Verdens mest avanserte 5G-nett er i Oslo sentrum

Haakon Bryhni, Research Professor
Simula Metropolitan Centre for Digital Engineering (SimulaMet)
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Verdens mest avanserte!

telenor

Telia

ice Lab

Operatører — Dekning, stabilitet, nye tjenester

Research & Development — Eksperimentelt, nye prinsipper, flere leverandører

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Understøtter våre prosjekter:

Center for Resilient Networks and Applications

GAIA CYBER SOVEREIGNTY

5Genesis

5G-VINNI

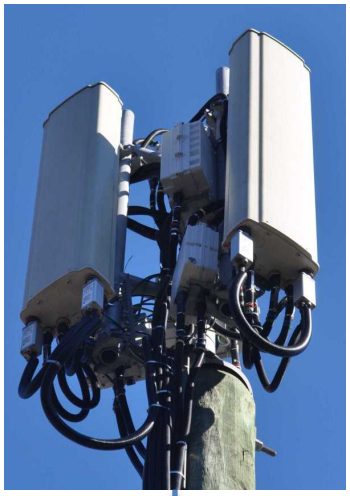
…og mange nye forskningsinitiativ: Beyond 5G tung infrastruktur, SFF, SFI, Horizon Europe
Innovasjon med små bedrifter og internasjonalt leverandørsamarbeid

Components in traditional mobile networks

Mobile phones

2/3/
4G

Wireless



UE with mobile modem (“IoT”)

Coax cable

Backhaul network

Core network

Internet

Traditional indoor and outdoor base stations

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Mobile network evolution with RRU/BBU

Mobile phone UE

4G LTE

Wireless

UE with mobile modem (“IoT”)

Antennas

RRU Remote Radio Units
(Basestation in tower with antenna)

CPRI

BBU Base Band Unit near tower

Backhaul network

Core network

Internet

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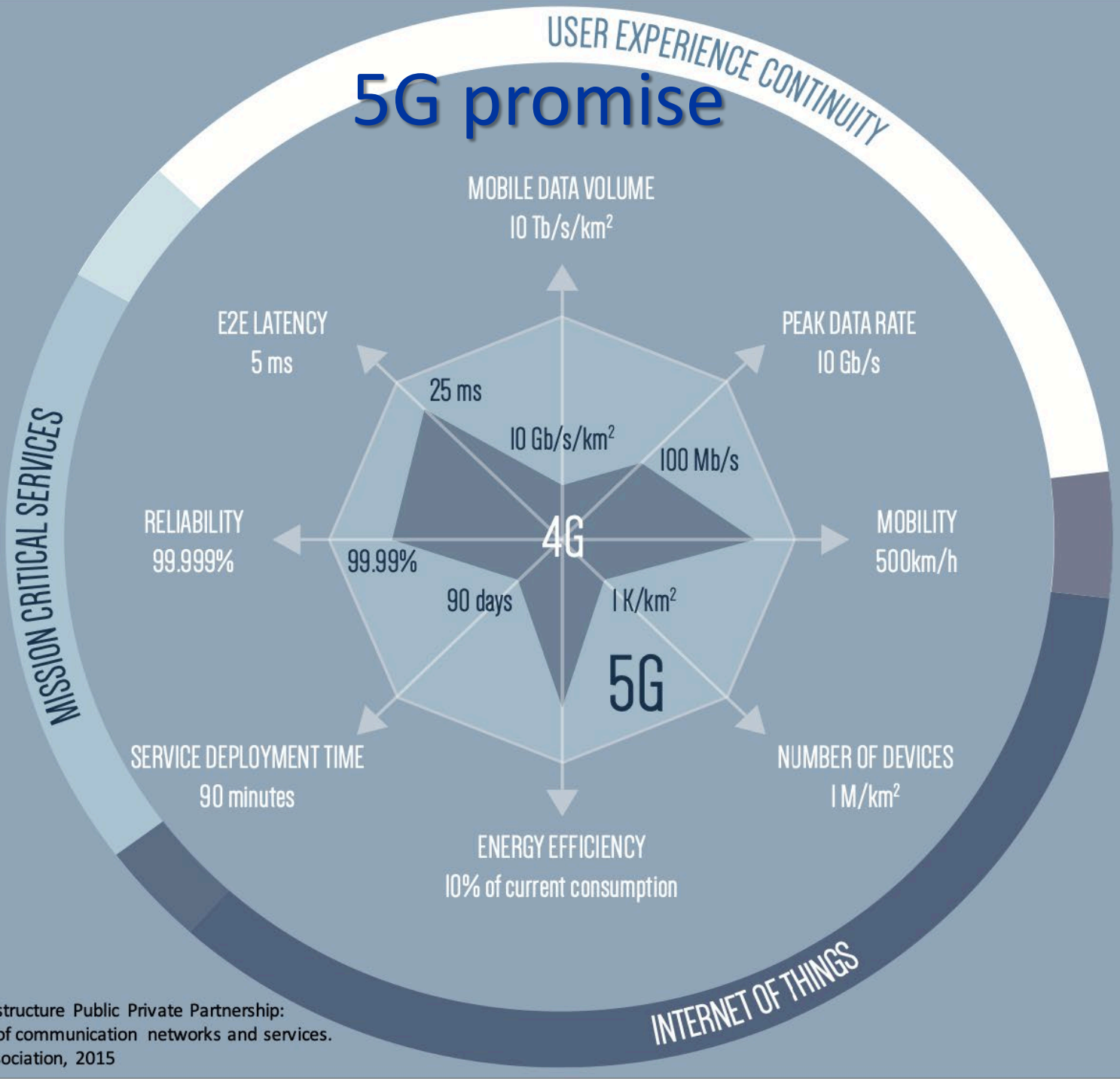
5G promise



Source: The 5G Infrastructure Public Private Partnership: the next generation of communication networks and services. 5G Infrastructure Association, 2015

4G needed for 5G-NSA
(not needed for 5G-SA)

5G mobile network components

4G LTE

5G-NR

Mobile phone UE

UE with mobile modem ("IoT")

Active Antenna Units
RRU integrated
with antennas

eCPRI -- Ethernet

Fronthaul network

Backhaul network

Core network

Internet

BBU Base Band Unit near tower

Edge computing

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5G- A computer or a network?

Sun microsystems

The Network is the Computer™

John Burdette Gage, 1994

Sun workstations connected via Ethernet

New technologies in 5G:
A/D and MIMO in the antenna
Ethernet Fronthaul network
Radio (BBU) implemented in Edge data centre
Realtime Applications in Edge data centre
Ethernet Metro network
All non-real-time applications in Data Center
Network Function Virtualization

In 5G, The Computer is the Network

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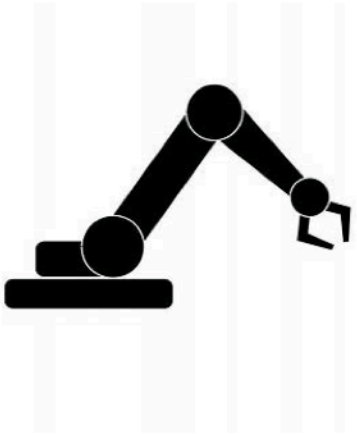
5G and new business models

- Aggregation of several networks
  - Evolution of commercial cellular networks (higher speed, lower latency)
  - Critical networks (replacing TETRA)
  - Railroad signalling networks (replacing GSM-R)
  - Military networks (green mobile basestations replacing military networks such as TADCOM?)
  - Internet of Things
- Enabling new user groups
  - Massive scale Internet of Things
  - Mobility (assisted and autonomous driving, multi-modal transport)
  - Wearable (clothes, shoes, watches, pendants, implants, sensors)
  - Cities
  - Homes
  - Grids
- Enabling new applications
  - Real-time guarantees, dependable computing, high bandwith, low latency, low power

The operators believe (hope?) that the sum of new user groups and corresponding business models will finance a massive mobile infrastructure upgrade. Business models are not yet in place and 5G rollout will be gradual as new applications form. It is expected that 5G will be the most important digital infrastructure in the coming 20 years.

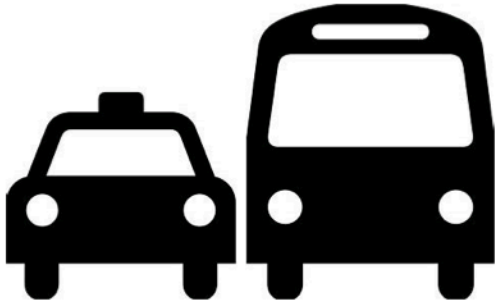
Future IoT applications will have stricter reliability and latency requirements

Factory automation



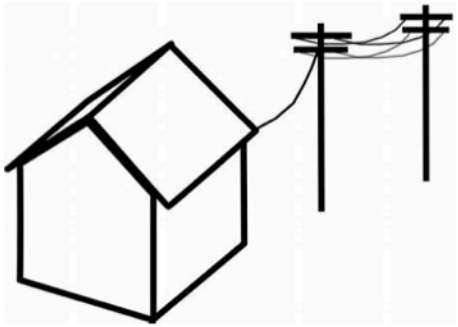
Latency: 0.25 to 10ms
PLR: 10E-9

Intelligent transportation systems



Latency: 10 to 100ms
PLR: 10E-3 to 10E-5

Smart grids



Latency: 3 to 20ms
PLR: 10E-6

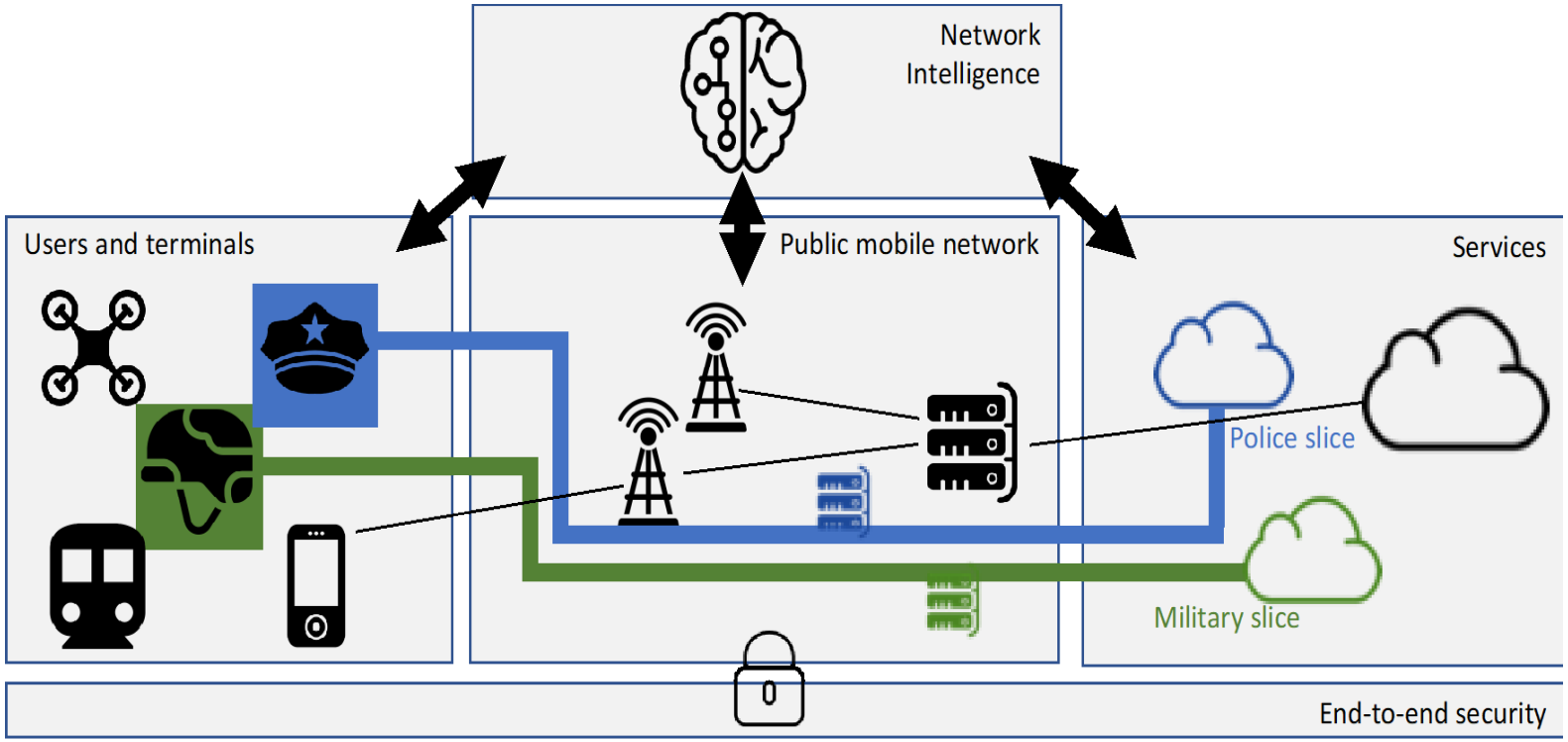
PLR: Packet Loss Rate

Schulz, Philipp, et al. "Latency critical IoT applications in 5G: Perspective on the design of radio interface and network architecture." IEEE Communications Magazine 55.2 (2017): 70-78.

Kilde: Ahmed Elmokashfi, Simula

Critical use of mobile networks

New user groups expect 5G to carry mission critical traffic



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5G Research at Simula Met

- Reliable and dependable 5G networks for critical use – **GAIA, CRNA**
- 5G distributed measurement infrastructure – **GAIA**, **5GVinni, 5Genesis, CRNA, UiO**
- 5G and new access networks (eCPRI, TSN) – **SMIL, TransPacket**
- 5G and edge supercomputing (Ultra Reliable Low Latency Communication) **SMIL, eX3**
- 5G and Internet of Things terminals (IoT) **CRNA, Telia, ICE**
- 5G and exact time synchronization (Alt. to GPS and IEEE 1588) **Justervesenet, Statnett**
- 5G and softwareization and virtualization (service mobility) **CRNA**
- 5G and self driving networks (automated network management) **CRNA, Uninett, B5G**
- 5G and security **GAIA**, **CRNA, Sintef**
- 5G for real-time instrumentation **5Genesis, 5G-Vinni, CRNA, new projects with UiO, NTNU, UiA, Uninett, B5G**
  - Power Grids
  - Autonomous navigation
  - Industry 4.0
  - Drone coordination
  - Tactile Internet
  - Remote teaching
  - Remote work
  - Remote care

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"SMIL"

5G Performance and Reliability → Heterogenous infrastructure

↓ Interoperability
Open standards

New groups of users

↓ Demanding requirements

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Interoperability lab

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CISCO JUNIPER NETWORKS

NVIDIA intel

HUAWEI 2 x 5G-NR base stations

NOKIA ERICSSON Planned in lab upgrade

5G handsets

Nasjonal kommunikasjons-myndighet

5G spectrum

Industrial

Automotive

Mobility

Personal

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