«MUSE - techno-economic results for fixed access network evolution scenarios»

- Methodology and framework – some key assumptions;
- Major results of the fixed broadband access evolution scenarios

Author: Thomas Monath, T-Systems International GmbH

Co-Author’s: Sandro Krauss, Mario Kind, T-Systems International; Chris Hawinkel, Jan Vanden Abeele, Alcatel; Antonio Elizondo, TID; Antoine Chuquet, Yann Denis, FT; Damiano Raspollini, TI; Daniel Ågren, Acreo; José Miguel Santos, Ricardo Afonso, PTI; Panagiotis Saltsidis, Thomas Kallstenius, Ericsson;
Outline

- MUSE “Gaming field”
- Objectives & Research Questions of MUSE techno-economics
- Methodology & Framework Assumptions
- Use Case Definitions and major Results
  - Migration use cases
  - Native Ethernet cases
- Main Conclusion of the fixed broadband access evolution scenarios
- Further Steps
Multiservice capable NGN leads to requirements:

- Platform functions converge
- Service & Network platform elements require new functions to be implemented
  (NT … aggregation nodes … BRAS )
- Bottleneck in the last mile must be overcome

- Lower cost
- Increased intelligence
- Functionality moving closer to subscribers
- Fixed-mobile convergence
- High bandwidth
- Increased fibre penetration
- New multimedia applications
- Applications initiated from various CP devices
- New revenues by “Multi-service” access
- CP terminals, networks, gateways

[Diagram showing access aggregation network with FTTH, Wireless, Kerb/Cabinet, DSL, Internet, PSTN, and OAM, Automated OAM, Application server, and Edge server.]
Objective & Research Questions

> Provide techno-economic validations of MUSE architectural choices

> Two major technology trends in NG Access and Aggregation using Ethernet transport technology between home gateway and service edge in order to provide IP based services:
  > Pure Ethernet based switching technology (IEEE 802.1 xx) based on MAC in combination with service (S)VLAN “pipes” and
  > “IP” based network architecture using IP forwarding functionality based on the IP packet source and destination information

> First year approach: Investigate several network migration and “Greenfield” scenarios focused on Network Access Provider (NAP)
Value-Chain Players & Business Roles

→ Allow each player in to tap on revenue stream
Methodology

Demand for the Telecommunications Services

Tool - environment

- Services
- DB
- Architectures
- Geometric Model

- Revenues
- OA&M Costs
- Investments

Economic Inputs

Cash flows, Profit & loss accounts

Year 0 Year 1 Year n ... Year m

NPV IRR

Discounted cumulated cash flows

First Installed Cost - CAPEX

IST-2000-25172 “TONIC”
General Assumptions

- Case study approach with focus on Access & Aggregation Network
- Study period 2005 – 2010
- Wholesale Business Model which seeds back a certain percentage of the revenues to all players
- Discount Ratio equals to 10% for all scenarios
- Network elements in general will be modelled based on publicly available price information combined with learning curves & maintenance costs assumptions
- OA cost model considers:
  - Network Operations incl. Management, Control,..
  - Employees depending expenditures
  - Provisioning costs
  - Sales and Marketing
General Assumptions
Running Costs

> Current running cost model implementation

Running Costs = O&A + Maintenance

\[ M = \% \times \text{Invest} + \frac{\text{MTTR}}{\text{MTBR}} \times \text{Cost/hour} \]

<table>
<thead>
<tr>
<th>OA Costs Model</th>
<th>Values assumed</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Operations</td>
<td>3%</td>
<td>% of cumulated System-Investment</td>
</tr>
<tr>
<td>Infrastructure Operations</td>
<td>2%</td>
<td>% of cumulated Infrastructure-Investment (incl. failure protection)</td>
</tr>
<tr>
<td>Network Management</td>
<td>4%</td>
<td>% of cumulated System-Investment</td>
</tr>
<tr>
<td>Administration</td>
<td>2%</td>
<td>% of annual System-Investment</td>
</tr>
<tr>
<td>Marketing and Sales</td>
<td>3%</td>
<td>% of Revenues</td>
</tr>
<tr>
<td>Provisioning</td>
<td>50 € per new provided customer</td>
<td></td>
</tr>
<tr>
<td>Service Launch Marketing ISP</td>
<td>15 € per potential customer per new service (costs mainly related to ISP)</td>
<td></td>
</tr>
<tr>
<td>Customer Support (network)</td>
<td>2 Man-Years per 5,000 customers</td>
<td></td>
</tr>
<tr>
<td>Customer Support (efficiency improvement)</td>
<td>1 Man-Years per 5,000 customers</td>
<td></td>
</tr>
<tr>
<td>Once-Invest for 2 management systems in parallel</td>
<td>3%</td>
<td>% of first year System-Investment (only relevant for migration scenarios A-C : A-D ; C-D)</td>
</tr>
<tr>
<td>Once-Invest for introduction process of a new technology</td>
<td>5%</td>
<td>% of first year System-Investment (only relevant for migration scenarios A-C : A-D ; C-D)</td>
</tr>
</tbody>
</table>

> Examples of Running cost in relation to the CAPEX and Revenues

Dense Urban - cumulated values in Mill €

(Study period 2005 - 2010)
Multi-Service Access “everywhere”

- First mile solutions that covers >80% of European Citizens
- Allow for large scale deployment of BB services

**Total Broadband Customer Targets by All Fixed Platforms in the EU**

<table>
<thead>
<tr>
<th>Year</th>
<th>Optimistic</th>
<th>Pessimistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>2001</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>2002</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>2003</td>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td>2004</td>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td>2005</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>2006</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>2007</td>
<td>70%</td>
<td>70%</td>
</tr>
<tr>
<td>2008</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>2009</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>2010</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**1th January values**

- **2000**: 0% (Optimistic) / 0% (Pessimistic)
- **2001**: 10% (Optimistic) / 10% (Pessimistic)
- **2002**: 20% (Optimistic) / 20% (Pessimistic)
- **2003**: 30% (Optimistic) / 30% (Pessimistic)
- **2004**: 40% (Optimistic) / 40% (Pessimistic)
- **2005**: 50% (Optimistic) / 50% (Pessimistic)
- **2006**: 60% (Optimistic) / 60% (Pessimistic)
- **2007**: 70% (Optimistic) / 70% (Pessimistic)
- **2008**: 80% (Optimistic) / 80% (Pessimistic)
- **2009**: 90% (Optimistic) / 90% (Pessimistic)
- **2010**: 100% (Optimistic) / 100% (Pessimistic)

**Percentage of the fixed lines (176 Mn in 2004)**

- **2000**: 0% (Optimistic) / 0% (Pessimistic)
- **2001**: 10% (Optimistic) / 10% (Pessimistic)
- **2002**: 20% (Optimistic) / 20% (Pessimistic)
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- **2010**: 100% (Optimistic) / 100% (Pessimistic)

**Source:** IDC; Monitor Analysis
General Assumptions –
Market Forecast and related Service Classes

Example - Germany T-Com - May 2005:
about 7 Mio DSL,
about 18% of the total fixed lines;

Penetration evolution based on various consultancy reports

Sources: Ovum, Yankee BB market Europe, OECD 2003, IST 2003, survey between the MUSE partners
General Assumptions
Area Description and Potential Market

Geo-Model
(Total Europe)
65,536 Total Potential

<table>
<thead>
<tr>
<th>Geo-Model</th>
<th>Average link lengths [m]</th>
<th>Covered LEx</th>
<th>Cabins per LEx</th>
<th>Buildings per LEx</th>
<th>Potential Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Customer- LEx</td>
<td>Customer- Cabinet</td>
<td>Cabinet- LEx</td>
<td></td>
<td>per Building</td>
</tr>
<tr>
<td>Dense Urban</td>
<td>1.267</td>
<td>207</td>
<td>1.060</td>
<td>2</td>
<td>128</td>
</tr>
<tr>
<td>Urban</td>
<td>1.417</td>
<td>290</td>
<td>1.127</td>
<td>4</td>
<td>64</td>
</tr>
<tr>
<td>Suburban</td>
<td>1.750</td>
<td>467</td>
<td>1.283</td>
<td>8</td>
<td>64</td>
</tr>
<tr>
<td>Rural</td>
<td>2.033</td>
<td>683</td>
<td>1.350</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>Low Density Rural</td>
<td>2.767</td>
<td>1,217</td>
<td>1.550</td>
<td>32</td>
<td>32</td>
</tr>
</tbody>
</table>

Total Connectivity: 65,536

→ Input of involved network operators
General Assumptions – Tariff Model – Network Access Provider (NAP)

The tariff default assumptions are most uncertain at present - especially the business related assumptions represents a quite aggressive approach.

Tariff model based on survey and capacity based model
Network element model based publicly available price information combined with learning curves & maintenance costs assumptions

Network element: Switch Router GbE
Application: Central Exchange
Reference scenario of incumbent network access provider:

- Considers existing “basic” and “silver” residential and “basic” business customers
- The existing network has been amortized up to 2005
- The existing equipment is depreciated and will further be used in all migration scenarios
- The OAM-costs of the entire existing network (without provisioning) will be considered as constant offset in all migration scenarios
- Cash-Balance considers the revenues of existing customers
Use Case Definition – Migration Scenarios

<table>
<thead>
<tr>
<th>Today</th>
<th>Trend</th>
<th>Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best Effort</td>
<td>QoS classes</td>
<td>Multi Service</td>
</tr>
<tr>
<td>ATM transport</td>
<td>Ethernet transport</td>
<td>Lower Investment</td>
</tr>
<tr>
<td>L2 Access Mux</td>
<td>Layer 3 AM (IP)</td>
<td>Functionality moving closer to subscribers</td>
</tr>
</tbody>
</table>

Today no QoS

ATM → Ethernet
PPP → DHCP
L2AM → L3AM

ATM with QoS

Ethernet with QoS

IP Access (IPv4/6)

Lower Investment: Ethernet transport
ATM transport
Multi Service: Functionality moving closer to subscribers
Use Case Definition – Migration Use Cases - Overview

First Mile

CPE
FP0

In-house cabling
FP1

Billing
FP2

Cabinet Location
FP3

Branch (1)
FP4

Local Exchange
FP5

Branch (2)
FP6

Central Exchange
FP7

DSL NT

(A-B)

DSL NT

(A-C)

DSL NT

(A-D)

Remote unit

IP-Backbone

LER

RADIUS-Proxy

DNS, Web-Cache

AAA Fct.

GbE

QoS; CoS

GbE

Multicast

GbE

ATM Interf.

GbE

New xDSL

GbE

First Mile Aggregation

→ still ATM but new services and functions

→ Ethernet AN

→ IP (v04/06) AN

→ All cases combined with First Mile remote DSLAM solution!

→ network element invests input from the MUSE consortium vendors
Major Results – Migration Use Cases

**Cash Balance Comparison of Migration scenarios**

- Migration from A to C or A to D is more economic than A to B

**NPV Evolution Comparison Migration A-C – FTTB/H EPON**

- Only for Dense Urban, NPV goes into positive direction
Major Results – Migration Use Cases

Migration Case A-D – FTTC EPtP - Comparison NPV evolution for various Areas:

- Dense Urban, Urban, and (almost) Suburban are positive scenarios
- Rural and Low Density Rural are negative scenarios

First year results
Major Results – Migration Use Cases

Migration - Infrastructure Investment

Example ATM Evolution:
complete FTTH (PON) investments are nearly 40 times higher versus FTTCab
Use Case Definition –
Native Ethernet Use Cases – (1)

- CPE
- In-house cabling
- Building
- Cabinet Location
- Branch (1)
- Local Exchange
- Branch (2)
- Central Exchange

First Mile
Aggregation

DSL CPE
(FTTC)

EPON ONU
(FTTH EPON)

Optical Splitter

(FTTH)
IG CPE

Twisted Copper Cable
UTP5 Cable
Fibre Cable

Average link-lengths [m]
| LL1 (User ↔ Floor) | 15 m |
| LL2 (Floor ↔ Basement) | 15 m |
| LL3 (Basement ↔ Cabinet) | 207 m |
| LL4+LL5 (Cabinet ↔ Access Node) | 1 060 m |
| LL6 (Access-Node ↔ Aggr.-Node) | 20 000 m |
| LL7 (Aggr.-Node ↔ EN) | 20 000 m |
Use Case Definition – Native Ethernet Use Cases – (2)

<table>
<thead>
<tr>
<th>CPE</th>
<th>In-house cabling</th>
<th>Building</th>
<th>Cabinet Location</th>
<th>Branch (1)</th>
<th>Local Exchange</th>
</tr>
</thead>
<tbody>
<tr>
<td>FP0</td>
<td>FP1</td>
<td>FP2</td>
<td>FP3</td>
<td>FP4</td>
<td>FP5</td>
</tr>
</tbody>
</table>

**First Mile**

- DSL CPE
- (FTTB, UTP3)
- IGb Fiber CPE

**Aggregation**

- Switch
- GbE
- Switch

**Central Exchange**

- BRAS
- GbE
- Switch

**Connection Types**

- Twisted Copper Cable
- UTP5 Cable
- Fibre Cable

**Average link-lengths [m]**

| LL1 (User ↔ Floor) | 15 m |
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| LL6 (Access-Node ↔ Aggr.-Node) | 20 000 m |
| LL7 (Aggr.-Node ↔ EN) | 20 000 m |

**Abbreviations**

- BTBT, UTP5, UTP3
- GbE
- 100-T, 100-FX, 100-TX
Major Results –
Native Ethernet Use Cases

Cash Balance Comparison first mile Native Ethernet “green field” scenarios

- Complete FTTC: most profitable in dense urban, only profitable in urban
- FTTH: only optimised roll out even in dense urban recommended
Major Results –
Native Ethernet Use Cases –

Native Ethernet - FTTH with and without CPE costs

- High impact in the case of the Native Ethernet FTTH taking CPE costs into account or not
In general the sensitivity analysis results support the key results that has been observed within the scenario comparison.

- Tariffs, OA-costs, Duct availability (especially in rural areas) and Learning Curve decrease (K-Value) have the highest sensitivity impact.
- The variation of most sensitivity parameters leads in all migration use cases to a very similar qualitative behaviour of the Cash Balance.
- When comparing different default Cash Balances use cases with opposite slope behaviour (rising and decreasing ones) only the Penetration variation leads to some different response functions in case of decreasing Cash Balance behaviour in the default case.
Main Conclusions

- Ethernet will substitute ATM in the Aggregation Area stepwise
- Functionalities moving closer to subscribers → increased intelligence in access (service enablers like QoS, multicast, DHCP; resource control functions,...)
- The techno-economic analysis supports the consolidated view on NG broadband access so far:
  - Migration from a best effort access network (A) to a QoS enabled multi-service architecture based on Ethernet (A-C) or IP forwarding (A-D) are more economic than the ATM-based evolution scenario (A-B)
  - Complete FTTCab: most profitable in dense urban, less profitable in urban
  - FTTH: only optimized roll out even in dense urban recommended
  - Native Ethernet “greenfield” scenarios show some advantages compared to the migration related scenarios
  - In general the sensitivity analysis results support the key results that has been observed within the scenario comparison.
Further Steps

- Framework improvement
  - Traffic service oriented bottom-up-model
  - Service based revenue model
  - OAM process oriented model “first approach” and

- Competitive value chain implementation, which means
  - Application of the business roles which has been defined
  - Identify and describe costs and revenue flows for different business models

- “First mile” related cases
  - Asymmetrical PON,
  - xDSL over optics (sub carrier multiplex)

- Functional network modelling
  - PPP versus DHCP,
  - QoS and
  - Multicast implementation
Thank you for your attention!

Further information:

**Contact:** Thomas Monath, T-Systems International

☎: +49 30 3497 4446

✉: Thomas.Monath@t-systems.com

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