Protected Ring Network in Optical Access Domain

J. Grubor, M. Schlosser, K.-D. Langer

Fraunhofer-Institute for Telecommunications
Heinrich-Hertz-Institut
Berlin, Germany

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Overview

• Motivation
• Access network concept
• Protection implementation
• Protocol options
• Migration path
• Summary and outlook
Future access networks

The Demand

• Greater demand for customers’ bandwidth
• Technology improvement and infrastructure upgrade

➢ Fiber-based access network (*Fiber To The Premises*)
➢ e.g. 10 Mb/s (mean) – 100 Mb/s (peak) customer’s bandwidth

The Issue

• Cost sensitivity of the network infrastructure
Motivation

Cost-effective features for access
• Few fibers → ring topology
• Passive outside plant
• Coarse WDM technology

1. Investigate technical feasibility of an optical network that would
   – exploit these features
   – use simple and commercially available components
   – be dimensioned to cover typical access areas

2. Investigate possibility of protection implementation
   as a feature of growing importance in the access area
Network structure based on rings

**HUB**
Active, CO

**FAR (Feeder Area Ring)**
max 16 CWDM channels
1.25 Gb/s/\(\lambda\)

**DAR (Distribution Area Ring)**
Point-to-point connections
Shared \(\lambda\) channels
Protocol driven access (Ethernet)

**End-User**
e.g. 10 Mb/s guaranteed

**ONU (Optical Network Unit)**
Active OE nodes,
building cellar, street cabinet

**High-End customer**
Dedicated \(\lambda\)

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Protection against a single link failure

...working case

...link failure in FAR

...link failure in DAR
Nodal architectures

<table>
<thead>
<tr>
<th>Additional Downstream hardware in HUB</th>
<th>Optical switch</th>
<th>Optical splitter</th>
<th>Tx</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAR protection</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>APSD possibility</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Insertion loss, dB</td>
<td>~1</td>
<td>~3</td>
<td>0</td>
</tr>
</tbody>
</table>

APSD – Automatic Power Shutdown

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Protection against HUB failure

Optical function drop-and-continue

Dual homing
(no change in fiber infrastructure)

HUB by-passing
(simultaneous link and HUB failures handled in all cases)

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# Protocol options for Ethernet-based solutions

<table>
<thead>
<tr>
<th>Standard</th>
<th>STP</th>
<th>RSTP</th>
<th>Vendor specific</th>
<th>RPR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restoration time</td>
<td>30 to 50 s</td>
<td>1 to 3 s</td>
<td>up to 1 s</td>
<td>50 ms</td>
</tr>
<tr>
<td>Pro’s</td>
<td>Available in most Ethernet switches</td>
<td>Fast restoration (up to 50 nodes)</td>
<td>Very fast restoration (up to 255 nodes)</td>
<td></td>
</tr>
<tr>
<td>Con’s</td>
<td>Difficult scalability</td>
<td>Difficult scalability</td>
<td>Not standardised</td>
<td>Complex structure</td>
</tr>
<tr>
<td></td>
<td>Very slow</td>
<td>Slow</td>
<td>Not compatible to STP/RSTP</td>
<td>Expensive</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not all functionality needed for access</td>
<td></td>
</tr>
</tbody>
</table>

STP – Spanning Tree Protocol  
RSTP – Rapid Spanning Tree Protocol  
RPR – Resilient Packet Ring

Too slow for real time applications, but this may be acceptable

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Migration Path

- Gradual and smooth transition to keep risk at minimum
- In the beginning...
  - Some CWDM channels saved for future use
  - Fiber laid only to RNs
  - Both passive and active hardware in RNs
  - VDSL / fixed wireless between RNs and end-users
  - Even possible to start with a non-closed FAR (no protection)
- Later on...
  - Fiber based DARs in some of the RNs’ DAs (passive RNs)
  - Optical interface at ONUs at/near customers premises / base stations
  - Protection in fiber-based parts of the network
Migration Path (cont.)

• And more later on…
  - Fibre dominant in distribution area (more DARs)
  - Insertion of new ONUs (larger DARs)
  - HEC customers with dedicated CWDM channels

• And eventually…
  – CWDM channels for new DARs,
  – DWDM for point-to-point overlay for HECs

• Upgrade from 1.25 Gb/s to 10 Gb/s for one $\lambda$-channel in parallel
  (8-fold increase of total capacity)

• More detailed migration path (especially in DA) for further study
Summary and outlook

- Feasibility of protected ring network in access domain using available components has been shown
- Passive remote nodes – OADMs with fixed wavelengths
- Possible protection against link/HUB failure
- Possible fast restoration with specific Ethernet based protocols or RPR
- Smooth evolution path shown
- Scalability to ~1600 customers with guaranteed 10 Mb/s
- Flexible capacity distribution up to ~1Gb/s
- Upgradeability to 10 Gb/s/λ (APD)
- ...
- Future research: experimental demonstration and further evaluation

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Thank you for attention...