Industrial perspective in 5G optical transport

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Overview

- Background
- Packet switching over fibre links vs. optical links
- 5G requirements
- Network densification
- Example device: mini-ROADM
- Summary

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Background / Perspective to look onto optical transport

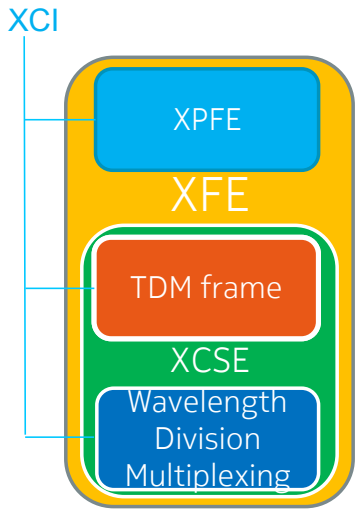
- Specification of transport features
- Definition of network configurations
  - LTE S1/X2 interfaces
  - WCDMA Iub interfaces
  - Any type of technologies: ATM, MWR, electrical, optical, leased lines, …
- 5G-Crosshaul project
  - Transport networks for both backhaul and fronthaul
  - Heterogenous technologies: MWR, PON, optical, …
  - Multi-layer switches: wavelength, TDM, packet

Uses of optical transport

- ‚Dark fibre'
  - Squeeze as high as possible bit rate over as many as possible wavelengths
    - Long range
- Ethernet over fibre
  - IP over Ethernet (backhaul, control and management, data center)
  - Radio over Ethernet (fronthaul)
- Some obvious (dis)advantages of optical vs. Electrical
  + Longer range, higher bandwidth, better surge insulation
  - No power transmission (PoE)

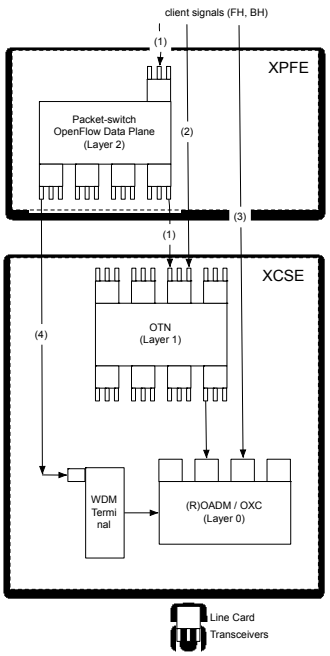
Multi-layer forwarding element / Overview

- XFE: Forwarding Element
  - XPFE: packet forwarding
    - Statistical multiplexing
  - XCSE: circuit
    - Low and deterministic delay
    - Packet switch off loading
- Layers are optional
- XCI: Control infrastructure
  - Software defined networks



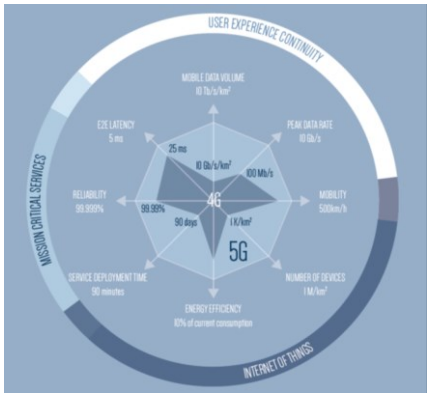
Multi-layer forwarding element / forwarding

- XPFE interfaces
  - Optical, electrical, MWR, …
- XCSE interfaces
  - All optical
- Different paths through node
  1. Packet – TDM – WDM
  2. TDM – WDM
  3. WDM
  4. Packet – WDM
  5. …



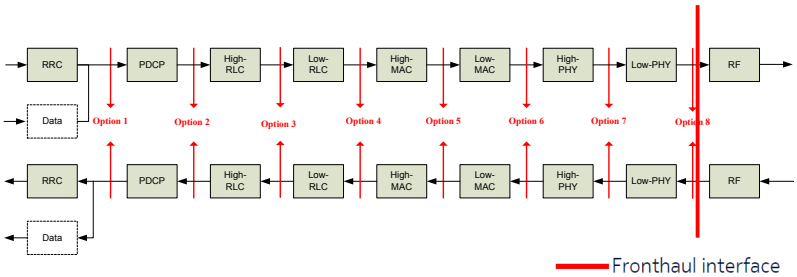
5G Requirements

- 5G mobile networks will offer disruptive network and service capabilities
- Use cases envisioned by 5G PPP, NGMN and METIS envision disruptive end user SLAs
  - e2e Delay: <= 1ms for e.g. industrial automation
  - end user datarate: >= 1Gbps e.g. for virtual reality office
  - Large traffic volumes per area: Tbps/km^2
- User scenarios
  - eMBB (extended Mobile Broadband)
    - 10Gbps peak throughput per user
    - 1Gbps experienced throughput per user
  - URLLC (ultra reliable low latency communication)
  - mMTC (massive Machine Type Communication)



Source: 5GPPP 5G Vision document

5G RAN Functional Splits



3GPP, 38.801

Bandwidth at fronthaul interface depends on antenna configuration, carrier bandwidth

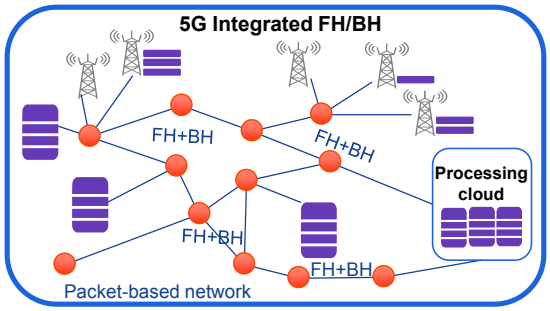
FH compression to reduce bandwidth, no miracles

Number of Antenna Ports	Frequency System Bandwidth		
	20 MHz	200 MHz	1GHz
2	2Gbps	20Gbps	100Gbps
8	8Gbps	80Gbps	400Gbps
64	64Gbps	640Gbps	3200Gbps
256	256Gbps	2560Gbps	12800Gbps

100G

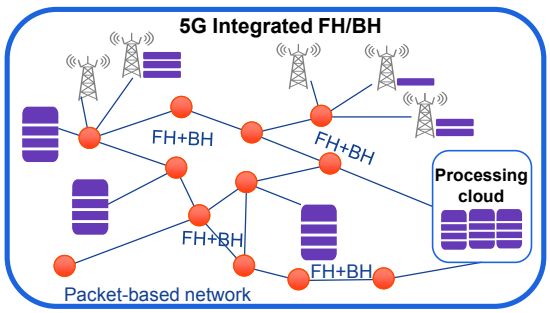
5G System

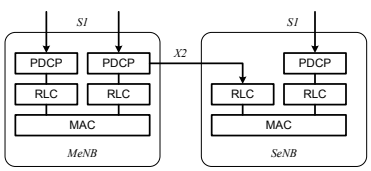
- Heterogenous traffic
  - Traffic of different functional splits
  - Different radio technologies, 5G, 4G, WiFi, …
- Densification
  - More small cells, which need to be connected
  - MWR, fibre, copper, self-backhauling
- Heterogenous networks
  - Different transmission technologies
  - New network nodes due to mobile edge computing
    - Mixture of connectivity and compute services
    - Hosts ‚speaking' Ethernet
- Increased flexibility, reconfigurability
  - SDN, NFV seen as enabler



Topology

- LTE
  - Tree-like: RRH-BBU, eNb-CN
    - Some X2-traffic among eNbs
  - ICIC, CoMP have significant traffic among eNbs (Baseband hotel)
- 5G
  - Dual connectivity like traffic
  - Coordination among small cells
  - Compute servers (MEC) communicating among each other





Software control

- SDN as enabler
- For example: Openflow optical extensions
  - Wavelengths, OTN channels correspond to ports
  - Port properties: wavelength, TX power, …
  - Forwarding: port granularity
- OAM, connectivity checks to be kept local
- Active devices, controlled and managed
  - In-band control
  - Control and management channel needs to be accessed
  - Relatively easy for packet and TDM, unclear for DWDM

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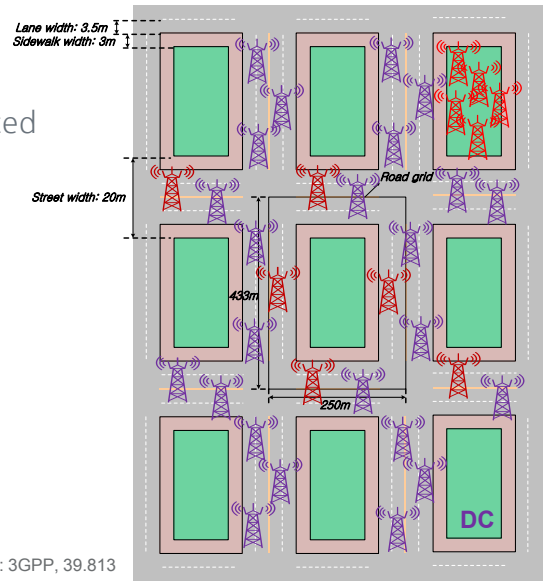
Densification

- How to connect many small cells in a limited geographical area?
  - Aggregation towards core
  - Traffic among BTSs
  - Regional Datacenter



Road grid: 3GPP, 39.813

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Densification / Possible impact of functional split

- ‚Low' functional split
  - Bandwidth requirements according to radio, stringent latency requirements
  - Aggregate on optical level
  - ROADMs with small number of ports
  - Many of them: cost efficient, energy efficient
- ‚High' functional split
  - Bandwidth requirements according end user traffic, higher latency tolerated
  - Ethernet over optical links for aggregation, BTSs and hosts might be connected electrically or with MWR
  - Packet switches with different connectors, ROADMs with packet interface

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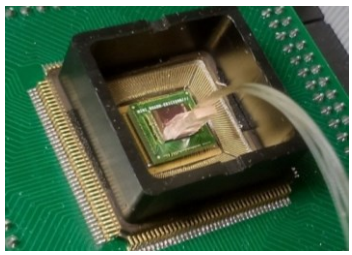
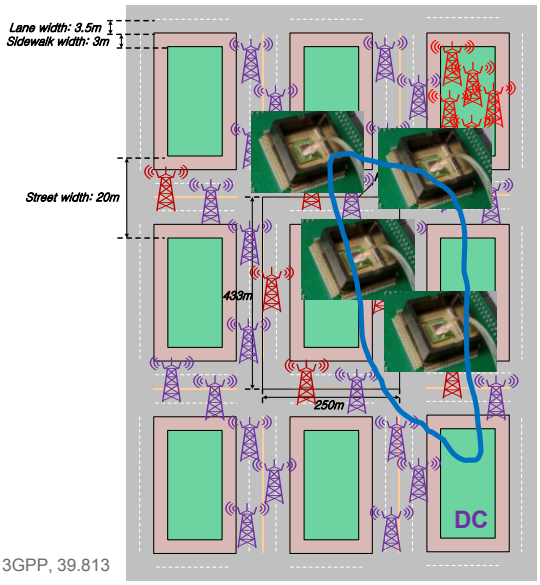
Small ROADM Example

- Silicon Photonics ROADM by Ericsson
- One line input, one line output -> ring
- Twelve (wavelength) local ports
  - Add/drop of 10Gbps per port





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10G optical becoming commodity

- Price of ‚compatible' products, ‚branded' products are more expensive
- At least 10KM reach, SFPx form factor, source http://www.fs.com/

Type	1G	1G DWDM	10G	10G DWDM	40G	100G
Price [USD]	7	200	34	280	380	2800

- DWDM transceivers considerably more expensive than ‚grey' transceivers
  - Example ROADM requires expensive SFPS
  - A packet switch might be cheaper, but it depends on statistical multiplexing gain whether 100G interface for ring could be avoided.

- Energy efficient (0,1Kw, 0.2€/Kwh ➔ 175€ per year)

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Summary

- End user bandwidth increases considerably compared to 4G
- Additional functional splits may be in use
- Densification requires small aggregation devices for optical links
  - Packet based traffic
  - ROADMs
  - Cost efficient

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Discussion

There is still a lot to defined for 5G…
… and even more to be seen what networks will actually be deployed

What devices for optical transport will you build in the future?

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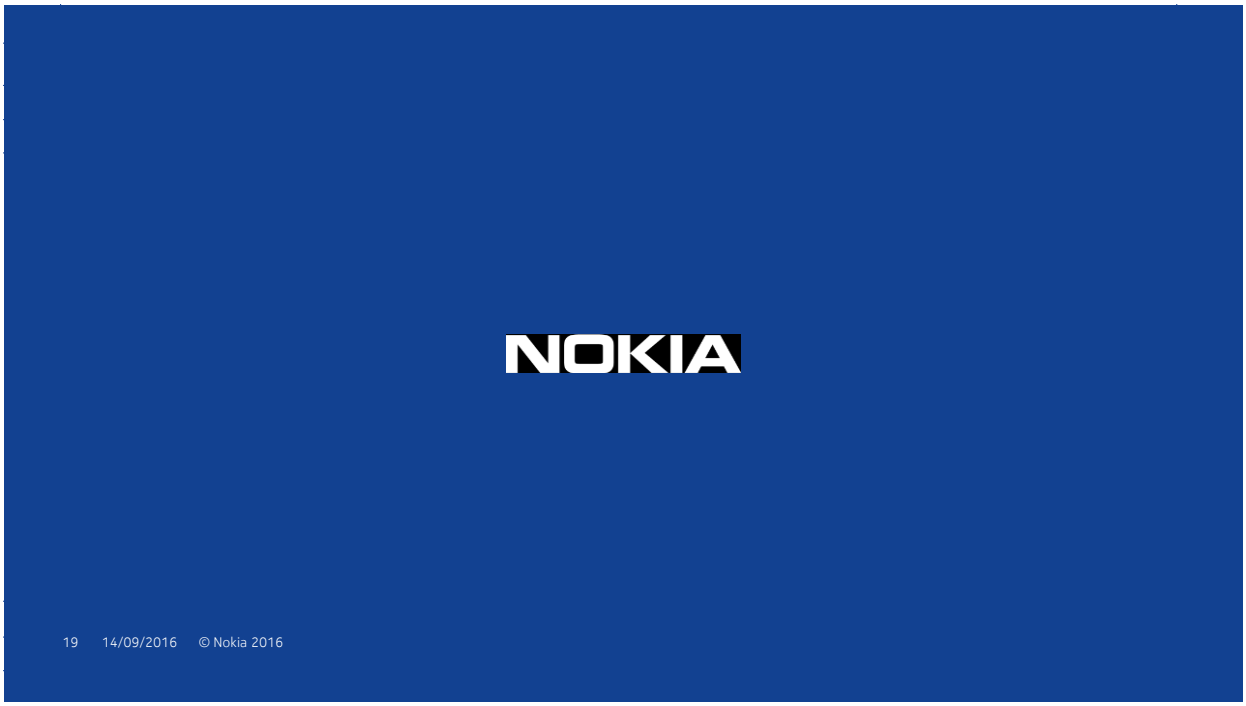
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