The need for 100G Ethernet DWDM PHY
in mobile backhaul

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Excerpts from the Ericsson Mobility Report

https://www.ericsson.com/en/mobility-report

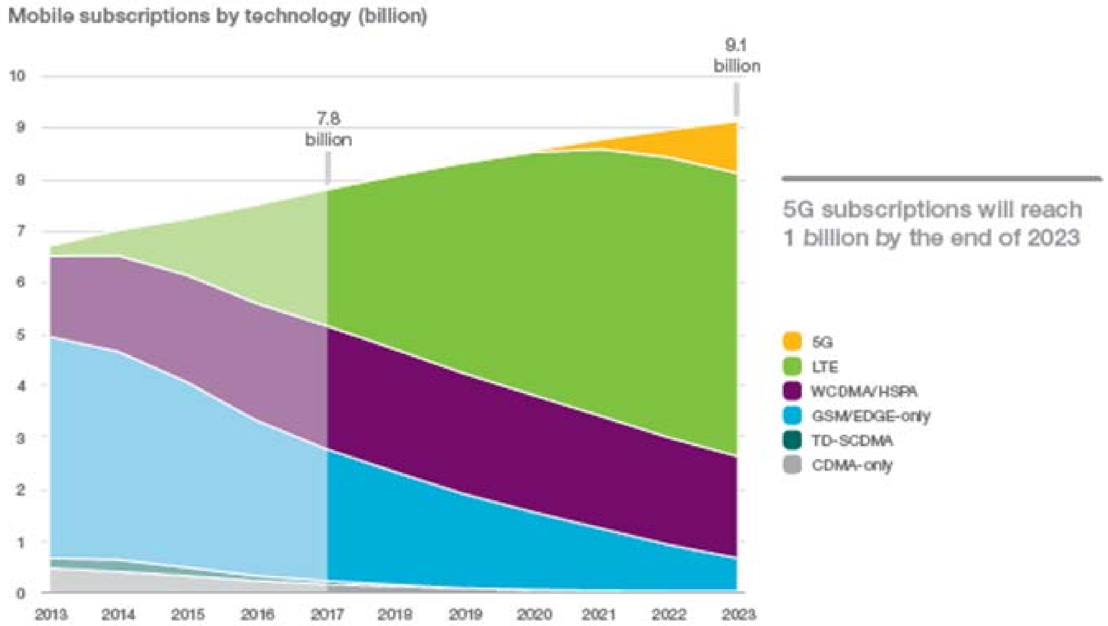


Figure note: IoT connections and Fixed Wireless Access (FWA) subscriptions are not included in the above graph

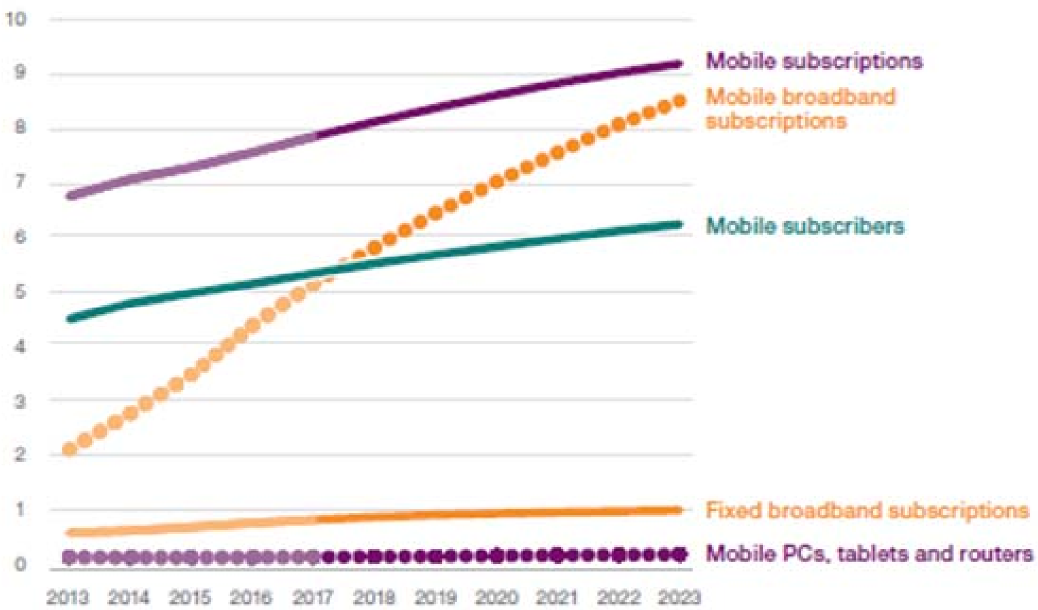
«Non-Standalone» 5G NR will utilize the existing LTE radio and Evolved Packet Core network as an anchor for mobility management and coverage, while adding new 5G radio access carriers to enable certain 5G use cases.

Since the adoption of LTE, the dominant technologies in Mobile Backhaul have been IP/MPLS and MPLS-TP with underlying **Ethernet transport**

Megatrends: two dominators

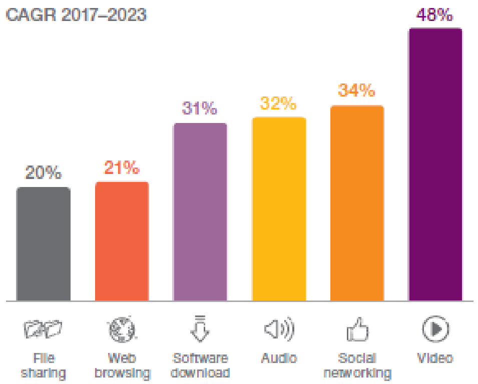
mobile broadband + video

Subscriptions/lines, subscribers (billion)

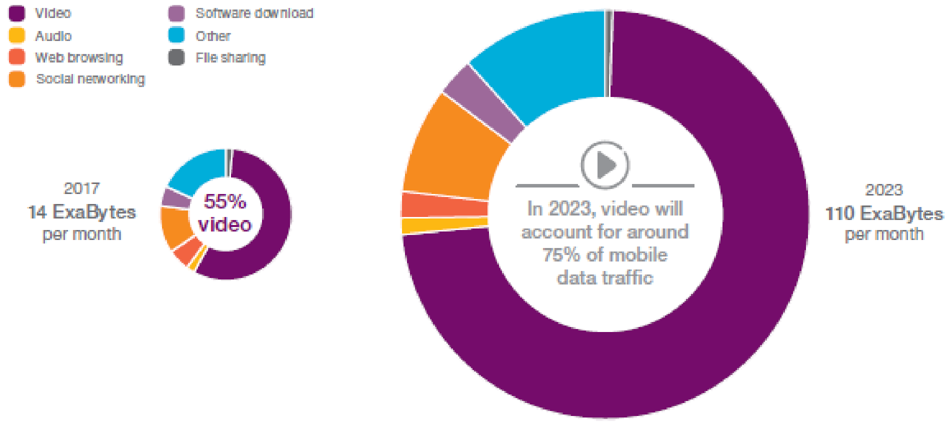


In 2023, there will be 9.1 billion mobile subscriptions, 8.5 billion mobile broadband subscriptions and 6.2 billion unique mobile subscribers

Mobile traffic by application category CAGR 2017–2023



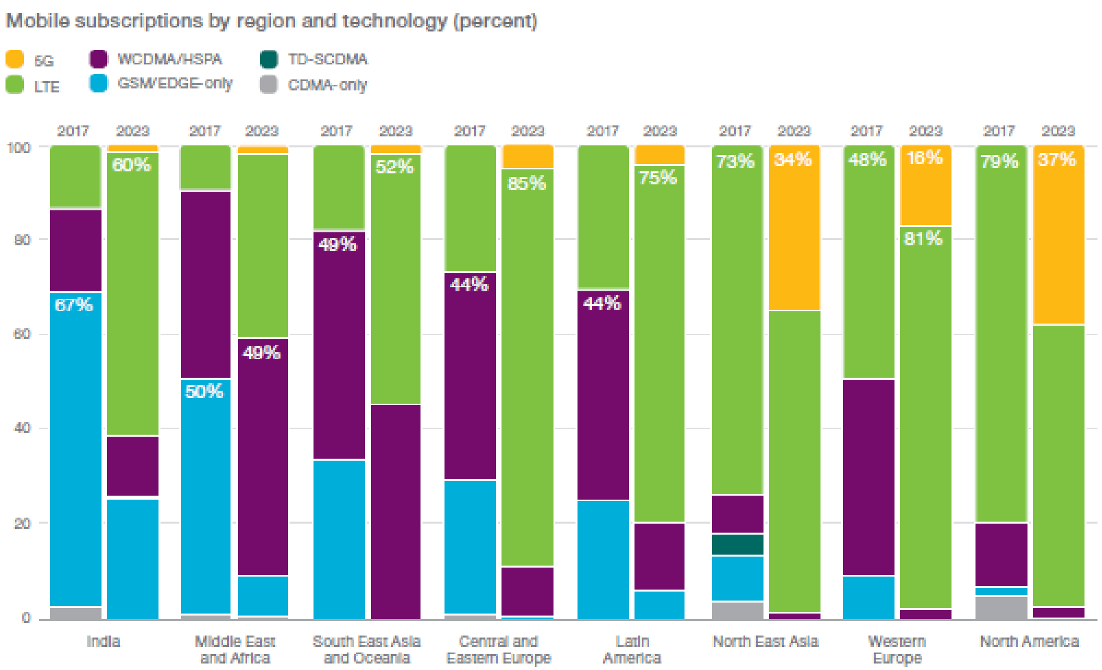
Mobile data traffic by application category per month (ExaBytes)



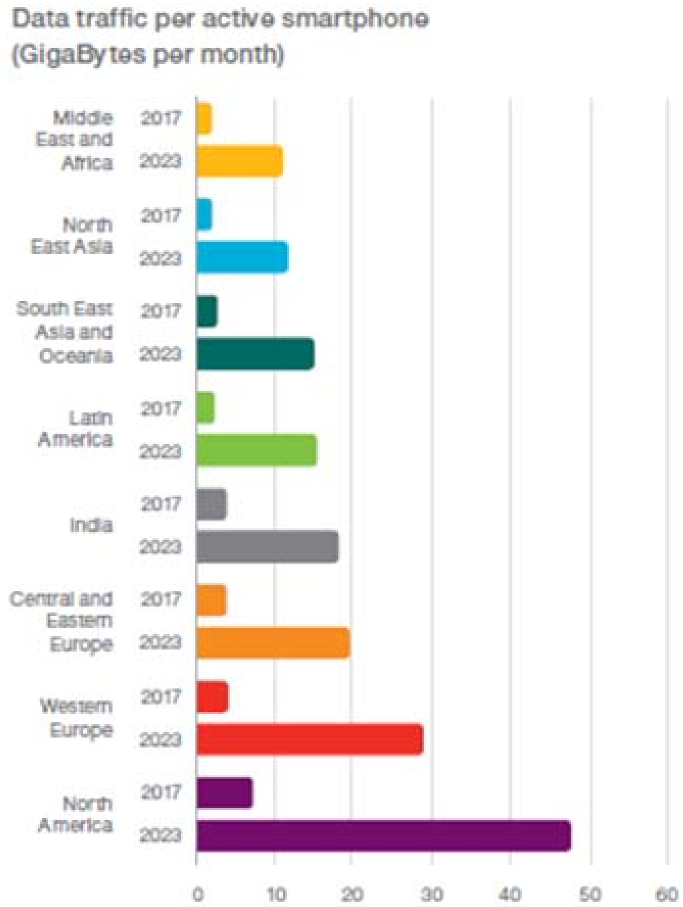
[1] Ericsson ConsumerLab, TV and Media (2017)
Base: Population aged 16–69 watching TV/video at least weekly and having broadband at home in Brazil, Canada, China, Germany, Italy, Mexico, Russia, South Korea, Spain, Sweden, Taiwan, the UK and the US

Regional outlook

North-East Asia and North America leading the 5G pack



Forecasted «data tonnage» per subscriber



From Gbytes/month/subscriber («tonnage») to bit rates: a crude estimation

Gbytes/month => assume uniform usage over the days => divide by 30,000 and obtain **Mbytes/day**

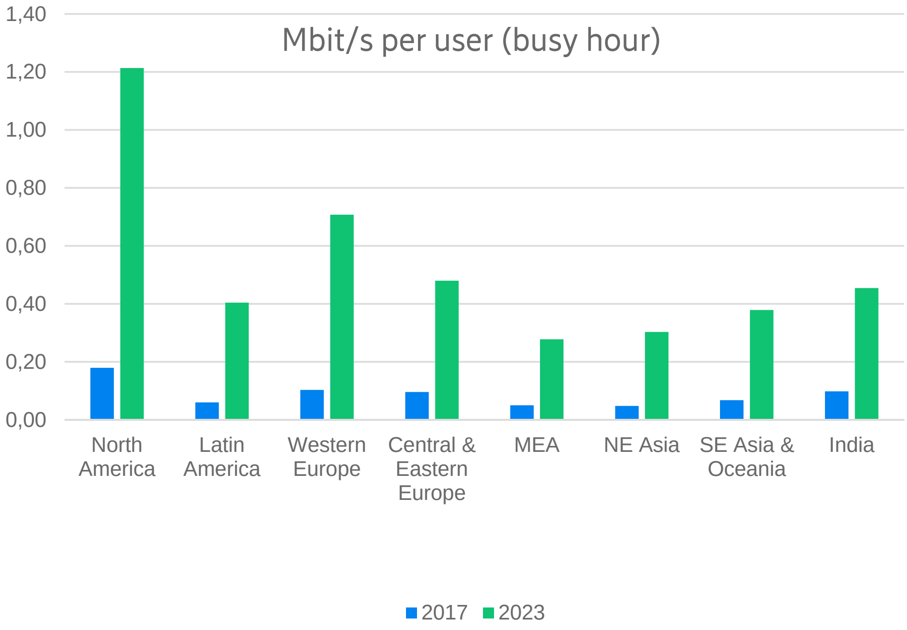
Part of the daily traffic is concentrated in a «busy hour», on average 30%
Mbytes/day => multiply by 0.3 => **Mbytes/«busy hour»**

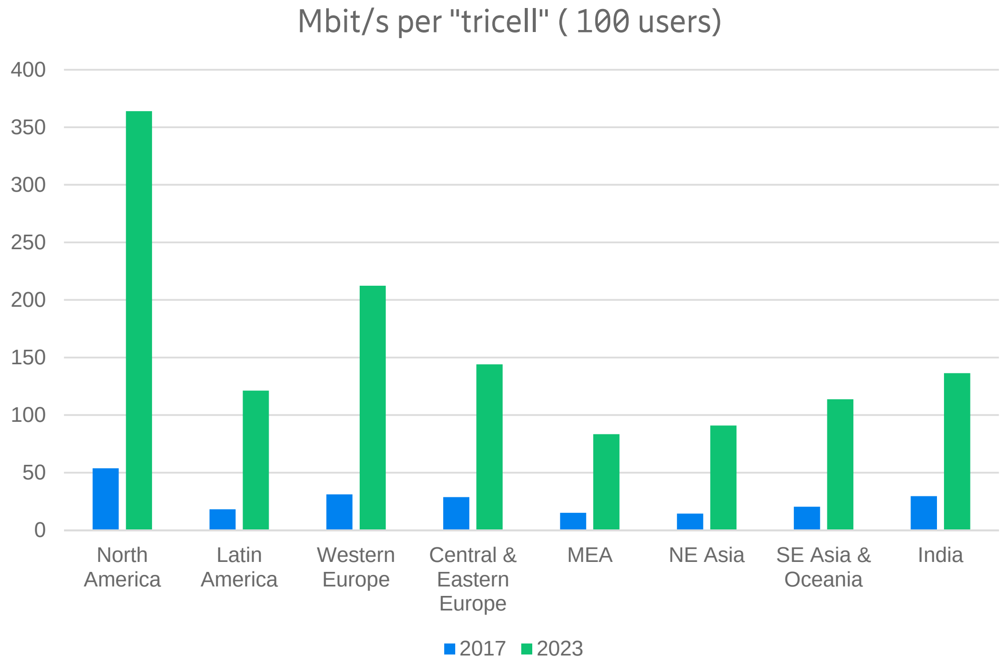
Mbytes/«busy hour» => divide by 3,600 and obtain average **Mbytes/s**

Mbytes/s => multiply by 1.024*8 => obtain average **Mbit/s** in congested hour per subscriber

A «not too conservative» estimation of *average* capacity requirements per subscriber

Some numbers ...





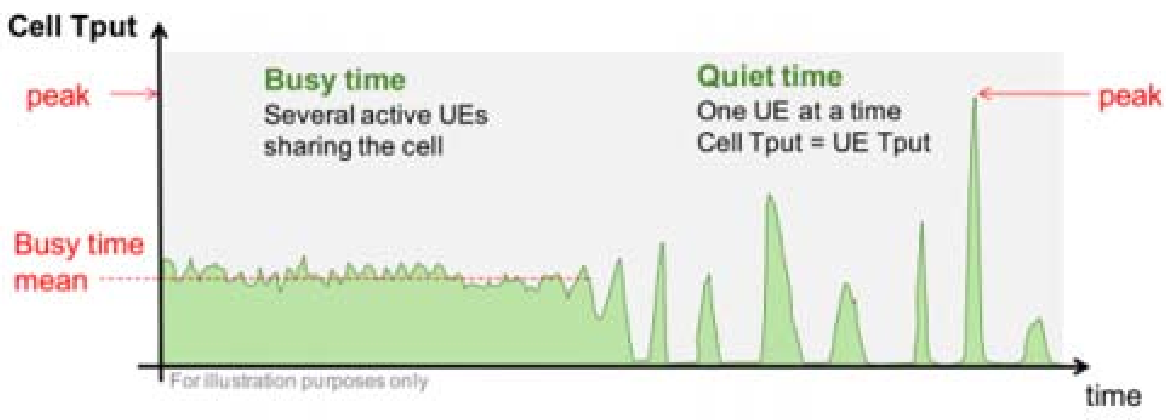
For a single mobile site, 3 sectors, only considering mobile broadband (MBB)

Backhaul dimensioning principles

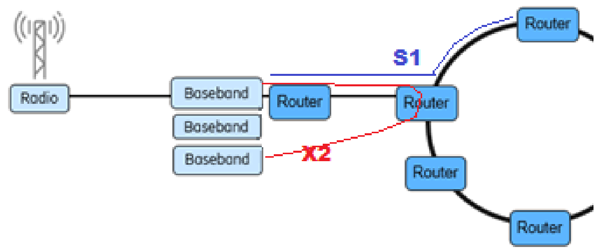
Backhaul for a mobile site is traditionally dimensioned considering the maximum between the sum of busy hour average bit rates on all sectors in a site and the «peak» capacity per sector (90% quantile, due to statistical gains)

«peak» = capacity experienced by one «lucky user» being alone and sitting right under the cell tower, with all the air bandwidth available and in ideal propagation conditions (allowing maximum spectral efficiency, i.e. SNR good enough for 64QAM and higher modulations)

«sum of average bit rates» tends to prevail in scenarios with a lot of users



Some «peak» estimations from the EU FP7 project «COMBO»



LTE-A Backhaul dimensioning per site

S1 traffic per macro site [Mbps]

X2 coordination traffic between sites [Mbps]

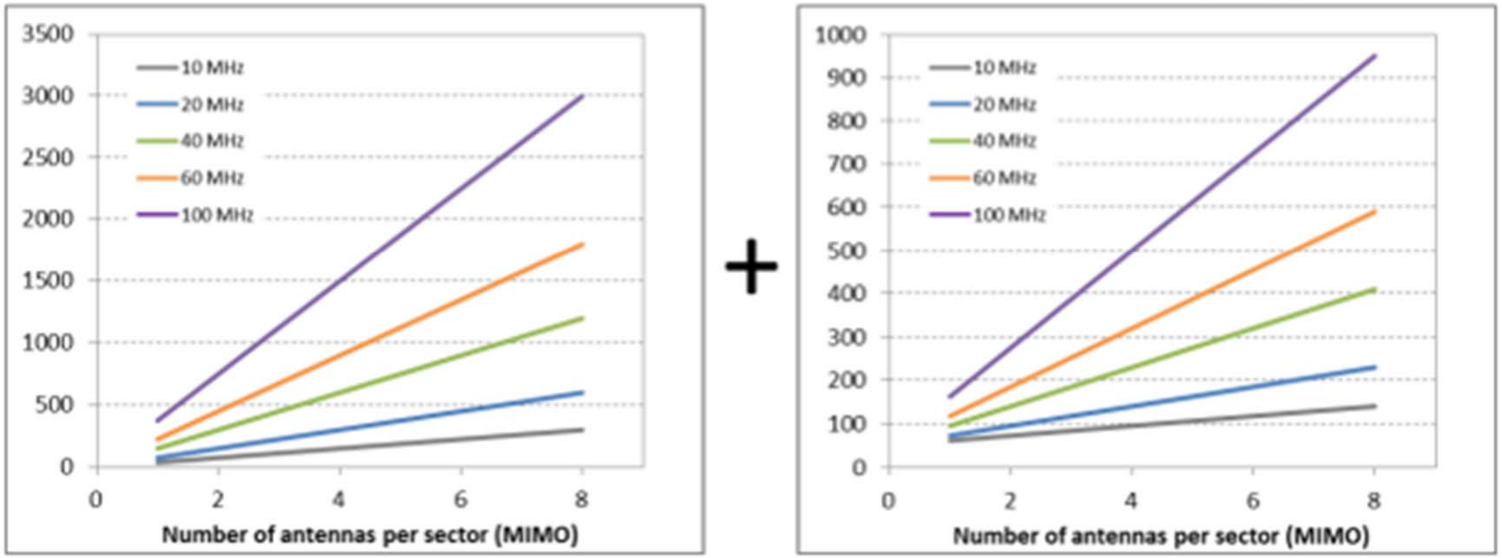
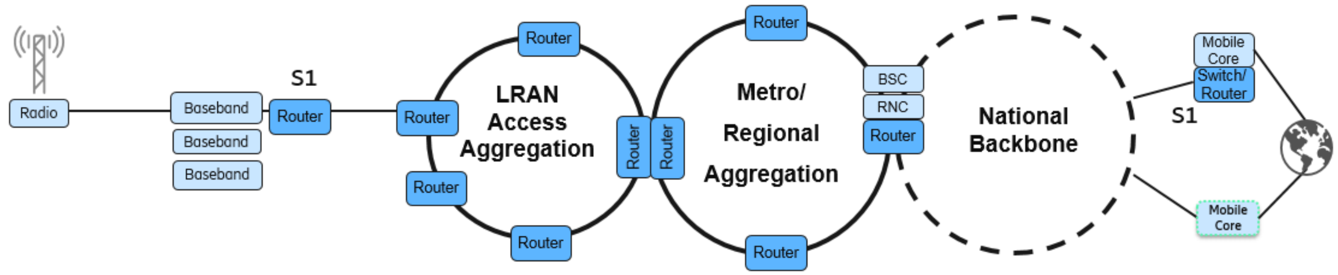


Figure 3: LTE-A Backhaul dimensioning per site

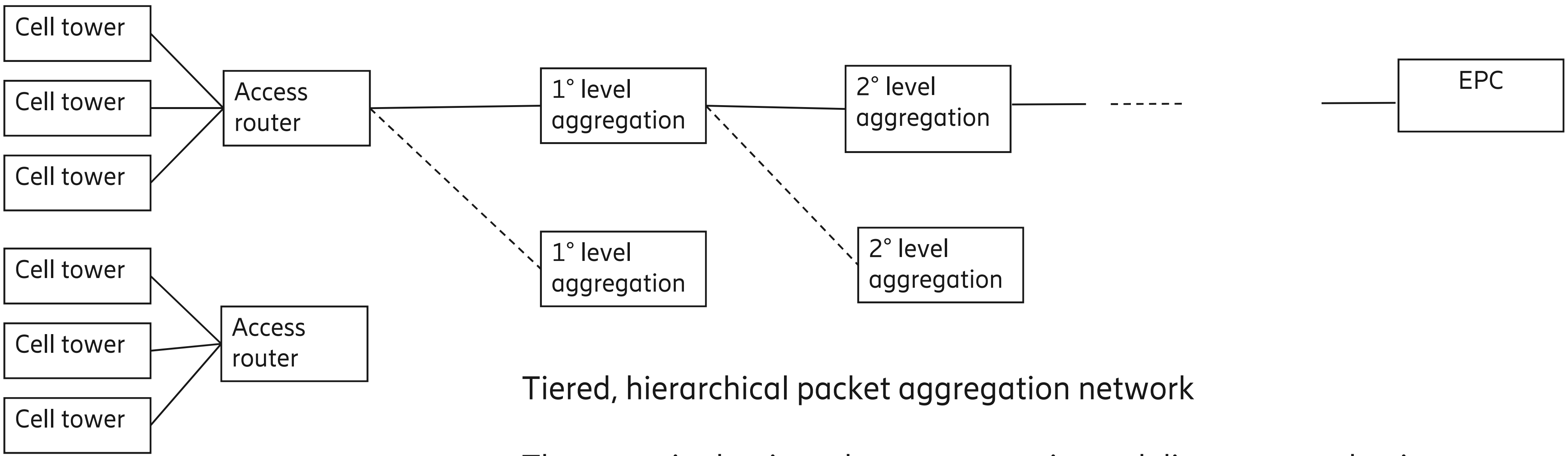
https://cordis.europa.eu/docs/projects/cnect/2/317762/080/deliverables/001-COMBOD33WP330June2015EABv10Ares20153369841pdf.pdf

What's between cell towers and the Evolved Packet Core (EPC) ?



Users/ km^2 => Gbps/ km^2 =>

number of cell towers per km^2 and backhaul capacity per km^2



Tiered, hierarchical packet aggregation network

The upper in the tiers, the more capacity and distances tend to increase

General principle: packet transport and statistical multiplexing help a lot!

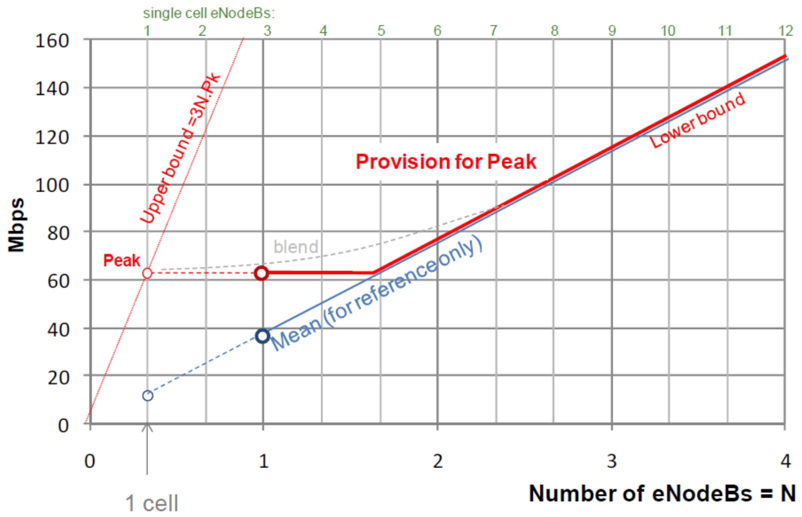
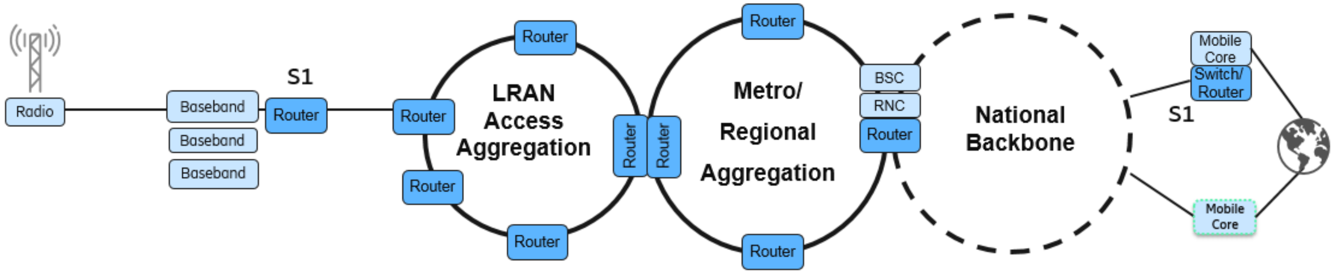


Figure 8 Principles for Provisioning for Multiple eNodeBs

NGMN White Paper, «Guidelines for LTE Backhaul Traffic Estimation»



Growing number of mobile sites and increasing capacity per user expected to **increase utilization** of current 10G/100G «transport pipes» in a variety of scenarios

5G use cases can require higher capacity on-demand, provisioned flexibly and quickly.

That can be solved either with **over-provisioning** capacity, or with **adding intelligence to the transport infrastructure** ,making it «radio-aware»

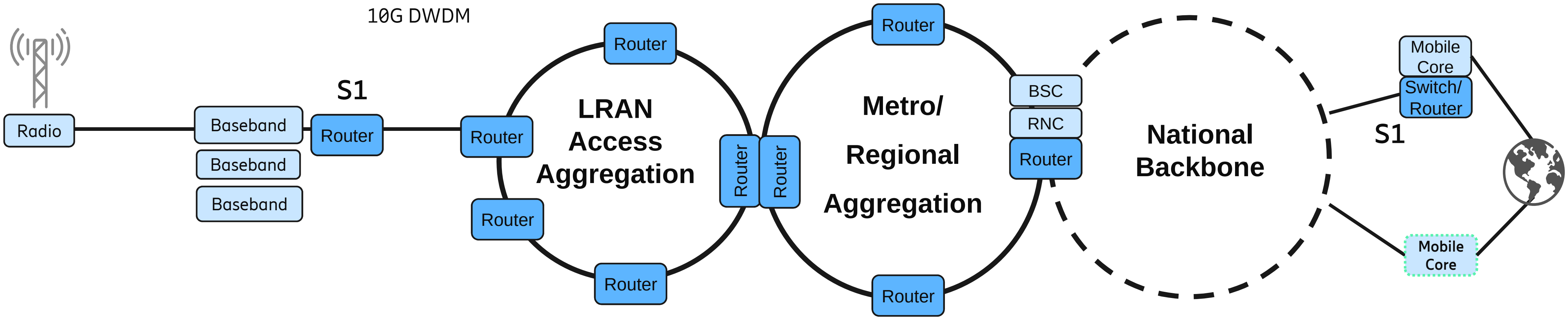
see for instance https://www.ericsson.com/en/ericsson-technology-review/archive/2018/enabling-intelligent-transport-in-5g-networks)

Specific network designs posing the need for higher capacity links can be addressed initially with LAG or , in the future, with higher speed Ethernet aggregates

5G backhaul capacity through 2021

10G
10GBASE-LR
10GBASE-ER
10GBASE-ZR
10G DWDM

100G
100GBASE-ER4 / 4-WDM-40 => **opportunity for standard interfaces with improved cost structure**
100G "-ZR"
100G DWDM (DirDetect or coherent)
200G DWDM coherent for spectral efficiency and lower $/Gbps
=> **opportunity for new standard interfaces**



Continued growth of 10G and 100G interfaces more connections, better utilized

- 50G and 200G might play a longer term role

- In the lower aggregation tiers, 40km 'grey' direct-detect interfaces are expected to have continued traction
- Up in the tiers, 80km/ "-ZR" without external EDFAs expected to become popular (coherent being the most natural fit)
- **DWDM may come into the picture, even in lower tiers, to solve specific network design challenges (fiber exhaust problems ,** "router optical bypass", **...)**

A simple example based on 10Gb/s deployment experience

- Greenfield design, point to point connections, L3 traffic terminated at each node, distances in the 40/80km range, few 100G per site
- The historical trends that yielded to 10G “ZR” are posing the need for 100G “ZR”
- Long distance outside plant fiber is a scarce resource: if operators need to lease fiber, lease costs tend to dominate OPEX of the solution
- “Coloring” ZR with DWDM adds scalability without consuming additional outside plant fiber resources
- «DWDM Ethernet PHY», link types 4 & 5