Fibre optic networks for Multi Service Broadband Access

Jeroen Wellen

Lucent Technologies

NOC 2004

Eindhoven, June 30
Outline

- MUSE Scope
- Objectives
- Approach
- Studies
- Conclusions
MUSE scope

Low cost, full service access and edge network for ubiquitous delivery of broadband services to all European users

FTTH
Access multiplexer
Home gateways
Kerb/Cabinet
Wireless feeder
DSL
Subscriber, QoS, and OAM management
Edge node
Internet
PSTN
Application server
Application servers
MUSE scenarios

Subproject B:  
Migration scenarios (ATM->Ethernet)

Subproject C:  
non-Legacy scenarios (P2P)

Subproject D:  
FttX scenarios
MUSE SPD scope

Low cost & high speed full service broadband access

FttX Solutions
FttX Objectives

Study **Access technologies and techniques** that:

- are Low cost
  - CAPEX & OPEX = Minimum power & footprint
- Support Migration

- Support multiple High speed services

- Serve many Europeans: Multiple first mile solutions
topologies,
  - xDSL,
  - FWA
Approach

Pre-Evaluation:
- FttP Migration support
- FttP deployment scenarios
- Installation Aspects
- Service support and evolution
- Techno-Economic Analysis
FttX & Migration
Network Migration

ADSL, Cable or other

FttP
Migration options

ADSL,..→VDSL →FttP

ADSL,..→FWA→FttP
Copper-Fibre migration
Deployment issues

CAPEX
- Ducts and fibres installation costs kept to a minimum
- CPE (ONU+GW), OLT equipment

OPEX
- Simple installation and replacement
- Easy maintenance and management

Service revenue
- Service integration (Triple play)
- Active fibre sites (VDSL, FWA)
  > integration with WiFi HotSpots and UMTS base stations

Future proof
- Fibre plant should be fit for future services, bandwidth and user upgrades
Tecno-economic analysis
TE studies: Purpose

- Comparing access technologies &
- Identifying TE deployment hurdles
- Provide recommendations
- Based on:
  - Topographic scenario
  - (pre)Installation roll-out strategy
  - Take ratio
  - Peak bandwidth
  - Applied multiplexing gain
Approach

Basic model:
- CO (AM) to CP (NT1)
- Minimal modeling of unknown effects
- Minimum parameters
Outside plant: topologies

Average distance

Depending on different topographic scenarios

Aerial  Bus/Ring  Mesh  Star/Tree
# Topographic scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>description</th>
<th>symbol</th>
<th>unit</th>
<th>Northern Europe</th>
<th>Central Europe</th>
<th>Southern Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Subscribers passed per CO</td>
<td>$N$</td>
<td></td>
<td>65536</td>
<td>16384</td>
<td>256</td>
</tr>
<tr>
<td></td>
<td>Subscribers passed per AGN</td>
<td>$n$</td>
<td></td>
<td>218</td>
<td>117</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>Characteristic distance</td>
<td>$l$ [m]</td>
<td></td>
<td>16</td>
<td>37</td>
<td>447</td>
</tr>
<tr>
<td></td>
<td>Front yard length</td>
<td>$l'$ [m]</td>
<td></td>
<td>5</td>
<td>12</td>
<td>149</td>
</tr>
</tbody>
</table>

MUSE WPA.3
Outside plant: Installations

Ducts, tubes & cables

Pre-installation levels
## Installation scenarios

<table>
<thead>
<tr>
<th>Component</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duct installation costs</td>
<td>€/m</td>
</tr>
<tr>
<td>Costs per duct</td>
<td>€/m</td>
</tr>
<tr>
<td>Cost per splice/tap</td>
<td>€</td>
</tr>
<tr>
<td>Tube installation costs</td>
<td>€/m</td>
</tr>
<tr>
<td>Costs per tube</td>
<td>€/m</td>
</tr>
<tr>
<td>Cable installation costs</td>
<td>€/m</td>
</tr>
<tr>
<td>Costs per cable</td>
<td>€/m</td>
</tr>
</tbody>
</table>
Breakdown comparison (Urban CE)

Comparison of the cost per connected CP
Urban CE scenario: rt=55%, B=49 Mb/s, T=2004
pre-installed Feeder: wires, Firstmile: ducts

Comparison of the plant cost per connected CP
Urban CE scenario: rt=55%, B=49 Mb/s, T=2004
pre-installed Feeder: wires, Firstmile: ducts
Breakdown comparison (Suburban NE)

Comparison of the cost per connected CP
Suburban NE scenario: rt=55%, B=49 Mb/s, T=2004
pre-installed Feeder: wires, Firstmile: ducts

Comparison of the plant cost per connected CP
Suburban NE scenario: rt=55%, B=49 Mb/s, T=2004
pre-installed Feeder: wires, Firstmile: ducts

J.S. Wellen, June 30 2004
NOC 2004, Eindhoven
Access Solution Studies
Access Solutions

A. FttX technology prototypes

B. E2E Access-Gateway demonstrator
## Access Technology Comparison

<table>
<thead>
<tr>
<th>Technology</th>
<th>OLT</th>
<th>Outside Plant</th>
<th>ONU</th>
<th>Services</th>
<th>Flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Complexity/Cost</td>
<td>Footprint/power</td>
<td>Complexity/Cost</td>
<td>Broadcast (in band)</td>
<td>Broadcast (Overlay)</td>
</tr>
<tr>
<td>P2P</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>TDM PON</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>TDM PON (deep split)</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>WDM PON</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>WDM PON (deep split)</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Ring</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

Score (-22..22): 3, 3, -3, 1, -5, 2

*OLT Services: Flexibility* (Outside Plant)
Multimode fibre with Sub-Carrier Multiplexing (TU Eindhoven)
CWDM VDSL oO (U. of Essex)
(C)WDM double ring (HHI)
Active Star-Ring

Issues
- Loop length
- Ring Initialisation/Restoration
- X/B lifetime (cycles)
- Switch array power consumption
- Cumulative switch loss
- TDMA Protocol (QoS)
- B/N
Asymmetric PON/AON network

Issues

- Low power
- 802.3 compliance
- Cheap components
- Concentration 1:32+
- Split ratio: 1 Gb/s -> 4 Gb/s
Asymmetric TDM/WDM PON

Issues

- Integrated WDM OLT receiver
- Wavelength independent/configurable ONU
- **Cheap components!**
Conclusions

- MUSE will perform FttX research with TE and deployment issues in mind
- Different technologies are being studied
- A low-cost high-speed access platform is being designed
Acknowledgements

- France Telecom R&D
- Portugal Telecom Innovação
- Broadband Society Århus
- Heinrich Hertz Institute
- Eindhoven University of Technology
- University of Essex