Leveraging FTTx infrastructure for green mobile backhaul: challenges and opportunities

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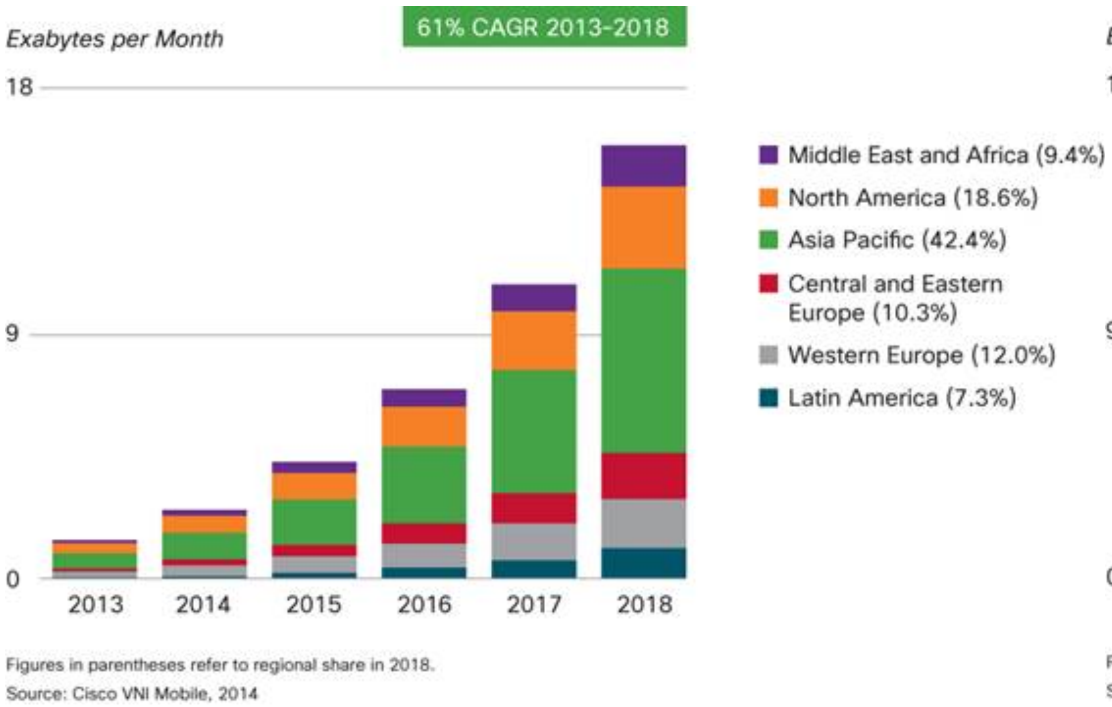
Paolo Monti

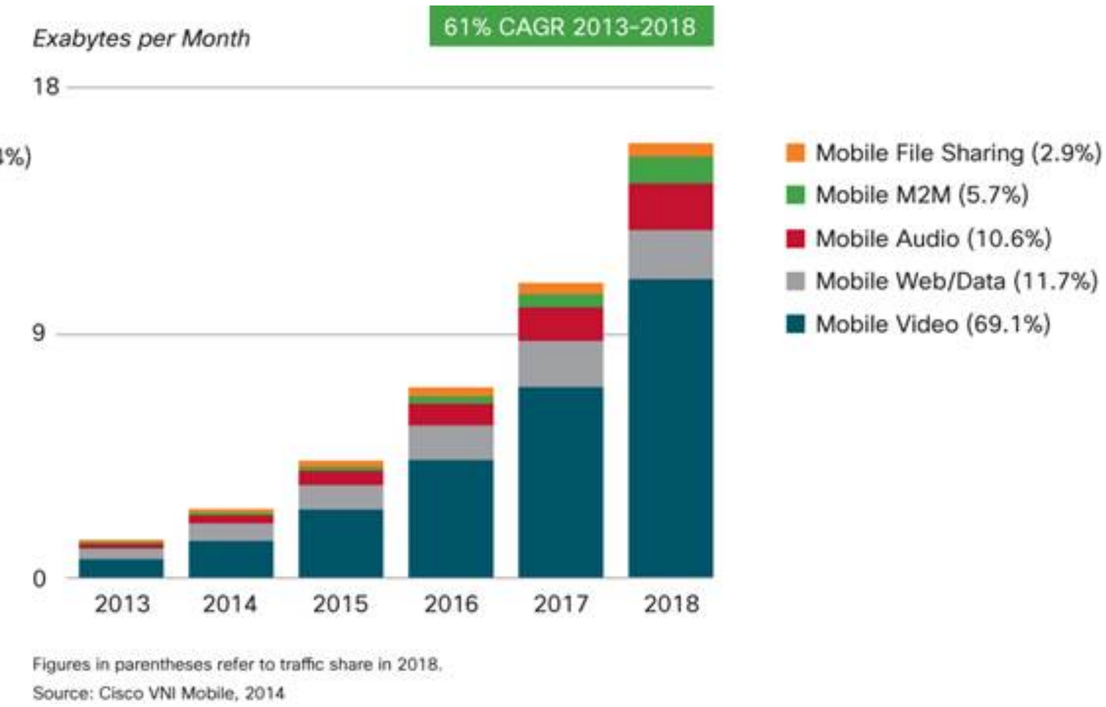
Optical Networks Laboratory (ONLab)
Communication Systems (COS) Dept.
School of Information and Communication Technologies
KTH Royal Institute of Technology, Kista, Sweden

Outline

- HetNet and energy efficiency
  - aren't we forgetting anything?
- Backhaul and energy consumption
  - HetNet still worth from an EE perspective?
- Case study: dense urban deployment
  - is there a best "FTTx" solution?
- Is energy the only important parameter?
  - some TCO considerations about backhaul
- Conclusions

Energy efficiency in mobile broadband access





- Mobile broadband data usage is experiencing a dramatic growth (11 fold since 2013)
- Clear challenge ahead: meeting the expected 2020-2025 traffic levels maintaining current or (at least) low power consumption figures

Possible solution: HetNet deployments

- HetNet is an alternative to macro cell densification
- Rationale: tailor network deployment to the expected traffic levels
  - selectively add small high-capacity BSs only where needed (hotspots)
- What happens to the aggregated data?
  - impact of backhaul on energy consumption and cost is usually neglected

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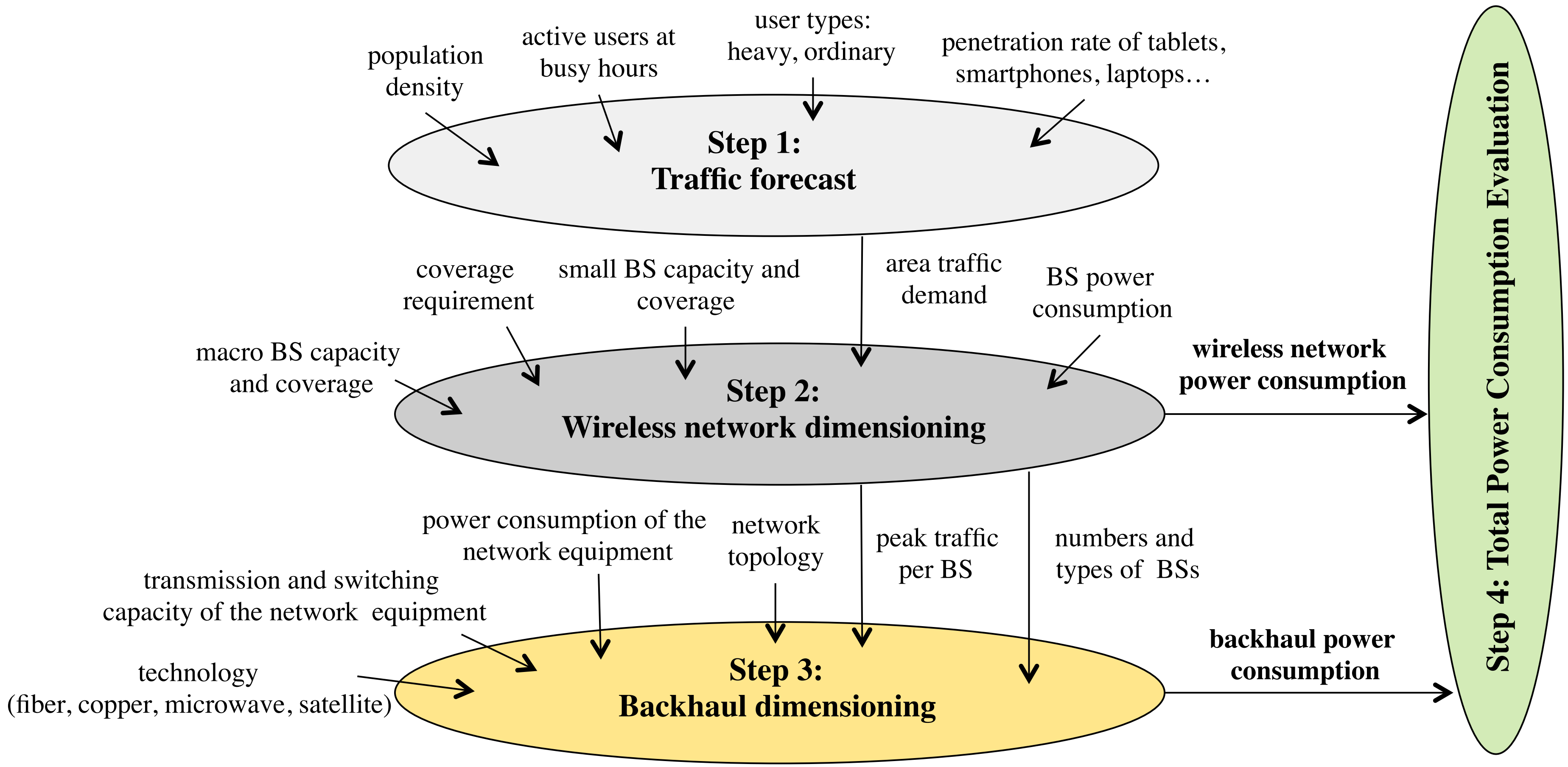
Role of backhaul in HetNet?

- Most HetNet studies consider only the aggregated power consumption of the base stations
- What if backhaul has a significant share of the energy consumption of a converged access infrastructure?
  - will HetNet still be convenient?
  - what is the best backhaul technology?
  - are any other TCO consideration to be made?

EE impact of backhaul: methodology



S. Tombaz, et al., "Is Backhaul Becoming a Bottleneck for Green Wireless Access Networks?" *in Proc. of IEEE International Conference on Communications (**ICC**), 2014*

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Use case: urban scenario

- ***Traffic forecast (step1)***: long-term traffic models from literature

$$R(t) = \rho\, \alpha(t) \sum_k r_k\, s_k, \quad [\mathrm{Mbps/km^2}]$$

user density ρ = 3000 user/Km^2

daily traffic variation $\alpha(t) = \alpha_{max}$ = 16%

avg. traffic demand for terminal *k*

ratio of subscribers for terminal *k*

- ***Wireless network dimensioning (step 2)***:
  - Homogeneous deployment: macro BS only
  - Heterogeneous deployment: macro BS + small indoor BS
- ***Backhaul dimensioning (step 3)***:
  - Fiber-to-the-node (FTTN) using VDSL
  - Fiber-to-the-building (FTTB) using P2P optical links
  - Fiber-to-the-home (FTTH) using PON
  - Microwave
- *Scenario*: 10x10km^2 area, with various pen. rates (η)
- *Terminals*: tablet, smartphone, and laptops

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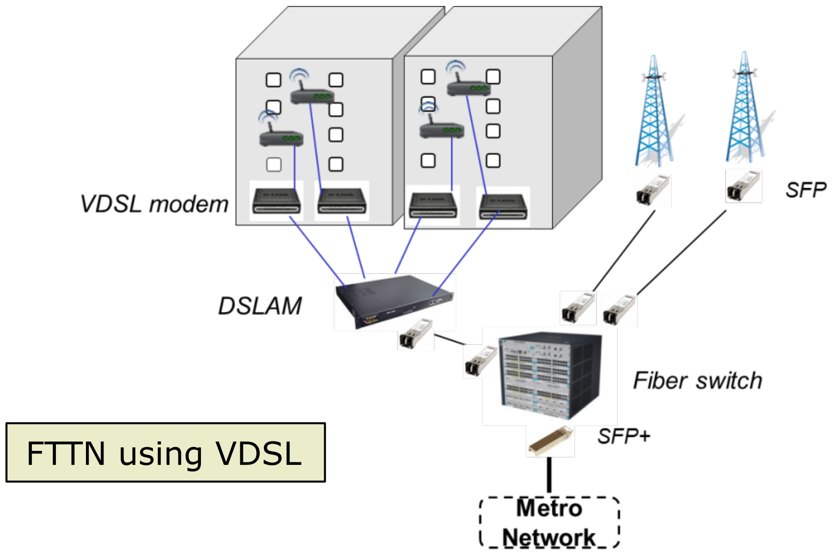
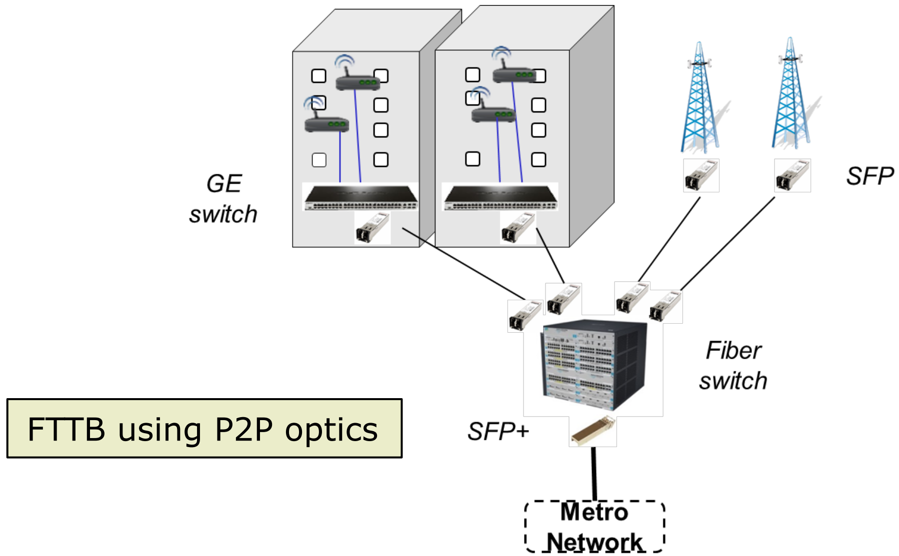
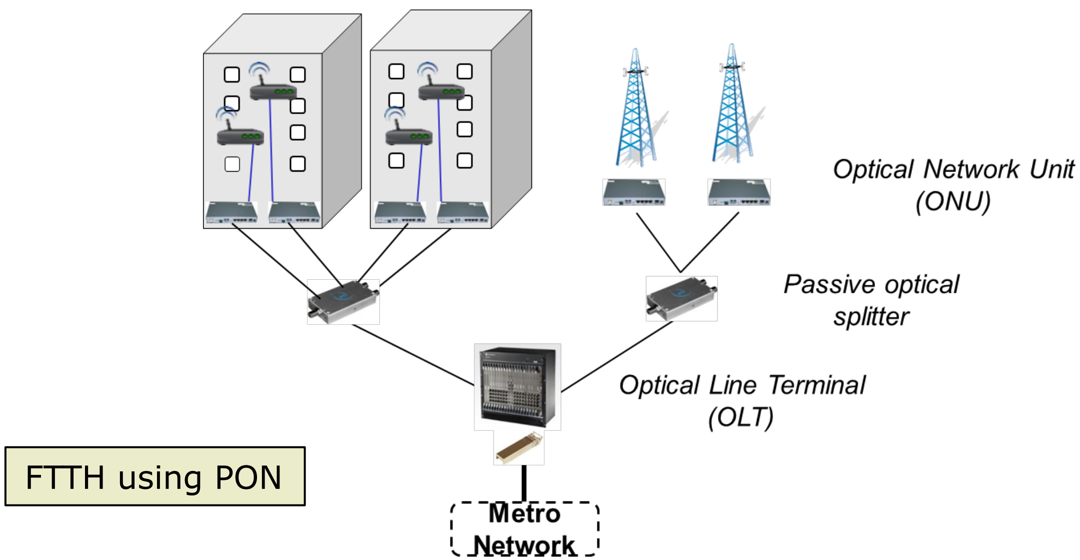
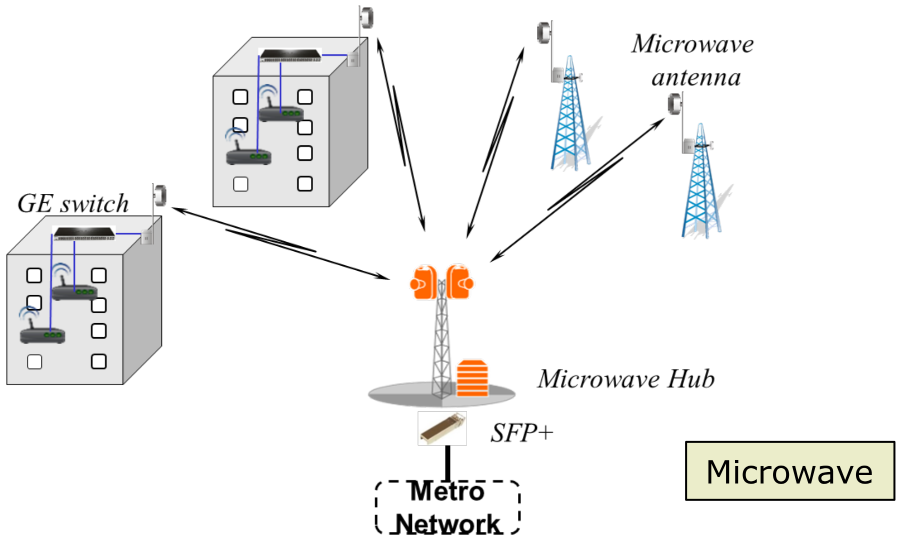
Backhaul architectures









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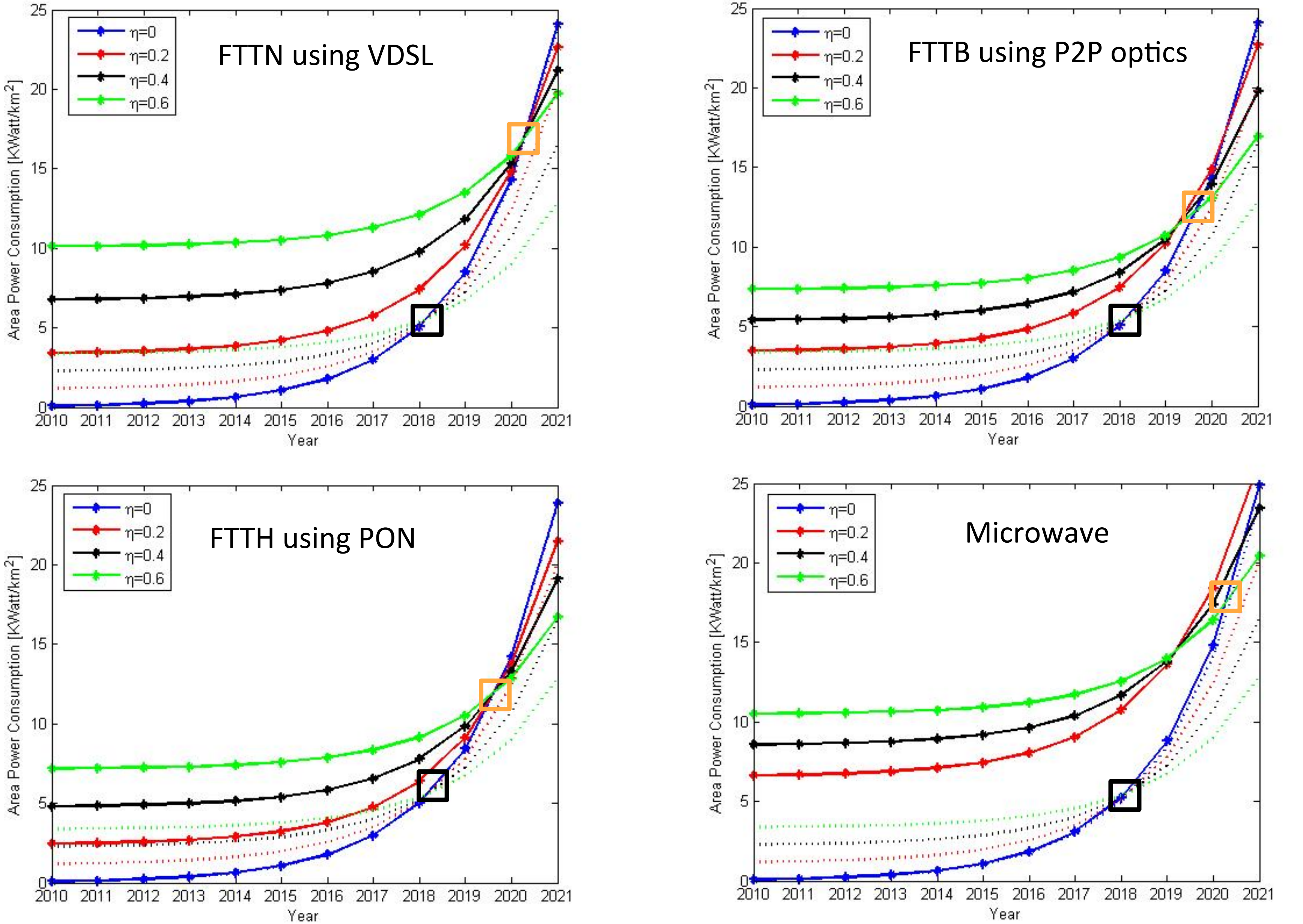
Power consumption: fixed η



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Power consumption: varying η

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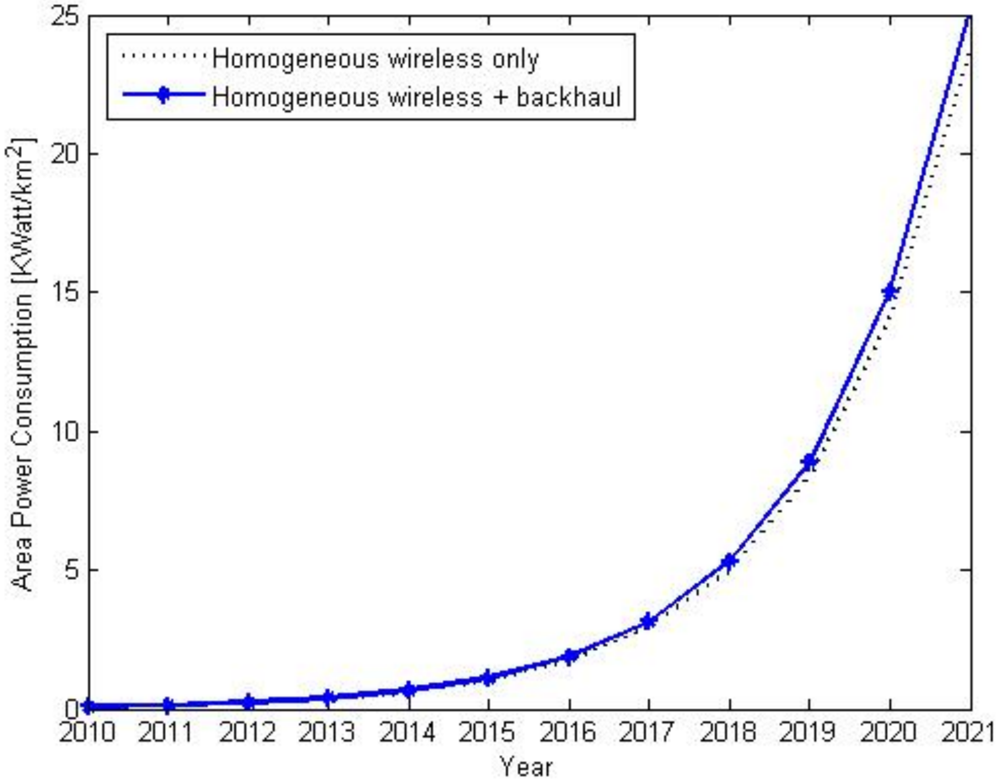
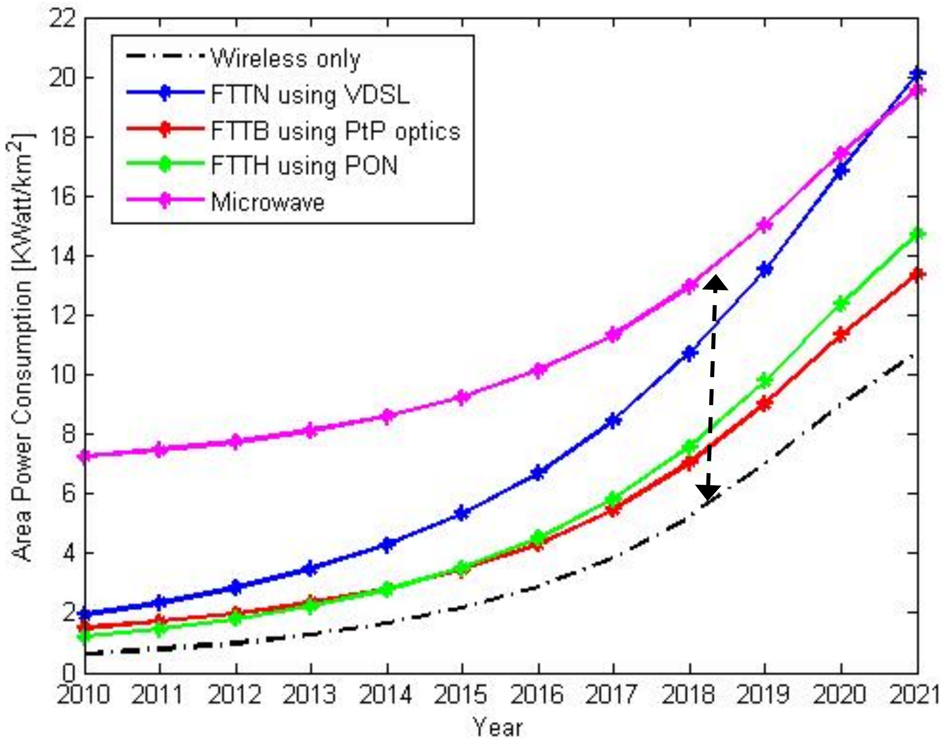
- η ∈ [0.1, 0.6] increases linearly in the considered region of 10x10 km^2



- Impact of backhaul on homogeneous wireless networks in 2020: 6%

- Impact of backhaul on HetNet wireless networks in 2020: 50%



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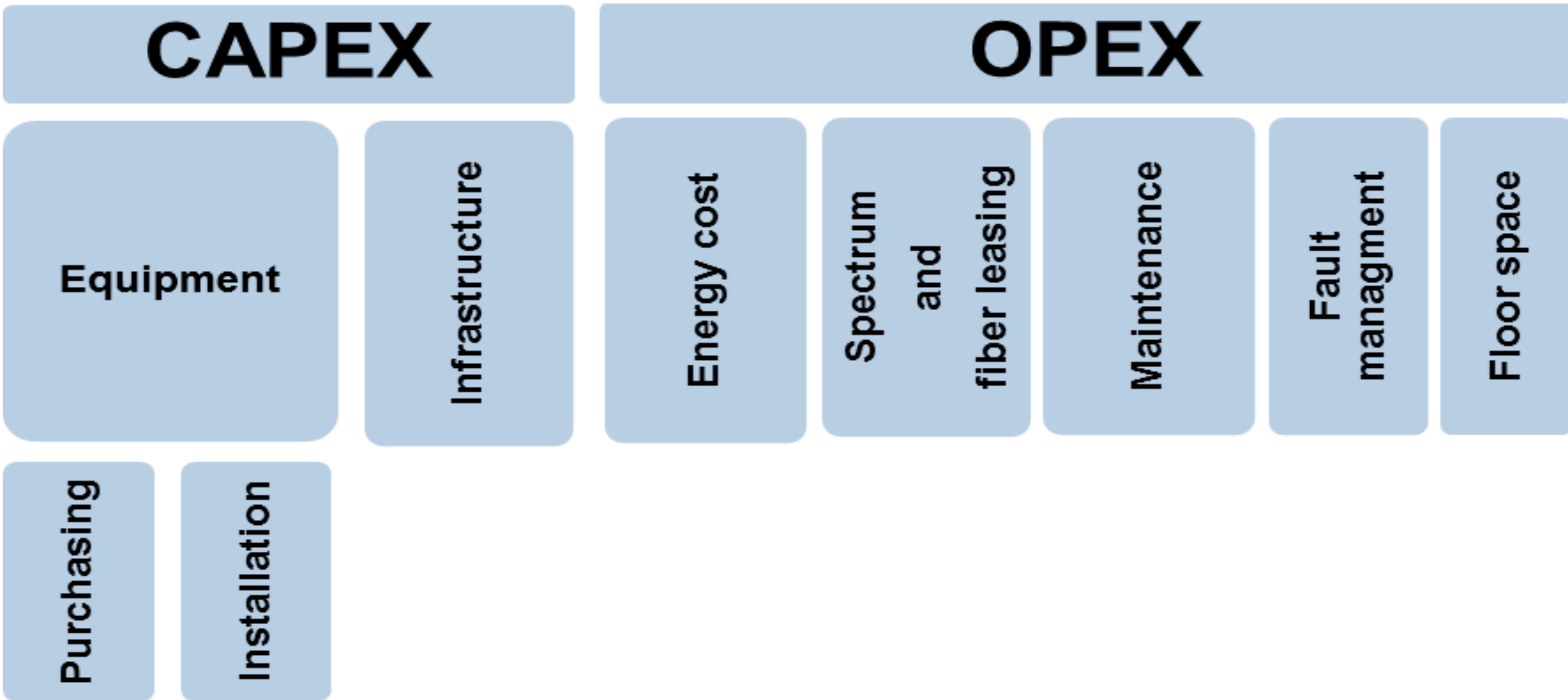
TCO modeling of mobile backhaul

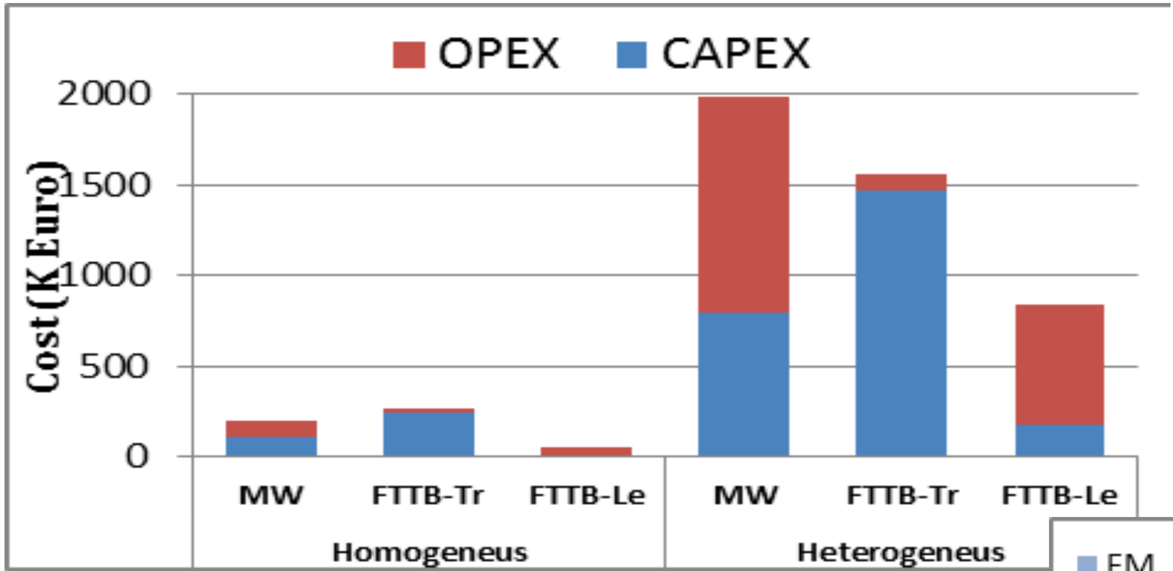
- Backhaul cost already a not negligible part of the total cost of ownership (TCO) of homogenous wireless networks
- The impact of the backhaul segment on TCO even more crucial with an increasing number of small cells used in HetNet deployments
- Crucial that mobile HetNet deployments are designed considering cost efficient backhaul architectures
- Help of detailed TCO modeling to evaluate the various cost factors (covering deployment and operational processes) for the different types of backhaul networks

Backhaul TCO cost classification

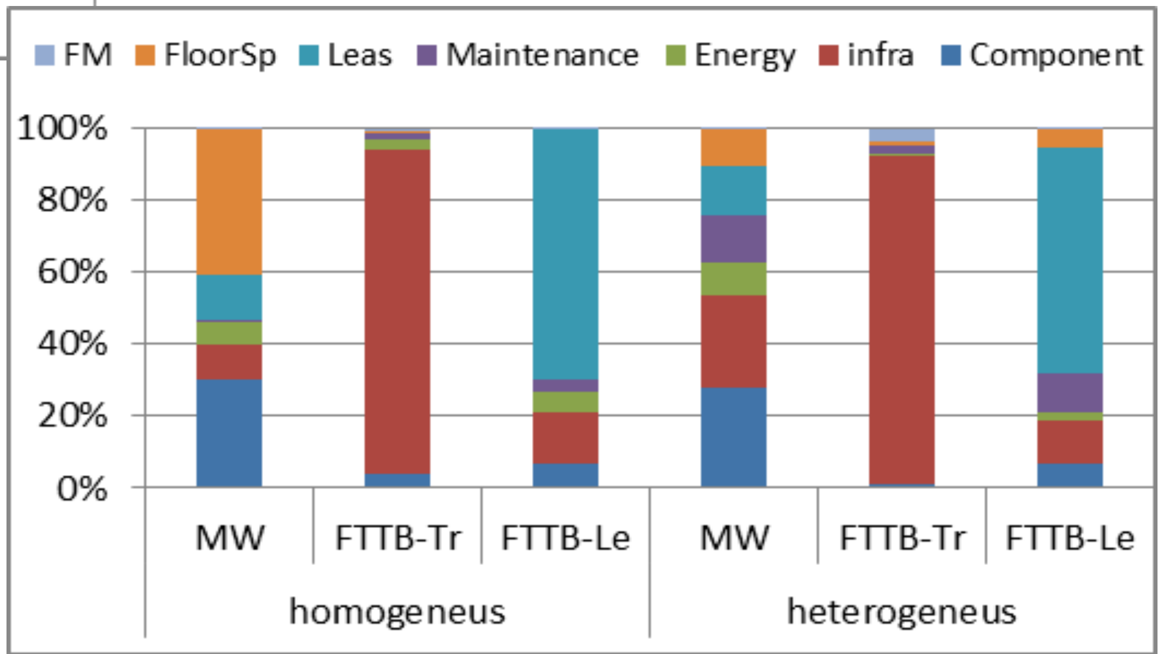


M. Mahloo, et al., “Cost Modeling of Backhaul for Mobile Networks” in Proc. *IEEE International Conference on Communication* (***ICC***), *2014*

Case study results: TCO over 20 years



- Dense urban 2x2 km^2 dense urban area
- Leasing is the most cost efficient option (plus fast deployment and easy capacity upgrade are possible)
- With HetNet microwave very costly while fiber-based backhauling is more cost-efficient, even if an operator needs to deploy its own infrastructure



- Each cost item has a different impact depending on the various options
- For microwave-based backhaul rental fee for placing the microwave antennas and hubs is a considerable part of the TCO
- Need proper planning and site acquisition strategies in case of microwave backhaul

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Conclusions

- Analyzed the role of backhaul in HetNet deployments
- FTTB/FTTH showed very good performance limiting considerably the energy impact of the backhaul segment in dense urban scenario deployments
- From TCO point of views for FTTB scenario leasing more convenient than trenching, but scenario might be different with FTTH case (also depends on operator business/strategy)
- Interesting to consider for the future:
  - rural areas: first results for FTTB/FTTH EE results also encouraging, but CAPEX vs. OPEX rationale will be different
  - fronthaul: allows for additional features (e.g., BBU hoteling) but what are the tradeoffs at play here?

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- Projects

  - ***eWIN***: Energy-efficient wireless networking
  http://wireless.kth.se/blog/projects/ewin/

  - ***GreenHaul***: Energy efficient backhauling for HetNet wireless deployments
  http://web.it.kth.se/~pmonti/GreenHaul/

  - ***5GrEEn***: Towards Green 5G Mobile Networks
  http://www.eitictlabs.eu/innovation-areas/future-networking-solutions/5green-towards-green-5g-mobile-networks/

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ROYAL INSTITUTE OF TECHNOLOGY

ONLab

Paolo Monti

pmonti@kth.se

http://web.it.kth.se/~pmonti

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Dense urban: numerical assumptions

Year	h	s_{pc}/r_{pc}^{heavy}	$s_{tablet}/r_{tablet}^{heavy}$	$s_{s.phone}/r_{s.phone}^{heavy}$	$R_{max} = max_t(R(t))$
2010	10	0.1 / 56.25	0.03 / 28.1	0.3 / 7	2.6
2015	20	0.2 / 900	0.05 / 450	0.5 / 112.5	82.8
2020	30	0.3 / 2700	0.1 / 1350	0.6 / 337	474.3

TABLE II
SIMULATION ASSUMPTIONS [4], [5]

Considered parameters for wireless deployment	Value
Population density per km^2	3000
Covered Area	10km×10km
Number of apartments	100000
Number of buildings	10000
Bandwidth	10 MHz
Number of sector Macro/Femto	3/1 m
Femto BS penetration rate	[0,0.6]
Path loss exponent	3.5
Power Consumption Parameters	**Value**
a_M/a_F	4.7/8
b_M/b_F	130/4.8 W
P_{modem}	5 W
$P_{ul}/P_{dl}/P_{SFP}$	2/1/1 W
P_s^F/P_s^{MW}	300/53 W
P_{DSLAM}/P_{GE}^{max}	85/50 W
P_{low-c}/P_{high-c}	37/92.5 W
$n_{ports}^D/n_{ports}^F/n_{ports}^{GE}/n_{sup}^{MW}$	16/24/12/16
C_{switch}^{MW}/U_{max}	36/10 Gb/s

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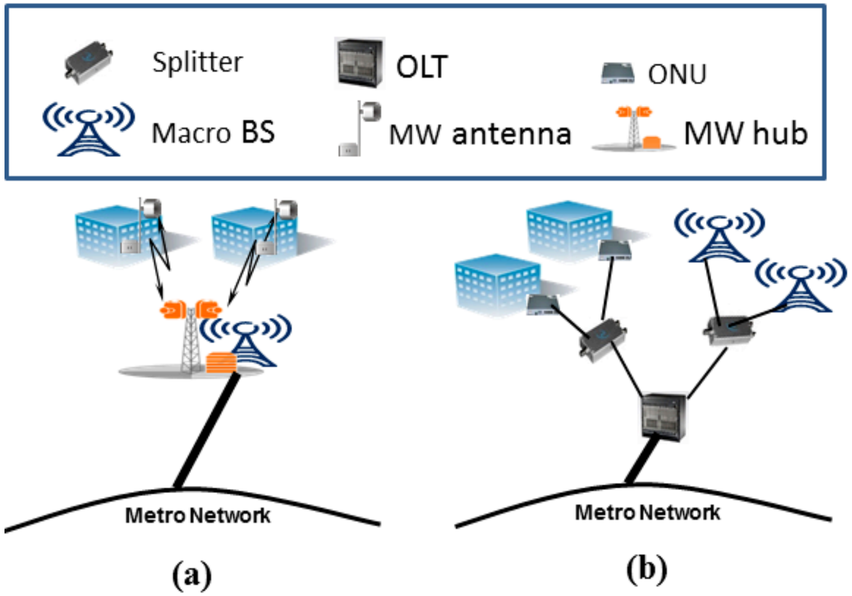
Numerical assumptions: TCO



Component/Parameter	Price (Euro)
Technician salary (hour)	52
Energy cost (kWh)	0,1
Indoor yearly rental fee (m^2)	220
Outdoor yearly rental fee (m^2)	180
Small/Large microwave antenna	200/2000
G-Ethernet switch	1800
Microwave hub + installation	50000
Ethernet switch	100
Yearly spectrum leasing per link	150
GPON/10GPON OLT	640/1750
GPON/10GPON ONU	50/105
Power splitter (1:16/1:32)	170/340
Fiber (km)	80
Trenching (km)	45000
Leasing upfront fee (km)	800
Yearly fiber leasing fee (km)	200