware Service



Problem Facing Time-Aware Service

- **Synchronization of NRM and data-plane network resource information**
 - ▶ **GMPLS and NMS control available network resources independently of NRM**
 - ▶ **Available network resources may change independently of NRM**
 - ✓ **Network failure**



Interruption in reserved optical path

Must synchronize network resource information in NRM and data plane

Synchronization of Network Resources

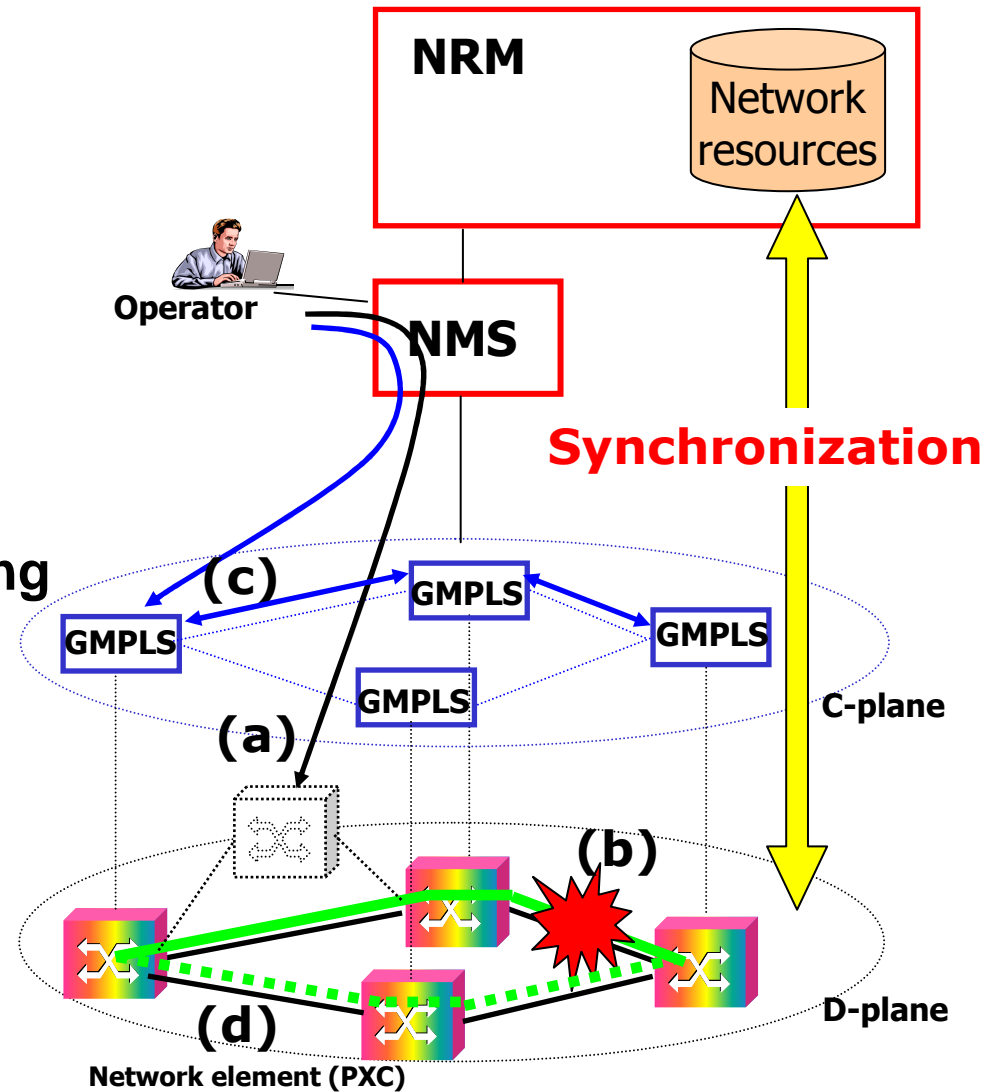
- **Changes in data-plane network resources**

(a) Addition and deletion of network elements

(b) Network failure

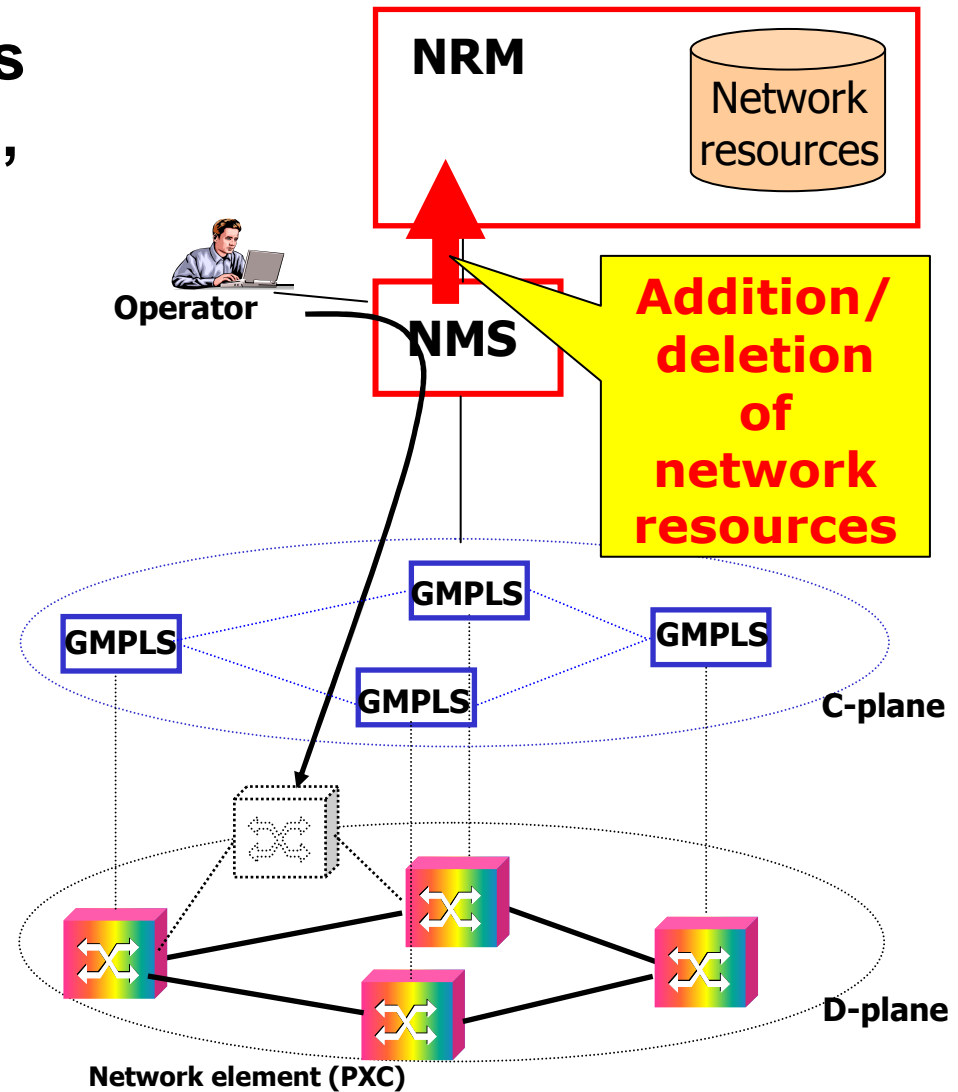
(c) Real-time path provisioning

(d) Network recovery (protection/restoration)



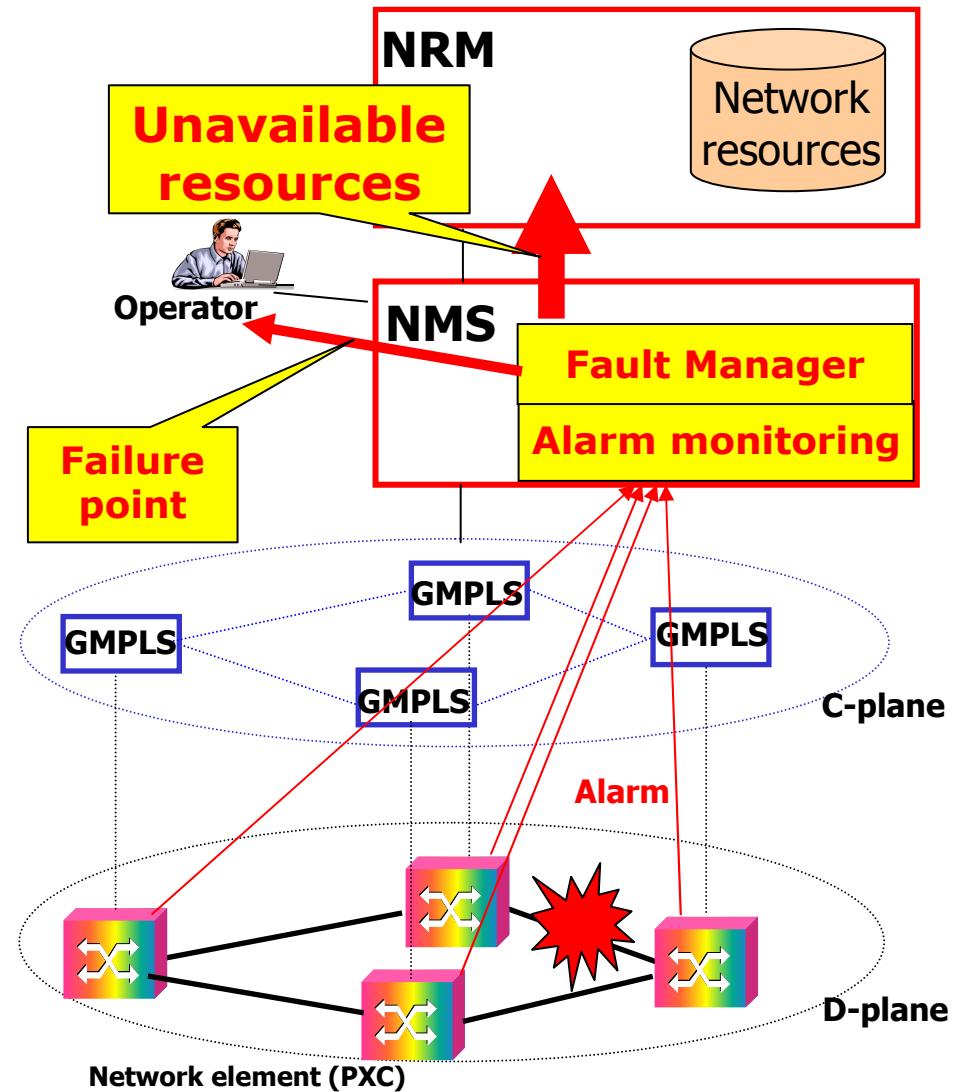
Addition and Deletion of Network Elements

- Operator adds or deletes network elements (node, link) through NMS
- NMS notifies NRM of addition/deletion of network resources



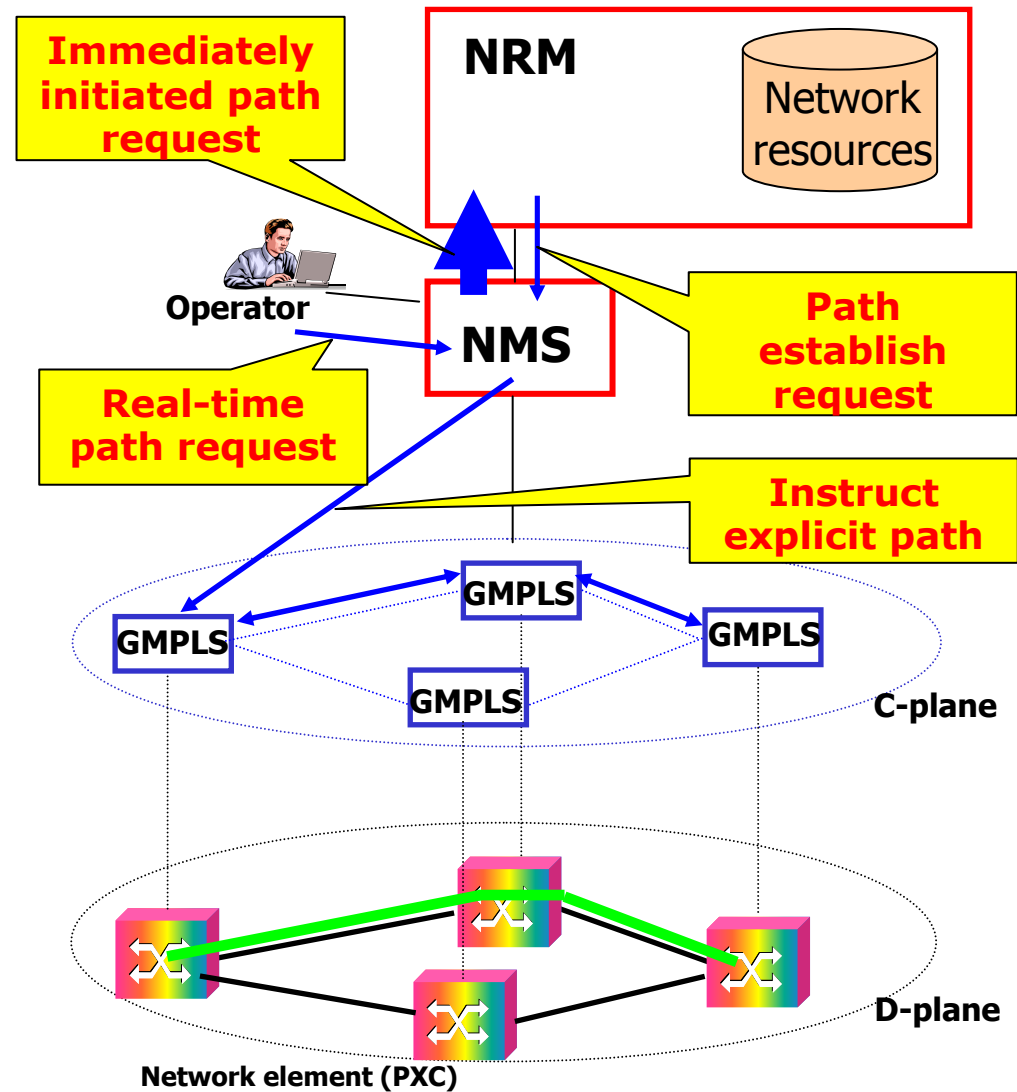
Network Failure

- Alarm monitoring
- Fault manager
 - ▶ Localize failure point
 - ▶ Notify operator of failure point
 - ▶ Specify unavailable resources
- Notify NRM of unavailable resources



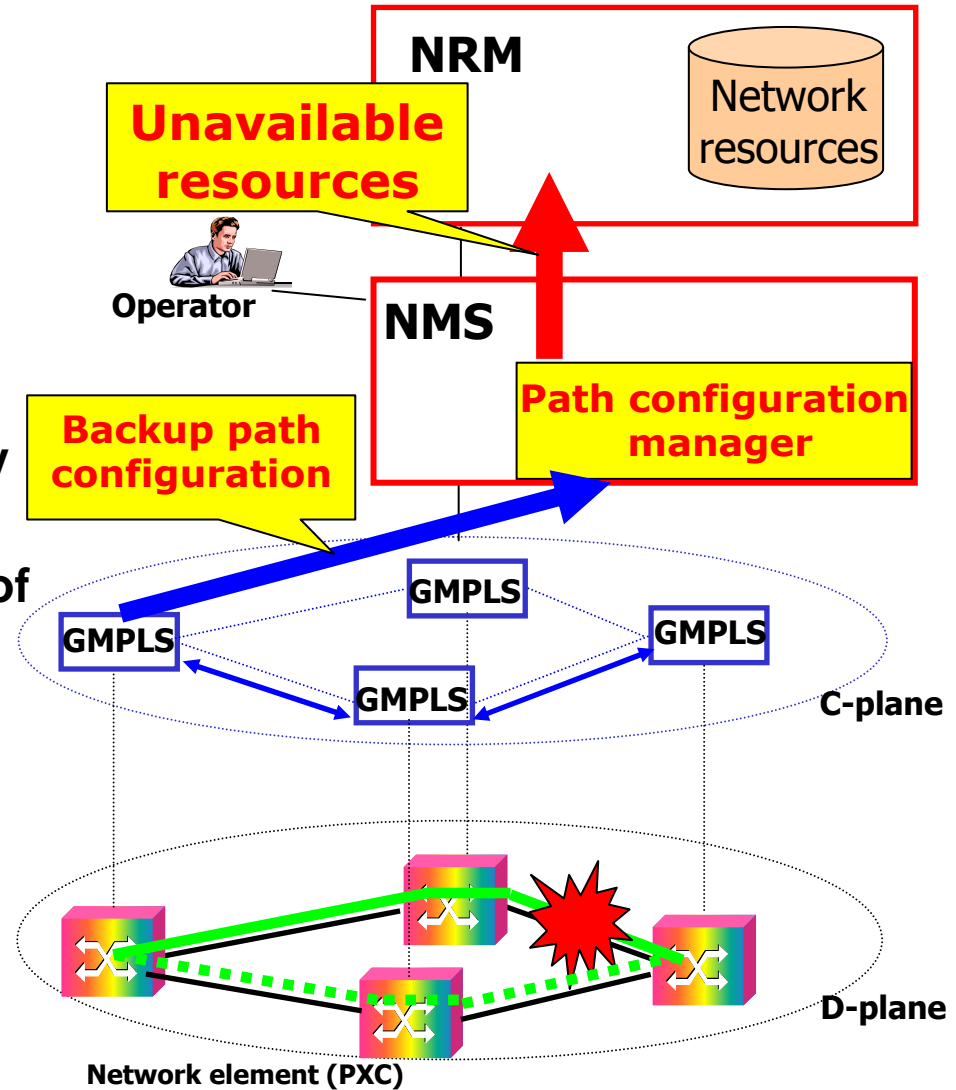
Real-Time Path Provisioning

- Real-time path request converted to immediately initiated path request in NMS
- NMS requests NRM to immediately initiate path
- NRM requests NMS to establish path
- NMS instructs control plane to establish explicit path



Network Recovery (Protection/Restoration)

- Protection/pre-planned restoration
 - ▶ NRM allocate backup path resources
- Full-rerouting restoration
 - ▶ Control plane autonomously establishes backup path
 - ▶ Control plane notifies NMS of backup path configuration
 - ▶ NMS notifies NRM of unavailable resources



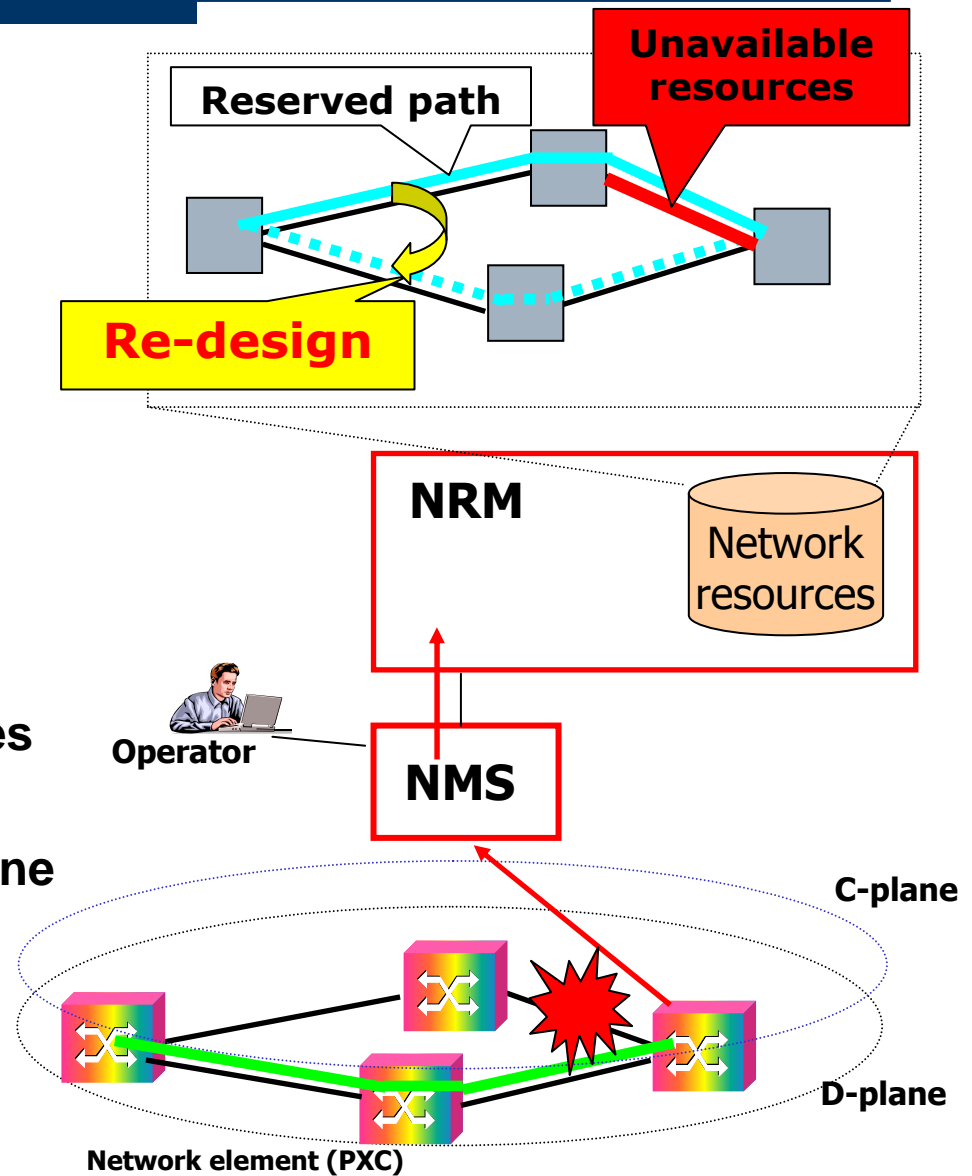
Re-design of Reserved Path

- Re-design of reserved path

- ▶ Unavailable resources
 - ✓ Network failure
 - ✓ Restoration path
- ▶ NRM changes network resource allocation

- Priority

- ▶ Total number of available network resources decreases
 - ✓ Unavailable resources
- ▶ Resources are reallocated one by one based on priority



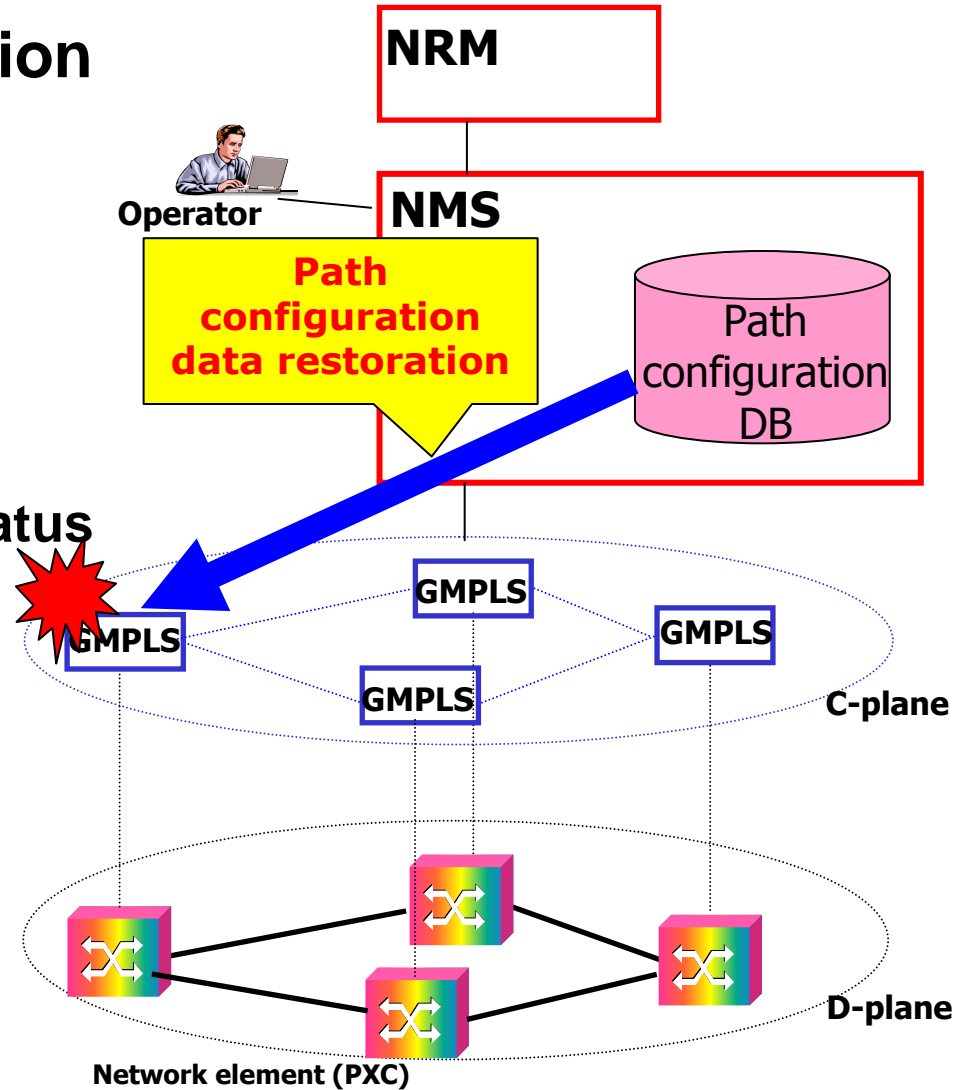
Path Configuration Management for Real-Time Path

- **Permanent connection (PC) path**
 - ▶ Path configuration is provided in management plane
- **Soft permanent connection (SPC) path**
 - ▶ Path configuration is provided in control plane
 - ▶ NMS obtains path configuration after establishing path
- **Switched connection (SC) path**
 - ▶ Path configuration is provided in control plane
 - ▶ Control plane notifies NMS of path configuration

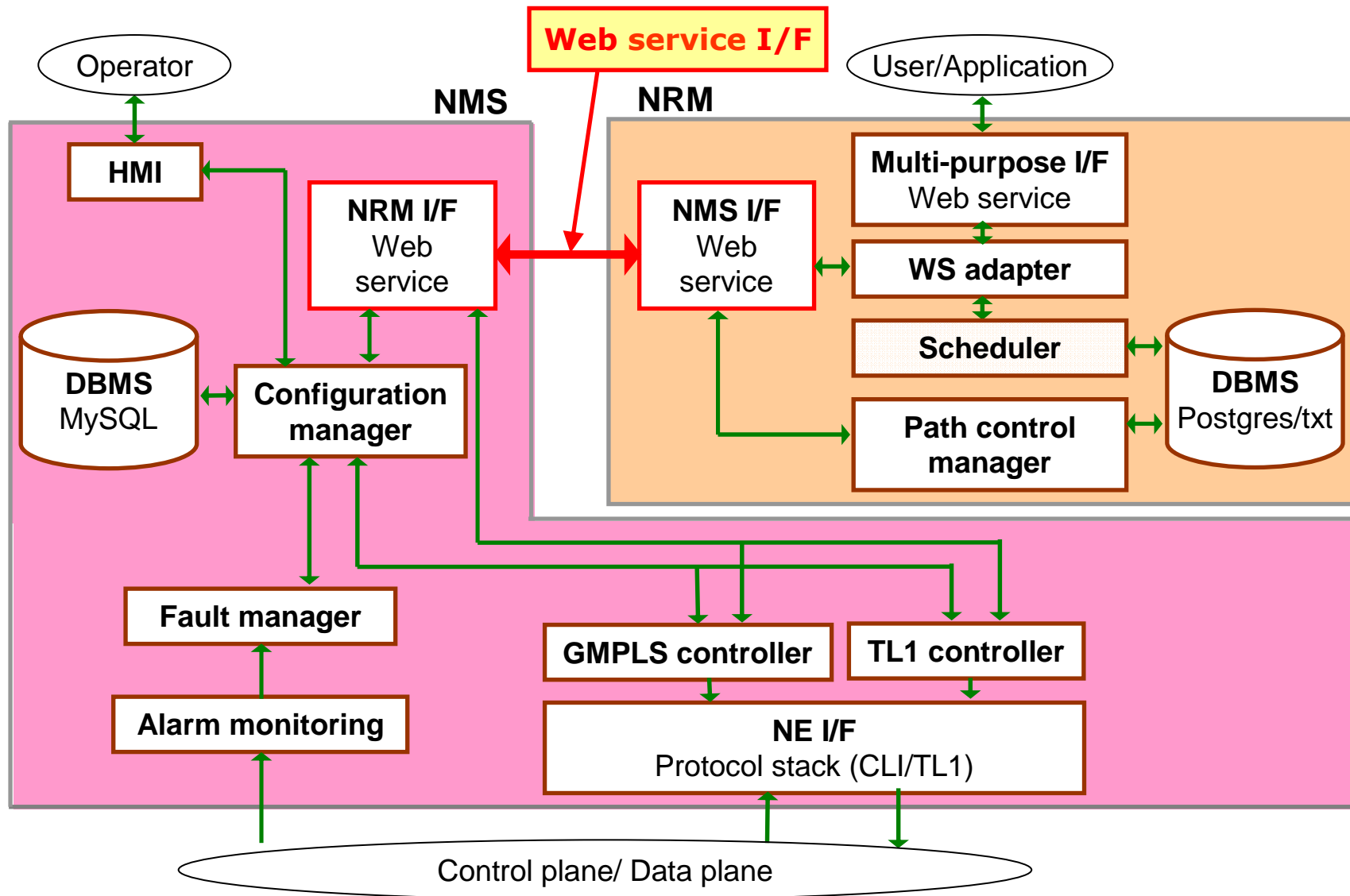
**Path configuration managed
in management plane (NMS)**

Path Configuration Data Restoration

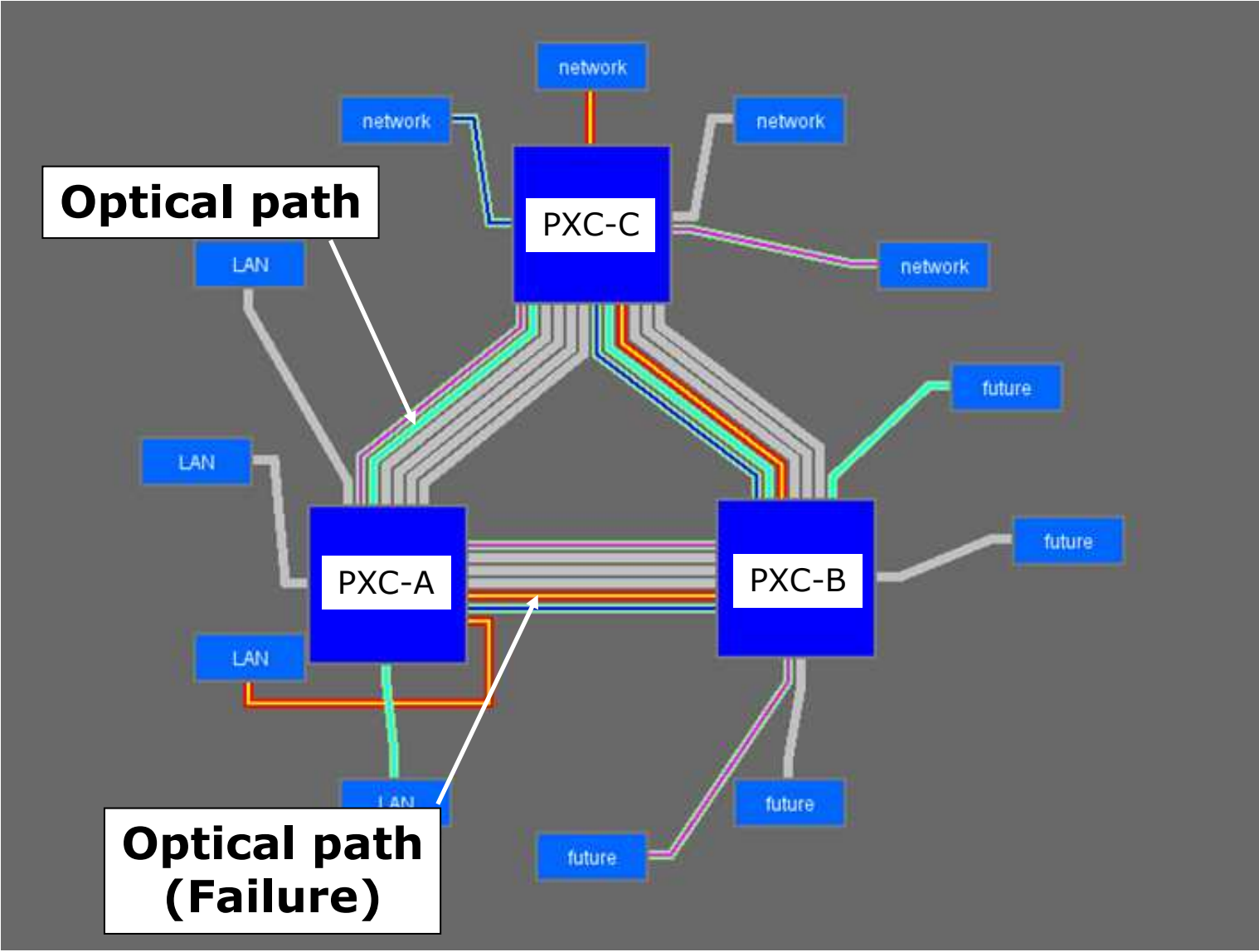
- Original path configuration data are stored in management plane
- Compare
 - ▶ Control plane: Path configuration data
 - ▶ Data plane: XC switch status
- Restore
 - ▶ SPC: Re-establish path
 - ▶ PC: Re-setup XC switch



Prototype System

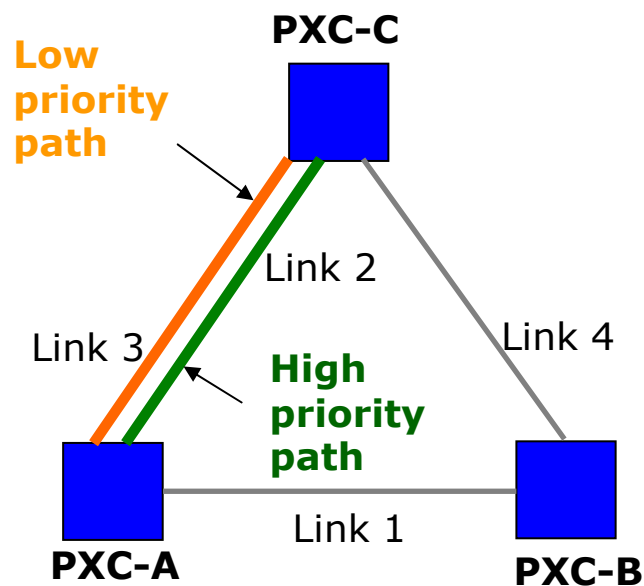


Management Screen

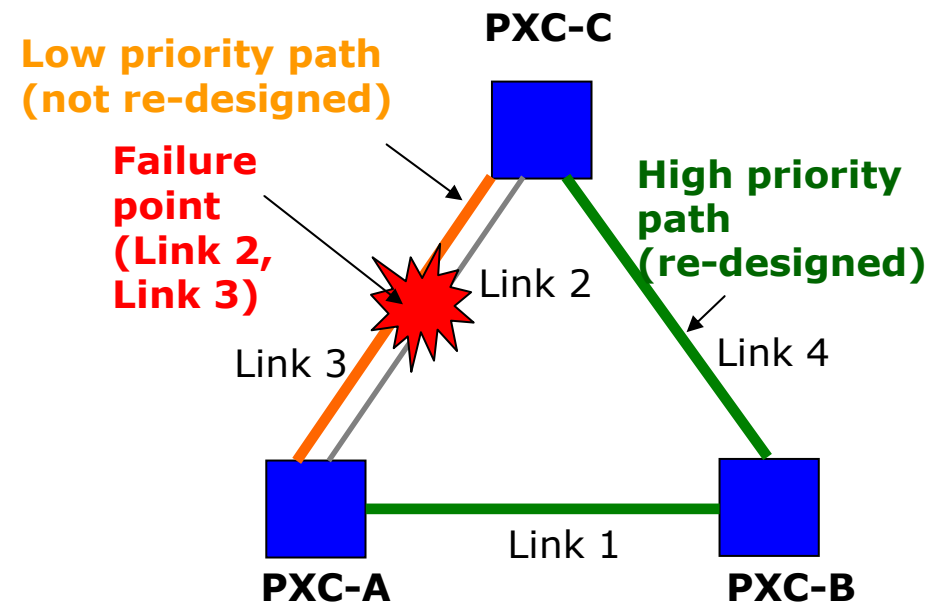


Results of Re-designed Reserved Path

- Two priority levels for reserved paths
 - ▶ High (Link 2) and low (Link 3)
- High priority path is successfully re-designed (Links 1 and 4)
- Low priority path is not re-designed
 - ▶ Available network resource insufficient



(a) Before network failure



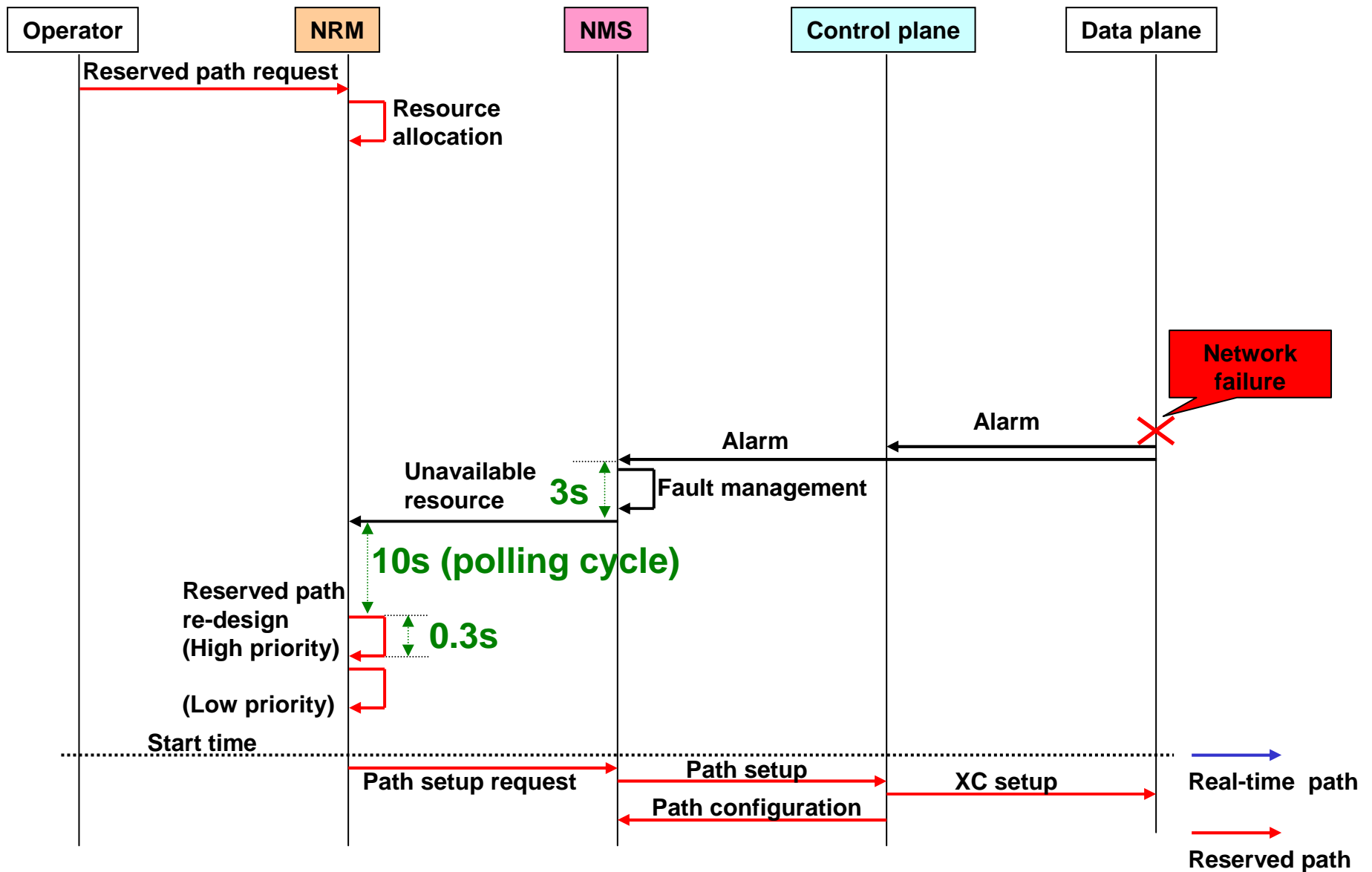
(b) After network failure

Conclusion

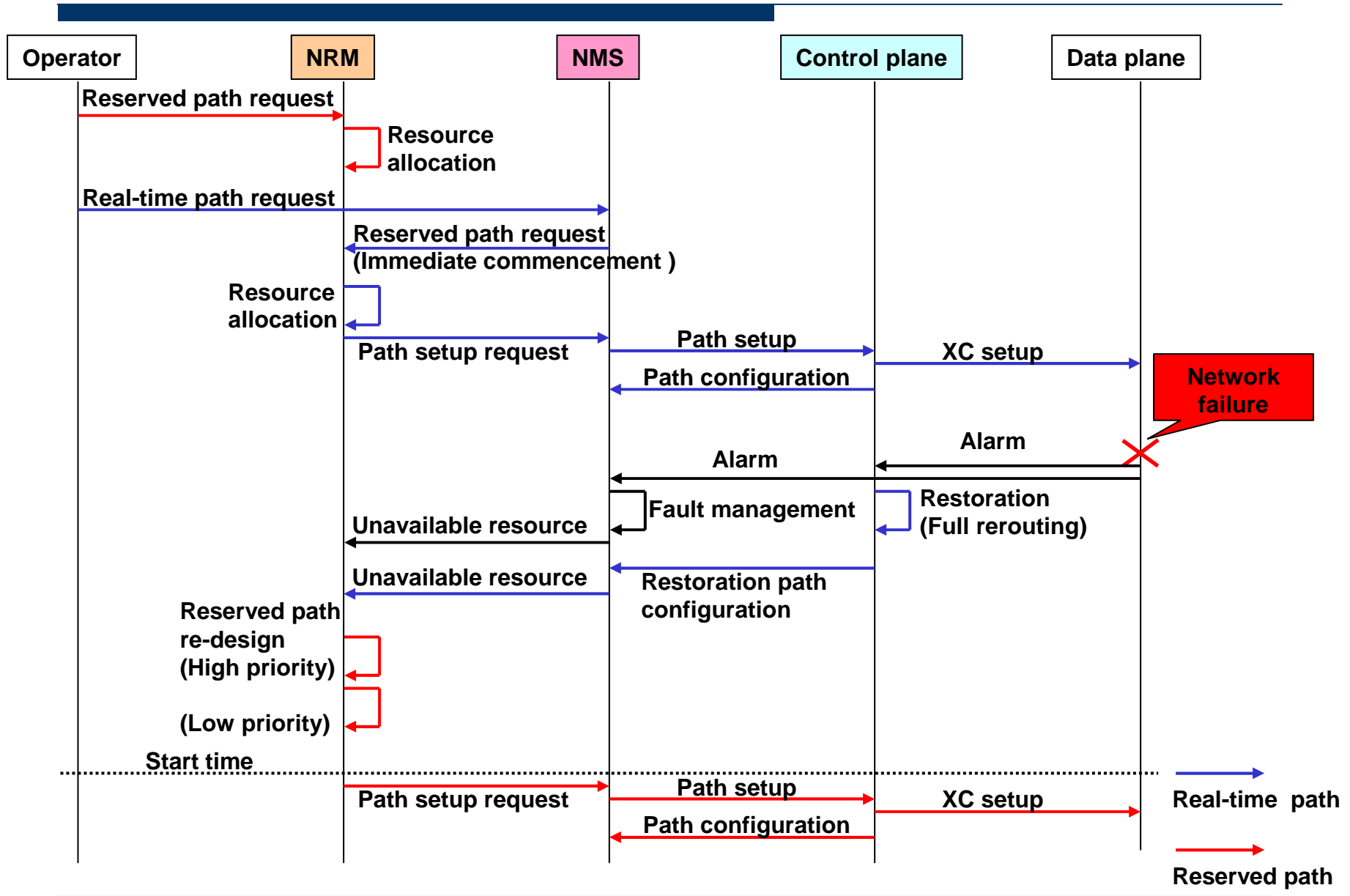
- **System architecture and problems facing time-aware service**
- **Synchronization method for network resources in NRM and data plane**
 - ▶ **Addition and deletion of network elements**
 - ▶ **Network failure**
 - ▶ **Real-time path provisioning**
 - ▶ **Network recovery**
- **Management of path configuration**
 - ▶ **Compare and restore method for control plane and data plane using management plane**
- **Prototype system and experimental results**



Procedure in Re-design (Network Failure)

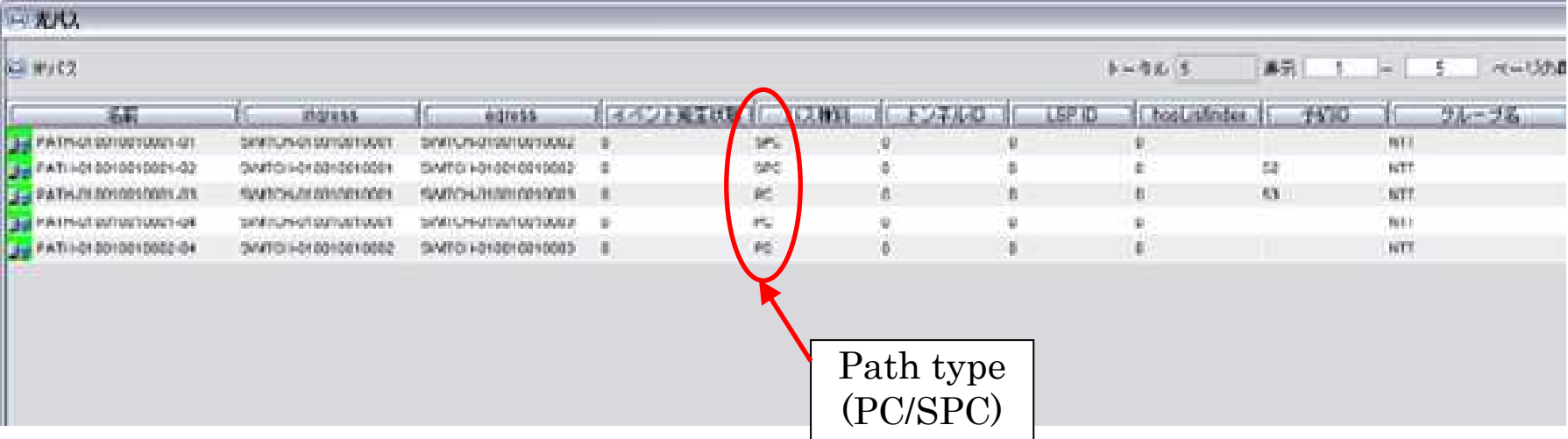


Procedure in Re-design (Restoration)



Management Screen of Optical Path (List)

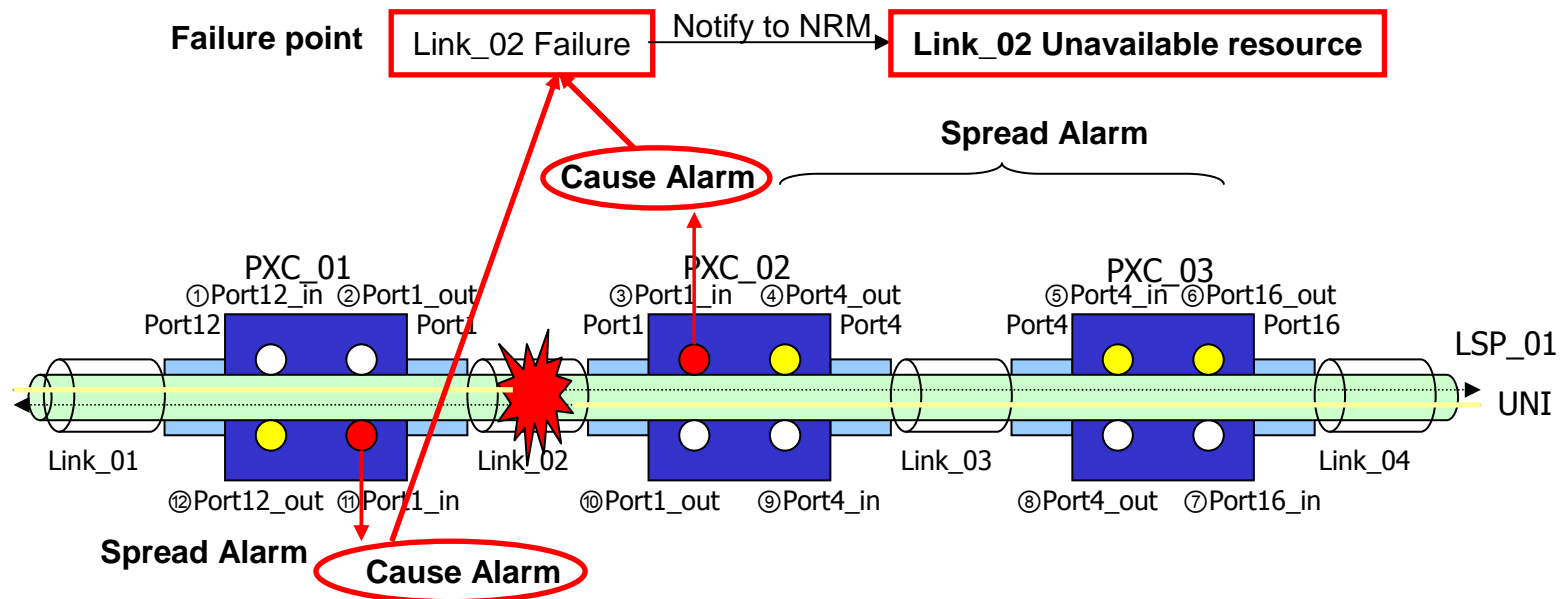
- PC path and SPC path are managed in NMS



名前	アドレス	アドレス	ポイント接続	タイプ	リンクID	トンネルID	LSP ID	ホストIndex	サブID	グループ
PATH-01-0010010001-01	SWTDC1-01-0010001	SWTDC1-01-0010010002	0	SPC	0	0	0	0		NTT
PATH-01-0010010001-02	SWTDC1-01-0010001	SWTDC1-01-0010010002	0	SPC	0	0	0	02		NTT
PATH-01-0010010001-03	SWTDC1-01-0010001	SWTDC1-01-0010010002	0	PC	0	0	0	03		NTT
PATH-01-0010010001-04	SWTDC1-01-0010001	SWTDC1-01-0010010002	0	PC	0	0	0			NTT
PATH-01-0010010002-04	SWTDC1-01-0010002	SWTDC1-01-0010010003	0	PC	0	0	0			NTT

Fault Management

- NMS specifies course alarm and spread alarm with received alarm and path configuration
 - ▶ Course alarm is furthest upstream (Critical alarm)
 - ▶ Other alarms are spread alarm (Minor alarm)
- NMS specifies failure point with course alarm
 - ▶ Port failure / Link failure
- NMS notifies NRM unavailable network resource (Node/Link)



Fault Management Screen for an Optical Path

