# *Optical Rings and Hybrid Mesh Rings Optical Networks*

***draft-papadimitriou-optical-rings-00.txt***

**Dimitri Papadimitriou - Alcatel**

# *Rationale for Optical Rings*

- **All-Optical switches for metro DWDM networks**
  - all-optical “revolution” comes from the metro networks since not impacted by distance (~ 800 km)
- **Metro networks high bandwidth needs (~ 1Tb/s)**
- **Coarser granularity than SDH/Sonet required**
  - “who needs” a 2 Mb LL-based management today ?
- **Transparent to the client signal framing (A / Sync)**
  - Ethernet - ATM - FR - SDH/Sonet are “perfect” clients
- **Dynamic resource allocation - resource optimization**
  - distributed and flexible bandwidth allocation
- **Need for a flexible wavelength assignment / conversion**
  - avoid wavelength blocking problem
- **Low-cost protection (Uni- or Bi-directional)**
  - “re-usable” protection capacity

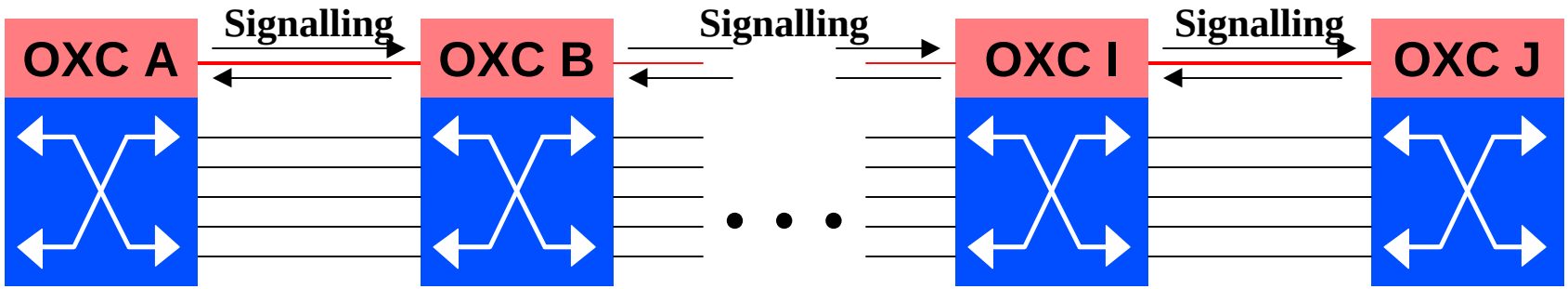
# *Scope - Introduction*

- **Optical rings : IP-over-Optical Metro networks**

  **$\Rightarrow$ Optical "Resilient Packet Ring"**
- **Signalling and TE-Routing extensions must be uniquely defined - interoperability at "boundary"**
- **Protection mechanism "The first SDH/Sonet added-value": provide the same fast protection functionality without known impairments**
- **Flexible ring design: Dynamic Ring Configuration**
- **QoS provide distributed TE - CoS mechanisms (Dynamic Ring Resource Allocation)**
- **Other PM to be defined - signal quality monitoring at optical level "The second SDH/Sonet added-value": to be defined** (on-going work)

# *Optical Network Topology*

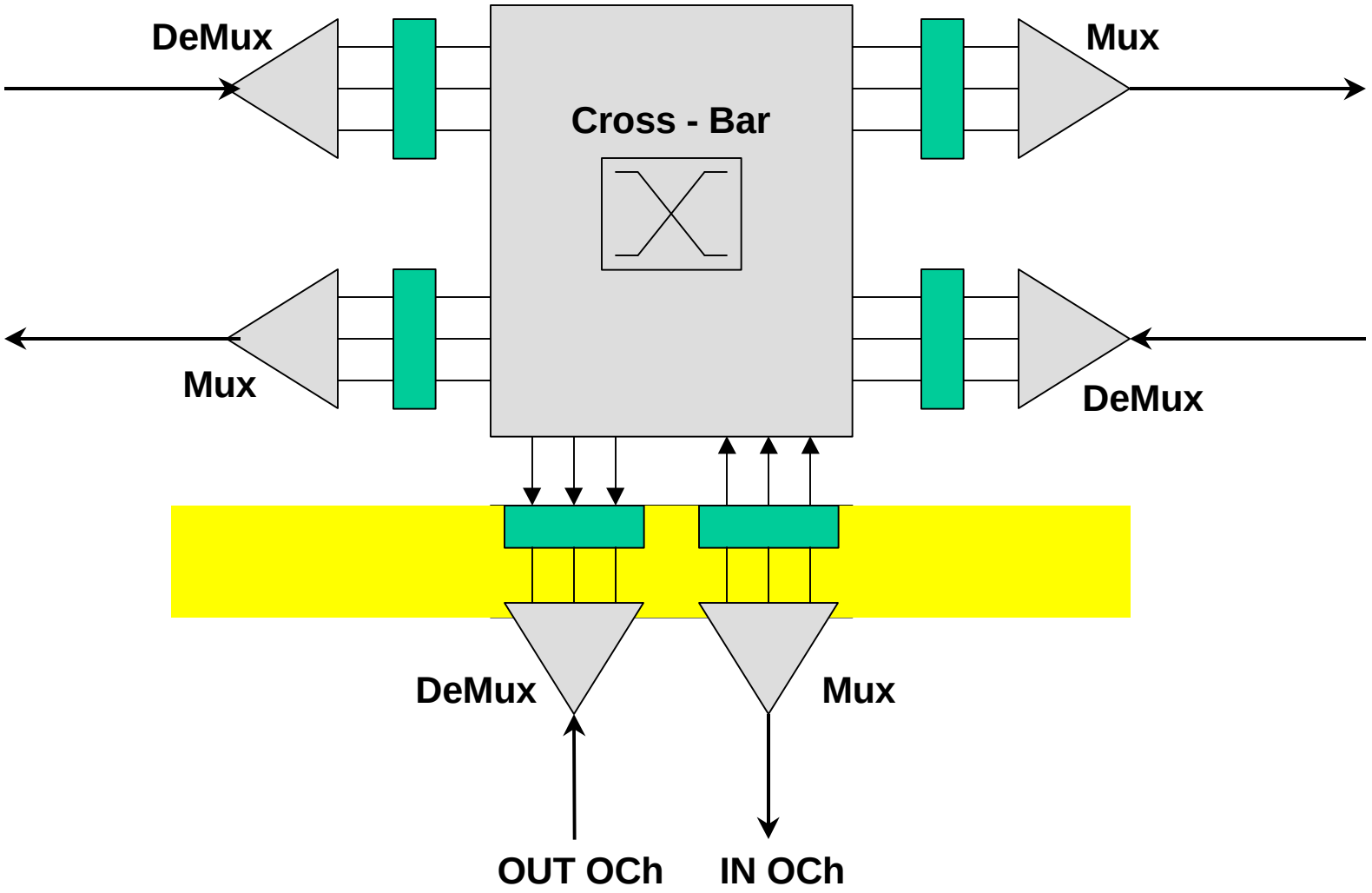
- Mesh and transparent optical network including OXC
- OXC ports: Lambda-Switch Capable (LSC) interfaces
  - **interface including WC capability (tunable lasers)**
  - **interface including DWDM capabilities**
  - **WC and DWDM could be external**
- Distributed IP Control-plane (internal or external)
- Signalling transport IF/OB (moving to IF/IB)
- Signalling protocol based GMPLS



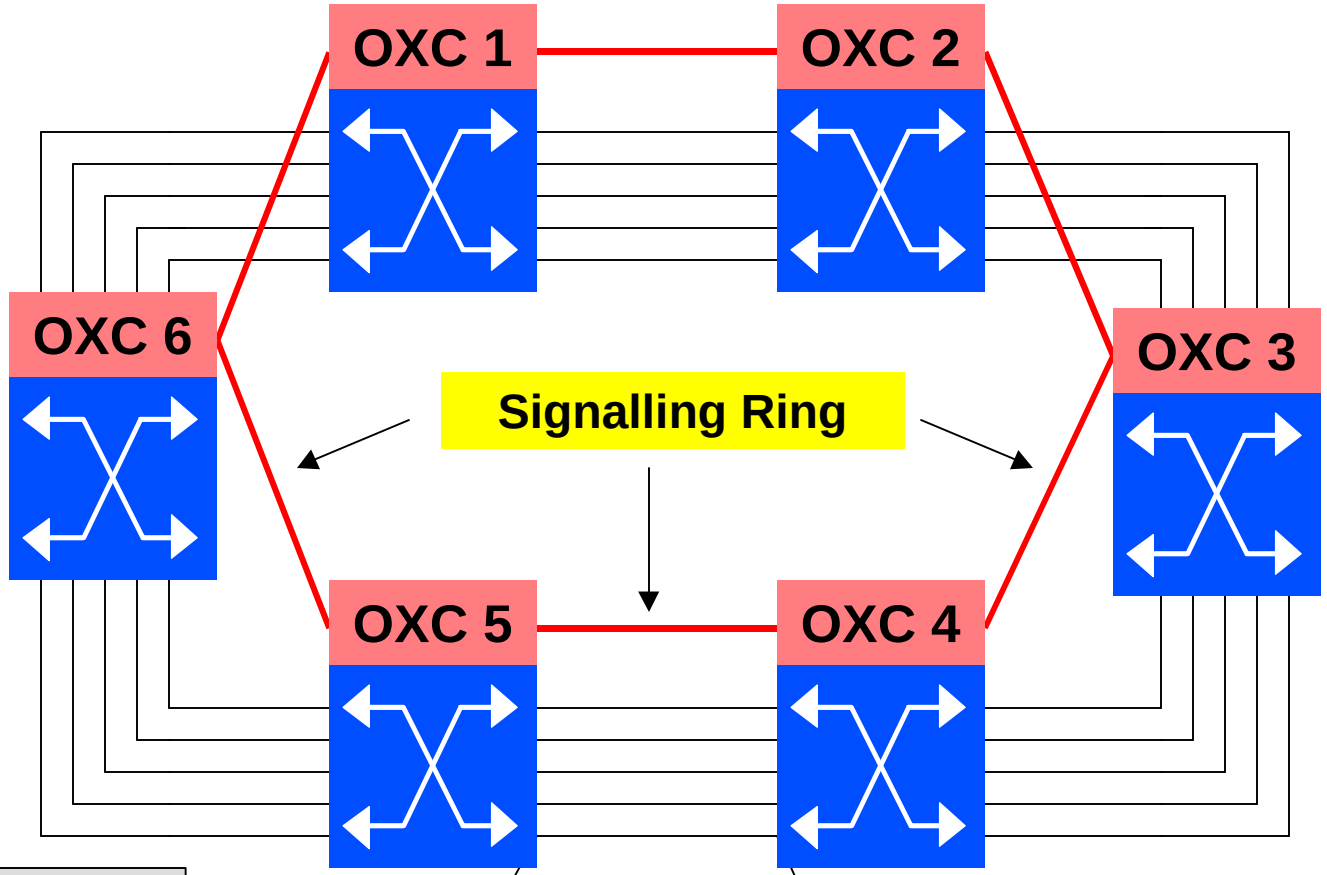
# *Optical Ring Emulation*

- **Dynamic configuration of logical rings on top of meshed optical topology including OXC (not only O-ADM)**
- **Ring Emulation requires:**
  - OXC switching matrix provides: Add - Drop - D&C - Protection (SNCP) functions
  - Working wavelengths (on shared links) belongs to only one ring at a time
  - Protection wavelengths (on shared links) shared between rings for protection
- **Dynamic Ring Configuration:**
  - Ring Identification
  - Ring Protection Type
  - Ring Architecture

# *OXC as O-ADM*



# *Optical Ring Topology*



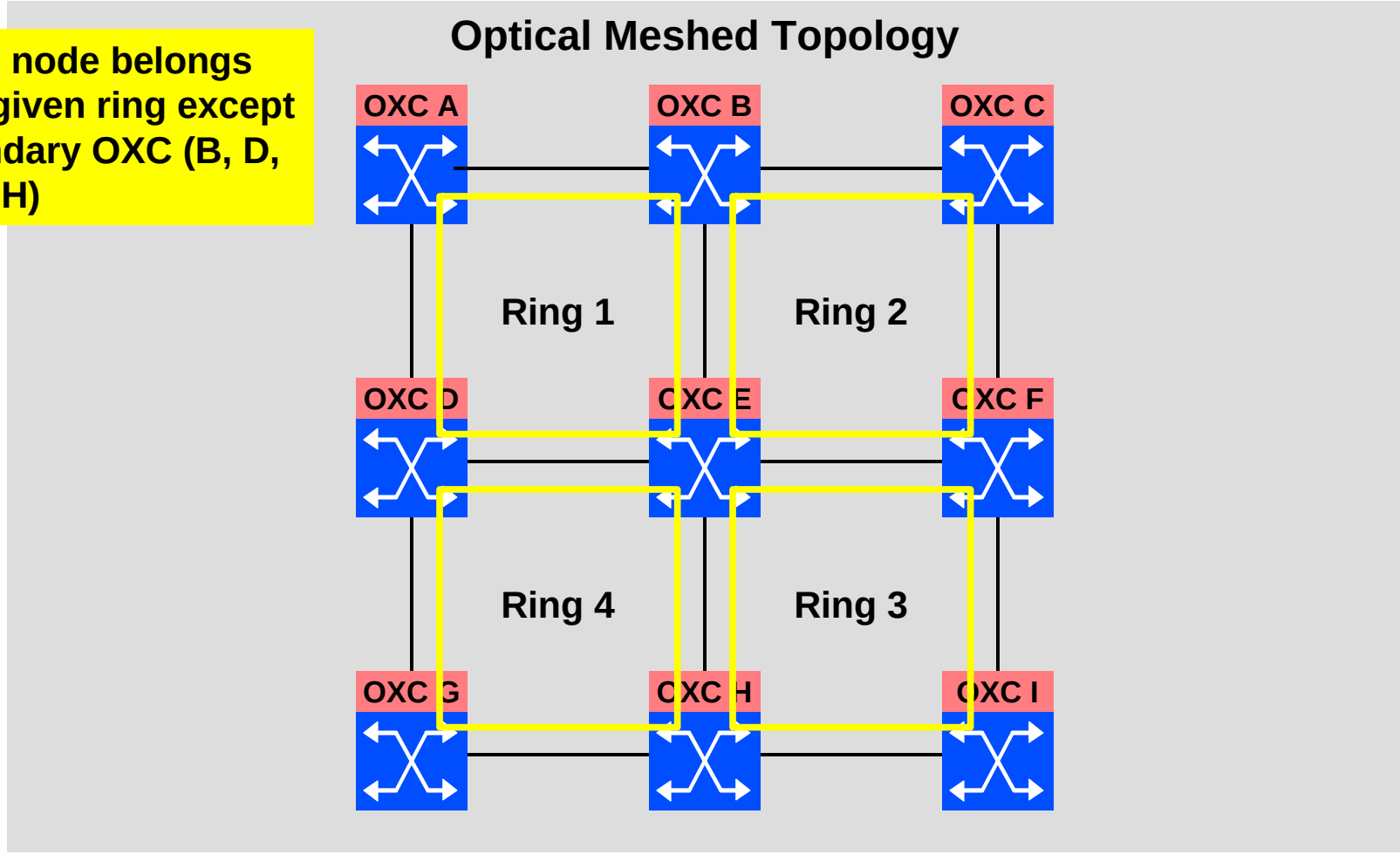

OXC 1 - IP Address1
OXC 2 - IP Address2

. . . . .

OXC 6 - IP Address6

# *Optical Ring Inter-Connection*

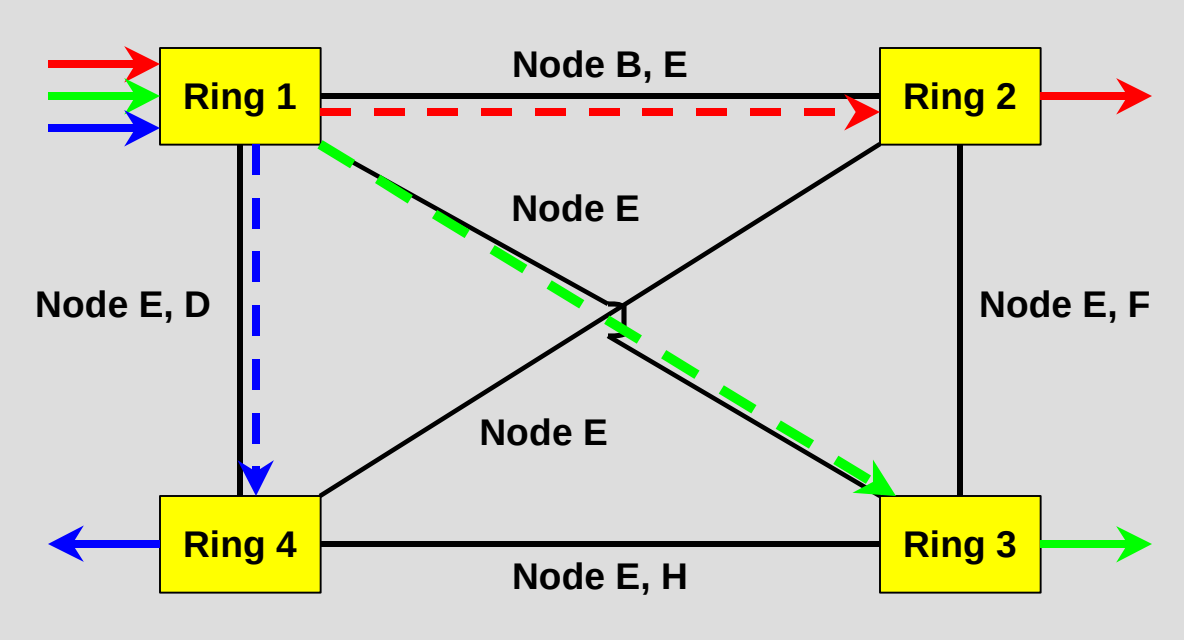
**Each node belongs to a given ring except boundary OXC (B, D, E, F, H)**




**Ring Cover: set of closed paths covering all links in the meshed optical network at least once (every node belongs to at least one ring)**

# *Inter-ring Routing Considerations*

- **Node E belongs to 4 rings:**

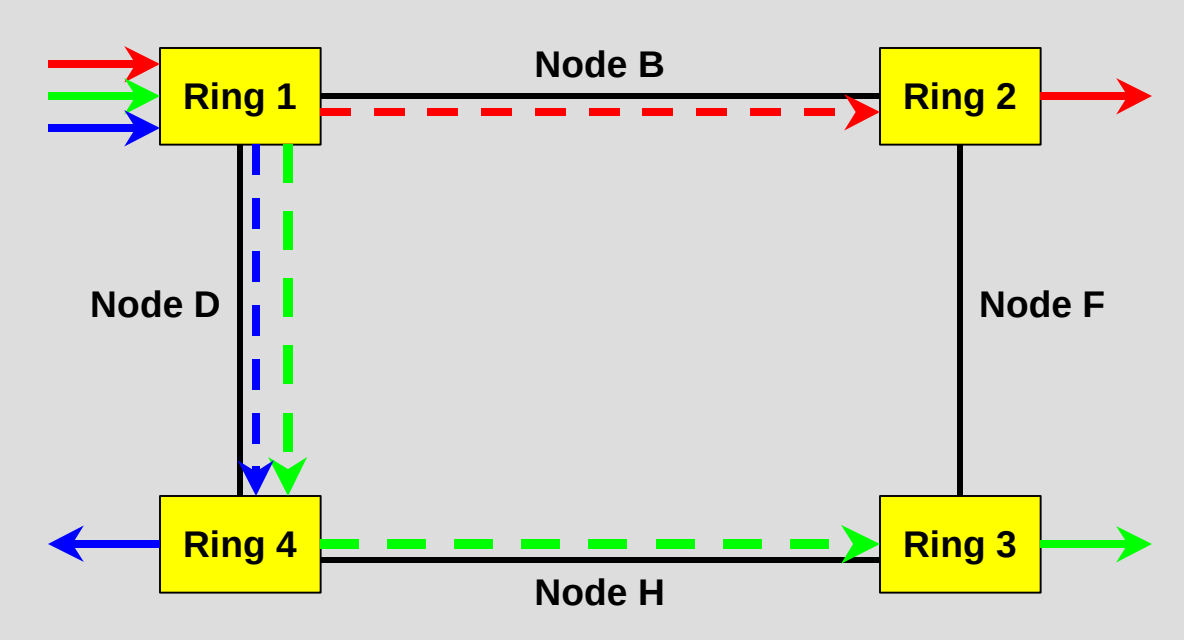



- **Node E provides 6 inter-connections (shortest path)**

➡ **Additional information required such as working and protection ring load to be shared between rings**
**Otherwise: node E “overloaded” and single point of failure**

# *Inter-ring Routing Considerations*

- **Node E failure:**




- **Does Ring 2 and Ring 4 provide enough capacity ?**

➡ **Additional information required such as working and protection ring load to be shared between rings**
**Otherwise: node E “overloaded” and single point of failure**

# *Optical Rings vs Mesh Protection*

| Protection Type | Mesh Protection | Ring Protection (ITU-T) |
|---|---|---|
| Dedicated Line | 1+1 - 1:1 | OMS-DPRing (O-ULSR) |
| Shared Line | 1:N (M:N) | OMS-SPRing (O-BLSR) |
| Dedicated Path | 1+1 - 1:1 | OCh-DPRing (O-UPSR) |
| Shared Path | 1:N (M:N) | OCh-SPRing (O-BPSR) |

| Ring Protection (ITU-T) | Protection Mechanism |
|---|---|
| OMS-DPRing (O-ULSR) | 1+1 dedicated fiber link (or wavelength) |
| OMS-SPRing (O-BLSR) | M:N shared fiber link (or wavelength) |
| OCh-DPRing (O-UPSR) | 1+1 dedicated LSP ‘segment’ protection |
| OCh-SPRing (O-BPSR) | M:N shared LSP ‘segment’ protection |

# *Dynamic Ring Configuration (DRC)*

- **Emulated ring determined by exchanging**
  - Ring ID (32-bit field)
  - Ring Virtual IP Address (32-bit field)
  - Loopback IP Address per OXC and per contiguous ring
  - Ring Protection Type (8-bit field)
  - Ring Protection Policy (8-bit field): Strategy - Scheme - Priority
  - SRLG Identifiers [draft-many-inference-srlg-00.txt]
  - Ring Metric (bootstrap initial DRRA)
- **Ring Metric**
  - Absolute weight: # Nodes (non-adjacent nodes)
  - Capacity: # Incoming - # Outgoing - # AD Channels
  - Maximum Restoration Time (MRT)

# *Dynamic Ring Resource Allocation (DRRA)*

- **Related to Intra-Ring Traffic Engineering**
- **Required to dynamically setup "LSP segments"**
- **Based on "classical" link TE information**
- **Ring Metric**
  - Ring Weight: working and protection ring

    Working RW = ( 1 / [ # Nodes ] ) x 100 x r1

    Protection RW = ( 100 - [ Working RW ] ) x r2
  - Ring Load (per time unit): working and protection ring

    Working RL = ( [ # Working LSP ] / [ Ring Capacity ] x 100 ) x r3

    Protection RL = ( [ # Protection LSP ] / [ Ring Capacity ] x 100 ) x r4
  - Maximum Restoration Time: MRT = MRT[N] x 100 x r5

    if MRT[N] > MRT[N-1] then maxMRT[N] = MRT[N-1] + ( k1 x MRT[N-1] )

    and MRT[N] = mean [ maxMRT[N] ; MRT[N-1] ]

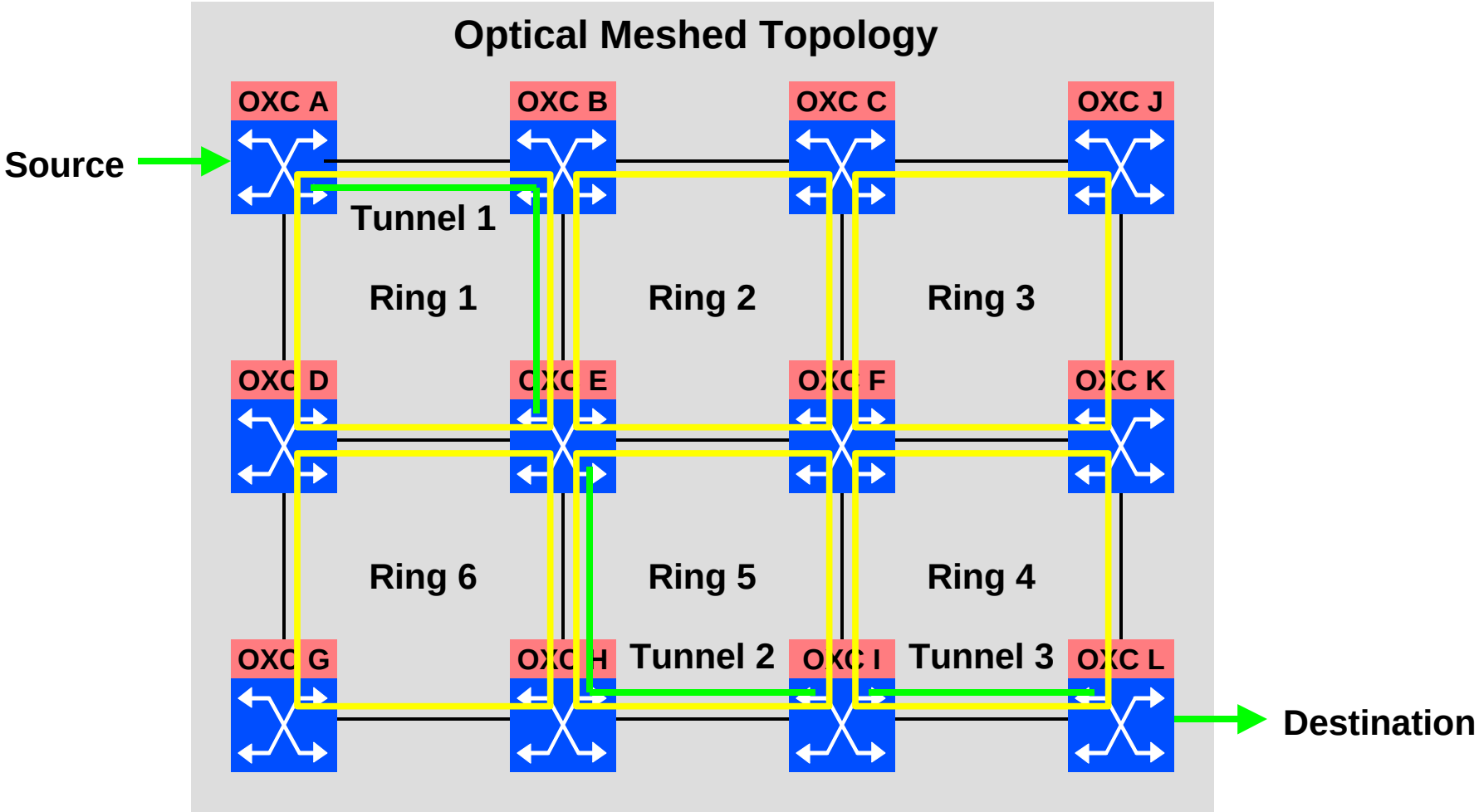
    if MRT[N] < MRT[N-1] then minMRT[N] = MRT[N-1] - ( k2 x MRT[N-1] )

    and MRT[N] = mean [ MRT[N-1] ; minMRT[N] ]

# *Inter-Ring Traffic Engineering*

- **Inter-ring TE LSA = TE Summary LSA (Opaque LSA Type-10)**
- **Generated at ring boundary nodes**
- **Carries TE Attributes including**
  - **Ring Count**
  - **Maximum Reservable Bandwidth**
  - **Minimum Reservable Bandwidth**
  - **Delay**
  - **Resource Class/Coloring**
  - **Inter-Ring TE Metric**
- **Inter-Ring TE Metric**
  - **Weighted sum of ring TE metrics (from Ring[1] to Ring[N])**
  - **IR-TE Metric = k[1] x Ring TE Metric[1] + k[2] x Ring TE Metric[2]**
    - **. . . k[N] x Ring TE Metric[N]**

# *Inter-Ring Traffic Engineering*




**Explicit Route [Source] : Node A - Node E - Node I - Destination**

**Explicit Route [A] : Node A - Tunnel 1 - Node E - Node I - Destination**

**Complete Route : Node A - T1 - Node E - T2 - Node I - T3 - Node L - Destination**

# *Signalling Extensions*

- **Signaled Protection (1:1 - 1:N - M:N)**
  - splitting of the signalling messages
  - draft-many-optical-restoration-00.txt
- **Non-Signaled Protection (1+1)**
  - 1+1 Protected LSP “segment”
  - Optical signal is physically split
  - Signalling message is logically duplicated
  - draft-poj-optical-multicast-00.txt
- **Inter-ring Signalling extensions**
  - Drop-and-continue (redundant inter-ring connection)
  - Optical signal is physically split
  - Physical Point-to-multipoint connection
  - Virtual Point-to-multipoint LSP “segment”

# *Conclusion - Proposal*

## Conclusion:

- **Transparent and All-optical rings "concepts" can be extended to IP over "Optical" Resilient Packet Rings**
- **Signaled Protection using IP-based O-APS like protocol**

  **or by extending current signalling protocols (CR-LDP - RSVP-TE)**
- **Ring concept is applicable with minor "extensions" to TE extended routing IGP protocols**
- **Inter-ring connectivity (drop-and-continue) key issue wrt optical network survivability**
- **DRC and DRRA mechanisms provide required flexibility while optimizing ring resources and facilitating their management**

## Proposal:

- **Accept the proposed contribution as an IPoRPR Protection and TE-Routing "document"**