Planning tool for optical access networks
ONDM 2017

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Agenda

- Motivation
- Methodology
- Models
- Planning tool overview
- Case Studies
- Conclusions and on-going work
Motivation

Operators
• Increase number of users
• Increase number of offered services
• Increase offered quality (BW, reliability...)
• At lowest cost

Users
• Connect more devices
• Access differentiated services
• Get higher quality
• Flexibility to change operator

Migrate/Upgrade the networks fast at lower costs $\rightarrow$ Effective planning
Methodology

Problem

- RAN
- Optical access (FTTx)
- Converged access
Methodology

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Scenario
- Area
- Requirements
- Cost models
- Technology/architecture
- Protection Scheme
Methodology

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**Planning**
- Optimal placement of components
- Optimal fiber/duct layout
Methodology

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Planning
- Optimal placement of components
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Techno-Economic
- Cost evaluation
- NPV, Payback period, etc.
- Sensitivity analysis
Models

- Geometric models
  - Based on average values (e.g. Buildings/km², distance between buildings)
    - Hard to follow changes
    - Hard to get values (depend on country)
  - Fast approximation
  - Examples:
    - Triangle model
    - Street models

- Geographical models
  - Solution for a particular area→ based on geospatial data
  - Accurate
  - Adapts to changes
Planning tool overview

Area

Component placement

Fiber layout

Evaluation

Get the data from OpenStreetMap

Filter required data \(\rightarrow\) buildings, streets
Planning tool overview

Get any data required for your study:
- Location of
  - Central Office
  - Base Stations
  - Small Cells
  - ...

We use ArcGIS(c) to plan our networks
Planning tool overview

Clustering is required for most of the architectures → mainly tree topology

GPON 1:32

Central Office

OLT

PS 1:32

Remote Node

ONU

ONU
Planning tool overview

Clustering is required for most of the architectures → mainly tree topology

WDM PON

OLT

Central Office

AWG

Remote Node

ONU

ONU
Planning tool overview

Clustering is required for most of the architectures → mainly tree topology

Hybrid PON

- OLT
- AWG
- PS
- Remote Node
- ONU

Area

Component placement

Fiber layout

Evaluation
Planning tool overview

Area → Component placement → Fiber layout → Evaluation

- Cabinets
- Base Stations
- Small Cells

5 8's/MBS (3x10G and 2x3G)
1 8's/Cabinet (10G)
1 8's/SC (10G)
Planning tool overview

Clustering given the splitting ratio of the remote node
- Not all the ports are used
- Adding few clusters may decrease the required fiber

Proposed modified K-means „Dimensioning and Assessment of Protected Converged Optical Access Networks” COMMAG´17
Planning tool overview

Area → Component placement → Fiber layout → Evaluation

Important to consider:
- Realistic location for remote nodes
  - Intersection points
  - Colocation with
    - Traffic lights
    - High buildings
    - Existing rooms/equipment/...
Planning tool overview

Interconnection of comments with fiber:
Trenching is the most costly aspect → duct-sharing routing
Planning tool overview

Area → Component placement → Fiber layout → Evaluation

Interconnection of comments with fiber:
- Trenching is the most costly aspect → duct-sharing routing
- Protection?
  → Disjoint fibers

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Planning tool overview

Interconnection of comments with fiber:
- Trenching is the most costly aspect → duct-sharing routing
- Protection?
  → Disjoint fibers
  → ring topologies → TSP
Planning tool overview

Area • TCO: Total Cost of Ownership
Component placement • NPV: Net Present Value
Fiber layout • Benefits
Evaluation • Payback period
• Analysis (e.g. sensitivity, risk)

Dense Urban area

Rural area

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Case Studies

- Next Generation access networks → at least 300Mbps/end user
- Converged access networks
- Protection schemes
- ITS
- Broadband access comparison in sparse areas
- Impact of
  - Different penetration curves
  - Different available infrastructure
  - Different clustering and fiber layout approaches
## Case Study-1

<table>
<thead>
<tr>
<th>Name</th>
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<th>Area</th>
<th>Total Buildings</th>
<th>Building Density</th>
<th>Total MBS</th>
<th>MBS Density</th>
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</thead>
<tbody>
<tr>
<td>Munich</td>
<td>DU</td>
<td>4km²</td>
<td>2042</td>
<td>510/km²</td>
<td>12</td>
<td>3/km²</td>
</tr>
<tr>
<td>Miesbach</td>
<td>U</td>
<td>28km²</td>
<td>2730</td>
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</tr>
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<td>4</td>
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![DU Map](image1.png)

![U Map](image2.png)

![R Map](image3.png)
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- Deficit of R can be subsidized by profit of DU & U in aggressive adoption type
- DU profit is not enough to cover deficit of R & U in likely & conservative types
- Connecting MBS in the first year is the best option since the revenues are higher than for fix users.
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**Penetration curves: Random vs. Bass model**

- **TCO [CU]**
  - Aggressive: Random 44734,71609, Likely 43909,18146, Conservative 43921,37942
  - Bass 44107,94568, 43722,81405, 43722,81405

- **TCO [CU]**
  - Aggressive: Random 50560,40806, Likely 50622,03711, Conservative 50664,47177
  - Bass 50601,138, 50664,9896, 50665,04137

Relative small TCO difference, which depends on the building and distribution density.
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**Penetration curves:** Random vs. Bass model

"Optimal Cluster" performs better in all areas

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<th>Conservative</th>
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<tr>
<td>Yearly</td>
<td>50601,138</td>
<td>50664,9886</td>
<td>50665,04137</td>
</tr>
<tr>
<td>Optimal</td>
<td>50982,15782</td>
<td>53066,64465</td>
<td>52587,71501</td>
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<table>
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<th>Likely</th>
<th>Conservative</th>
</tr>
</thead>
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<tr>
<td>Yearly</td>
<td>44107,94568</td>
<td>43722,81405</td>
<td>43722,81405</td>
</tr>
<tr>
<td>Optimal</td>
<td>45324,82752</td>
<td>45624,55343</td>
<td>46247,92668</td>
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</table>
Case Study-2 Joint vs. disjoint planning
Case Study-2 Joint vs. disjoint planning

- Darmstadt, Germany
  - 9.63 km²
  - 6056 buildings
  - 32000 households

Disjoint HPON, Joint HPON and Joint NGPON2 planning options offer 19%, 29% and 23% savings, respectively, with respect the Disjoint GPON case.
Conclusions and on-going work

- Available tool for real access network planning
- Advantages of geographic area data

- Extending with optimization tools and new heuristics
- Artificial topologies
Questions?