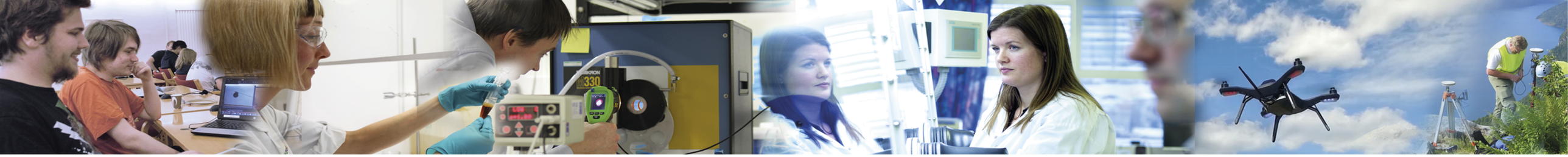

UiO : Department of Technology Systems
University of Oslo

Vestre Bærum Medlemsmøte - 15Mar2021

Mobilutviklingen - hva er 5G og hvordan kommer vi å bruke 5G?

Prof. Dr. Josef Noll

University of Oslo (UiO) & Basic Internet Foundation, Norway
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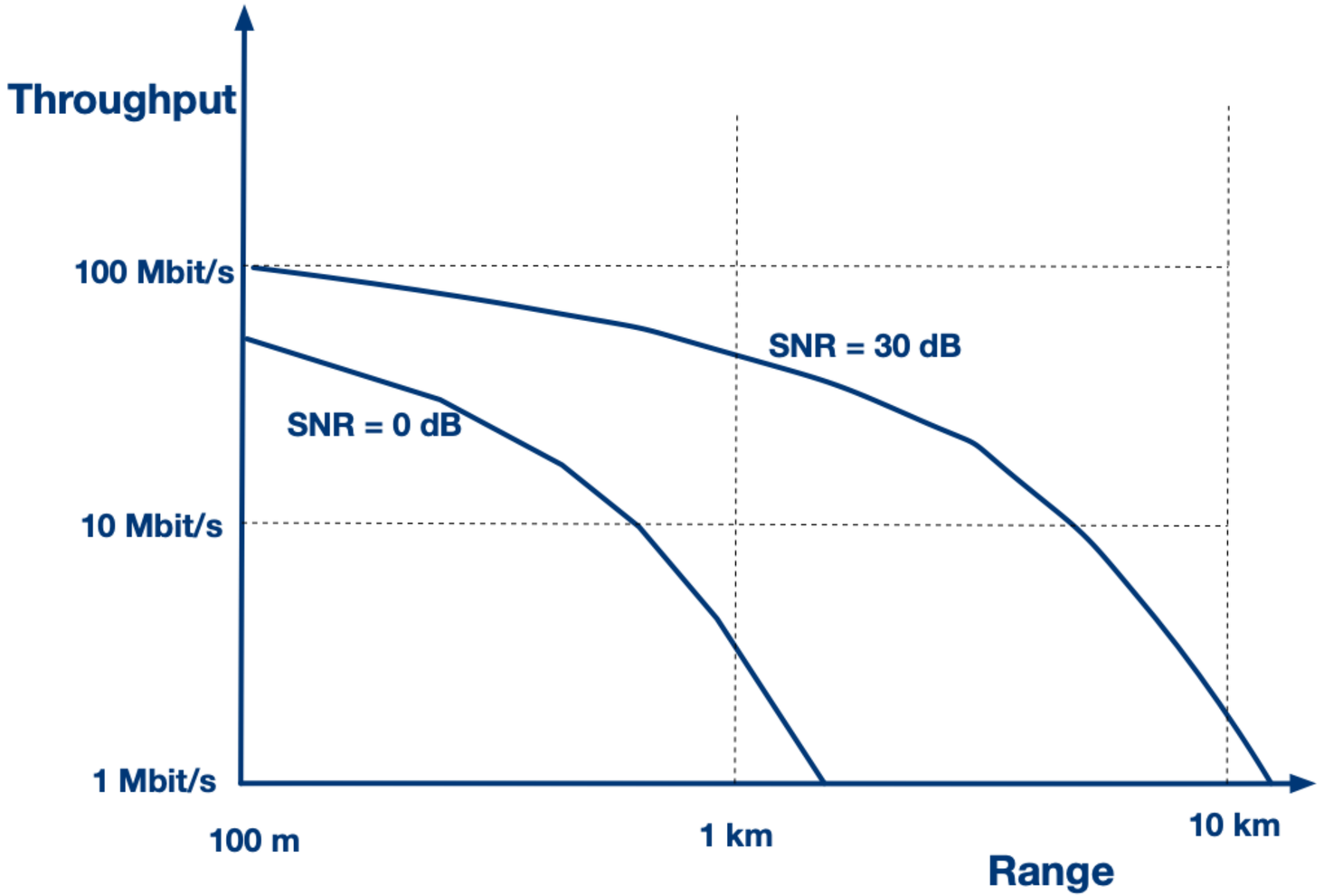
How did we measure the quality of the mobile network

Hovedspørsmål: Rekkevidde og kapasitet

- Coverage/Range (2G, 4G)
  $f \sim 1/R$
- Capacity (3G, 4G, 5G)
  $C = B\log_2(1 + SNR)$
- Security (2G, 3G, 4G,…)
- Radio technology



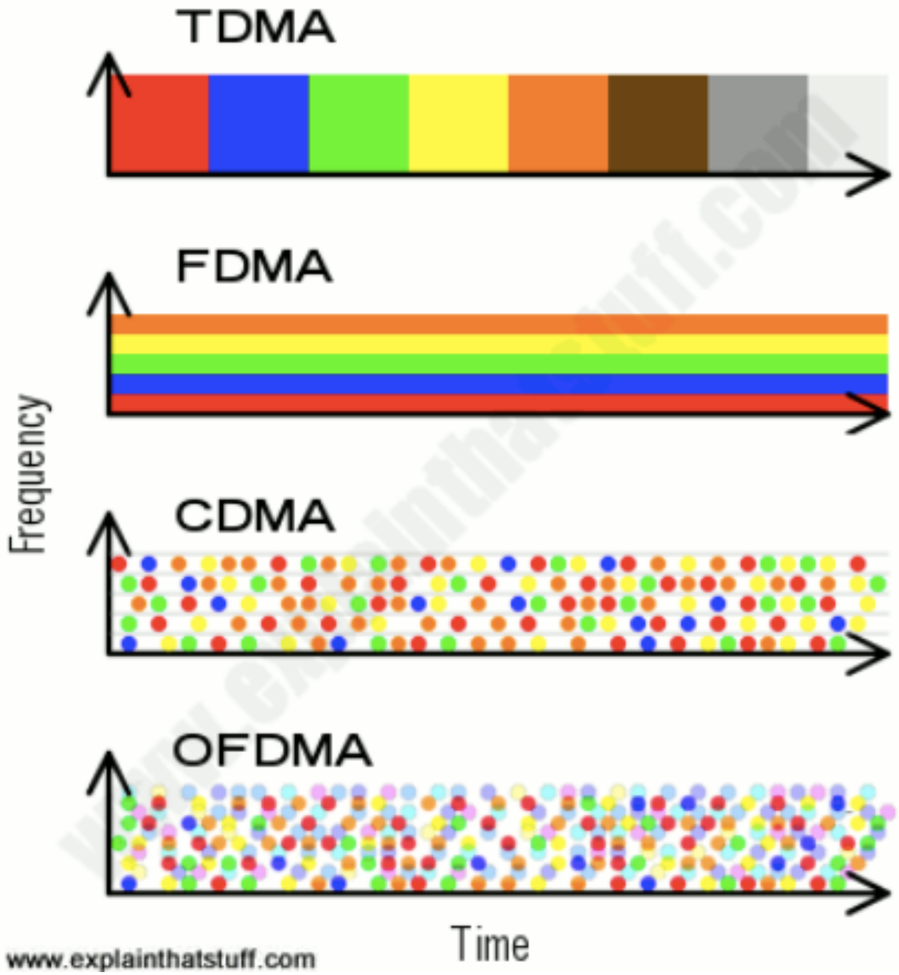
Mobile nett i Afrika

og spørsmål om 5G:
https://titan.uio.no/teknologi/2020/5g-nettet-er-til-fordel-teleoperatorene-ikke-forbrukerne

G

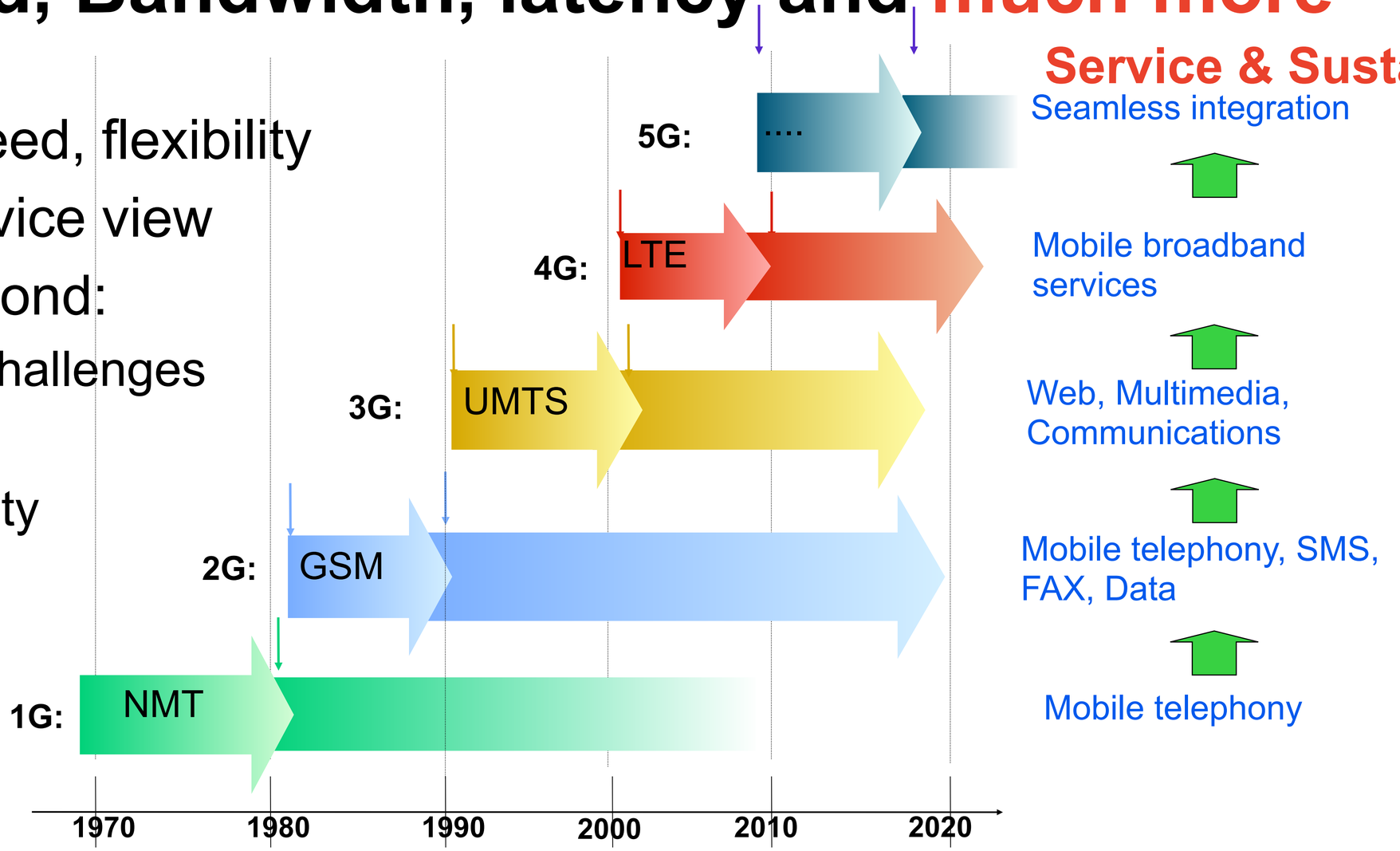
Principles 2G-5G

- Principles
  - frequency, time, code
  - allocation
- New applications
  - Internet of Things (4G, 5G)
  - Control systems (5G)
    - latency, reliability



5G: Speed, Bandwidth, latency and much more

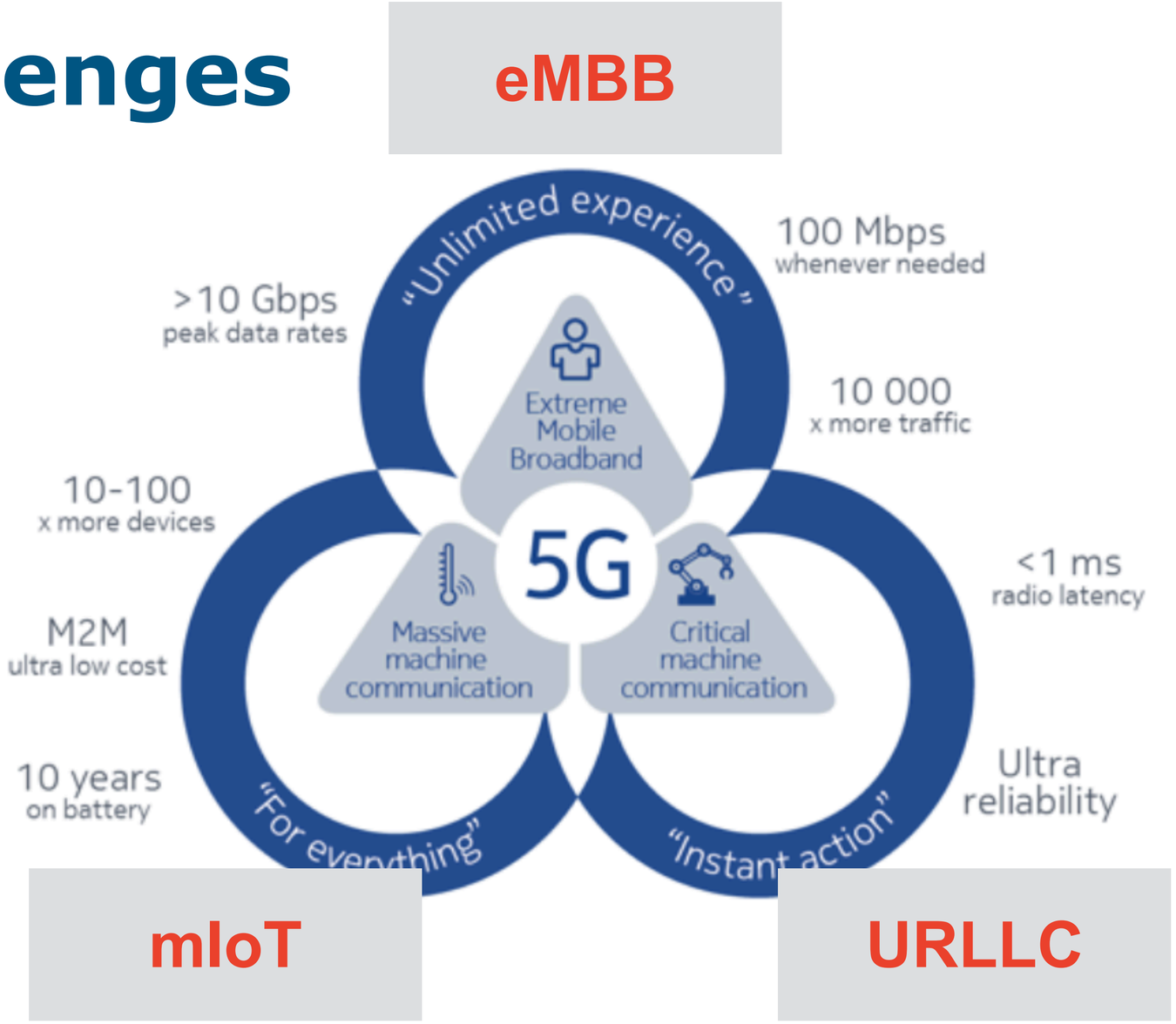
- 1G-3G: Speed, flexibility
- 3G-4G: service view
- 5G and beyond:
  - Business challenges
  - ownership
  - sustainability



[adapted from Per Hjalmar Lehne, Telenor, 2000]

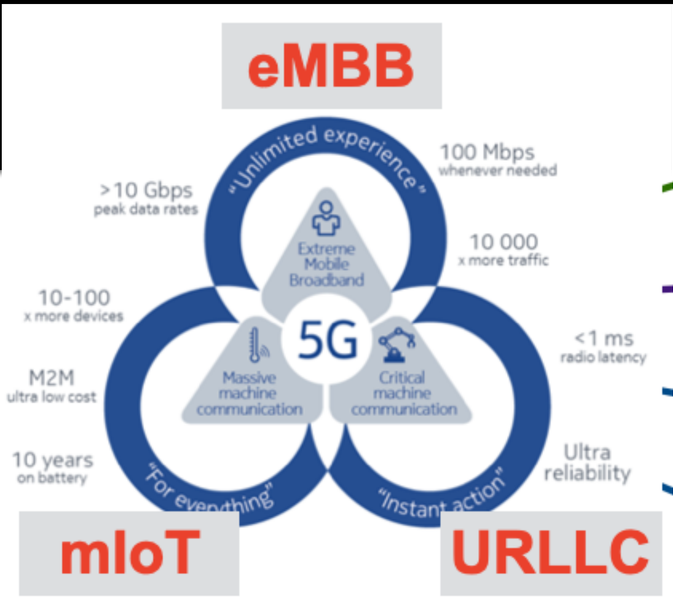
5G: Industrial Challenges

- enhances Mobile Broadband
- massive IoT
- ultra Reliable, Low Latency communication



[source: Nokia https://networks.nokia.com/5g/get-ready]

5G anvendelser



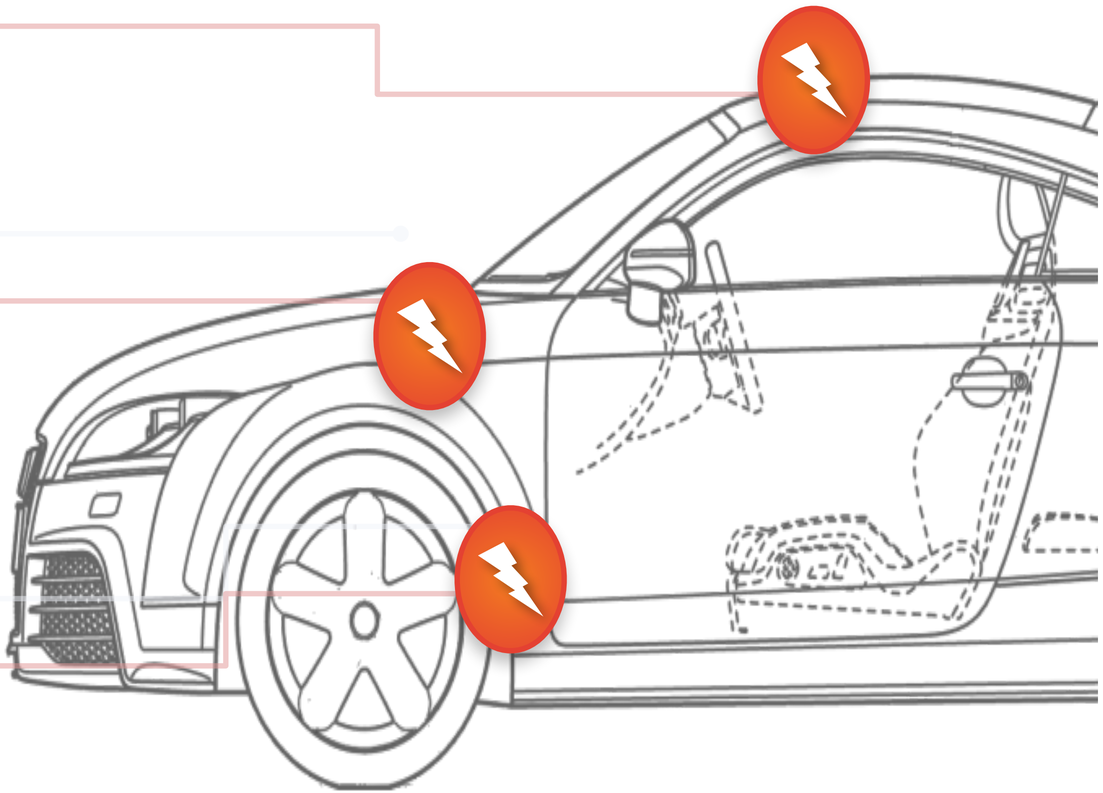
- eMBB (enhanced mobile broadband)
  - ➡ økt kapasitet i nett
- mIoT (massive Internet of Things)
  - ➡ masse dingser, alle dingser har et SIM kort
- URLLC (ultra-reliable, low latency communications)
  - ➡ prosess industri, styring av f.eks. aluminium produksjon
  - ➡ lastebiler som kjører samlet
  - ➡ lav forsinkelse <1 ms, <10 ms,..
  - ➡ 99.99997% uptime, delivery within 5 ms

Example: The Connected Car

WIRELESS ROUTER
- Online entertainment
- Mapping, dynamic re-routing, safety and security

CONNECTED SENSORS
- Transform “data” to “actionable intelligence”
- Enable proactive maintenance
- Collision avoidance
- Fuel efficiency

URBAN CONNECTIVITY
- Reduced congestion
- Increased efficiency
- Safety (hazard avoidance)



Trust for IoT

2 Trains following each other
- wireless!

SCOTTproject.eu

Teknologier for 5G

- høyere frekvens: >20 GHz
  - ➡ økt båndbredde
- bedre koder
  - ➡ prosesseringskapasitet har økt
  - ➡ hente 2-3 ganger mer data ut av lufta
- flere antenner (MIMO)
- virtualisering
  - ➡ “alt er programmvare”
- deling av nett (“network slicing”)

MIMO = multiple input, multiple output

5G Air Interface

- Scalable **OFDM**-based 5G NR air interface
  - ➡ Scalable numerology, scalable slot duration (efficient multiplexing of diverse latency and QoS requirements)
  - ➡ Frequency localisation
  - ➡ lower power consumption
  - ➡ Asynchronous multiple access
- Flexible slot-based 5G NR framework
  - ➡ Self-contained slot structure (independently decode slots and avoid static timing relationships across slots)
  - see: https://www.5gtechnologyworld.com/the-basics-of-5gs-modulation-ofdm/

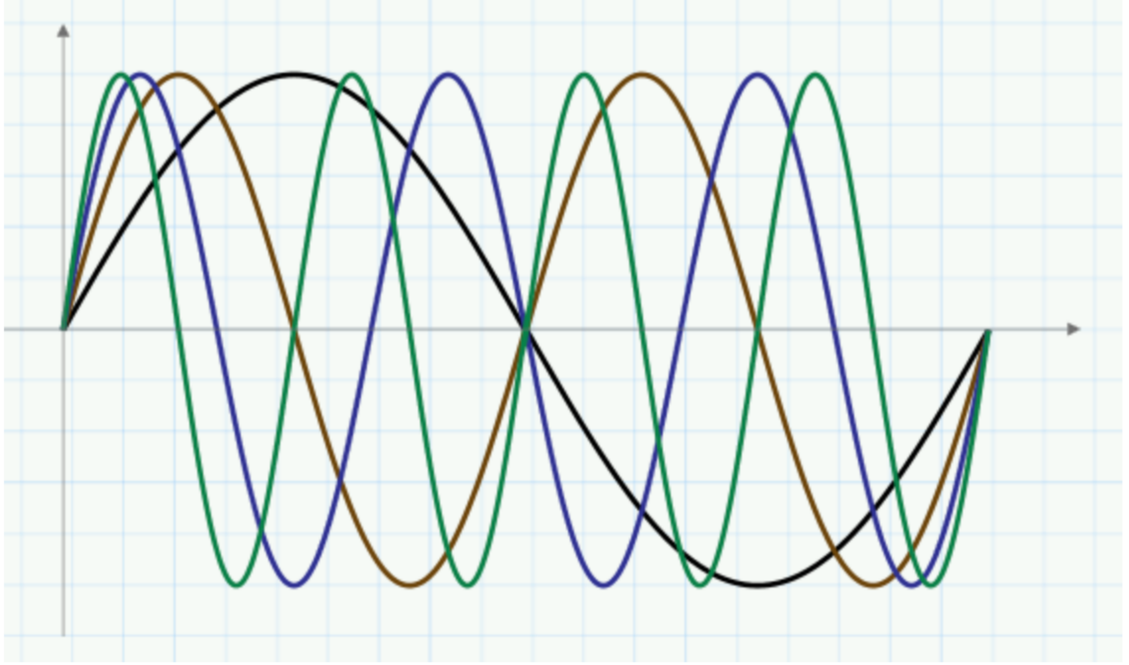


Figure 3. This OFDM signal contains four carriers spaced apart by ⊠f corresponding to f0, f1, f2, f3.

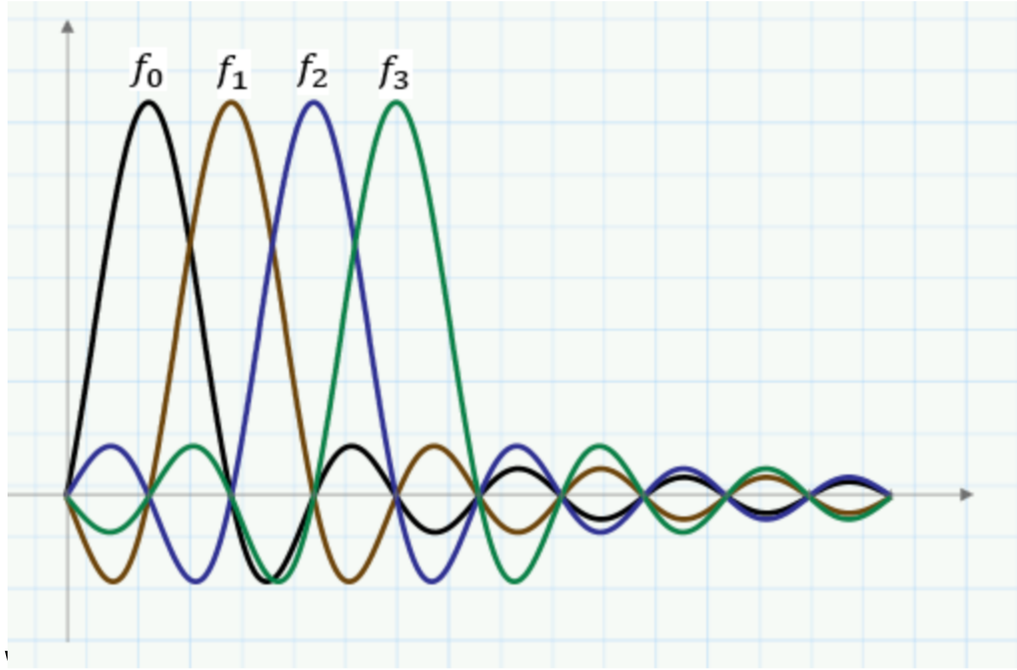


Figure 4. Frequency domain representation of a four-carrier OFDM signal

5G Channel coding

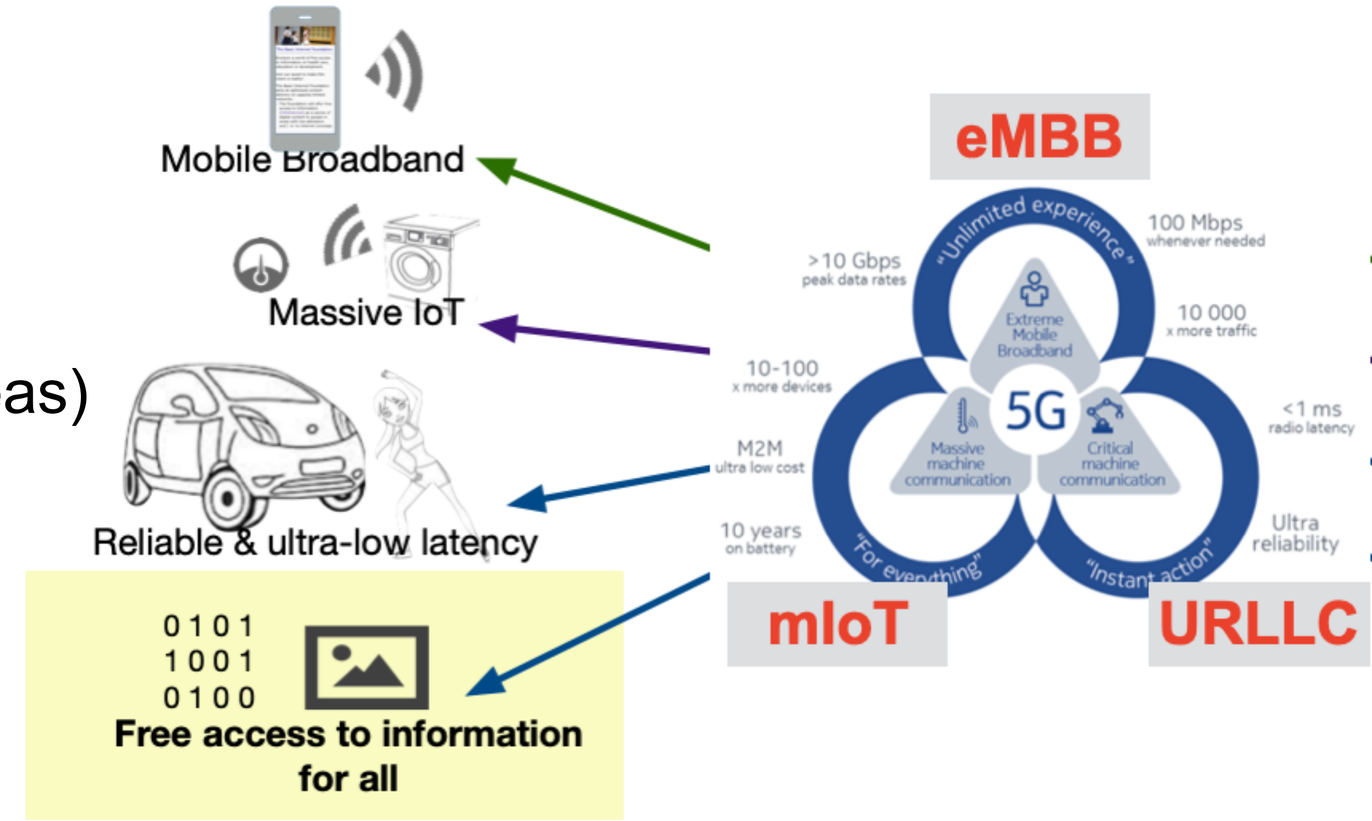
- Channel coding
  - Advanced ME-LDPC channel coding
  - more efficient than LTE Turbo code, 4x at Code rate (R)=0.65, 5 at R=0.9
- **3x increase** in **spectrum efficiency**
  - explicit 3D beam forming with up to 256 antenna elements
  - typical 3.8x increase from 4x4 MIMO to 5G NR Massive (256 antennas) MIMO (52 Mbps to 195 Mbps)
- Large BW opportunity for mmWave
  - 5G NR sub-6GHz (3.4-3.6 GHz)
  - 5G NR mmWave (e.g. 24.25-27.5 GHz, 27.5-29.5 GHz)

5G Challenges

- require:
- overcome significant path loss in bands above 24 GHz
- robustness: innovation to overcome mmWave blockage from hand, body, walls, foliage - non-LOS is a problem
- Device size/power integration into a mobile
- Dense network topology and spatial reuse (150-250m distance)
- colocation of 28 GHz on LTE channels

5G - hva mangler vi

- #5GforAll
  - radio interface: Large cell, low mobility sites (low density rural areas)
  - freemium model for access (freemium = free + premium)



- Missing aspects in 5G
  - interface mobile-home network
    - we become network operators
  - application-specific routing (service quality)
  - interference with unlicensed technologies

Public Opinion on 5G

- 5G - opinion by people
  - convenience <-> privacy,
  - national competitiveness <-> national security
  - speed <-> price

- need to have? 0% ?
- nice to have? 5% ?

- Opinion: no contribution to SDGs

https://www.politico.com/news/agenda/2020/02/25/poll-5g-what-do-people-really-v

THE 5G FUTURE

The 5G World: What People Care About

The coming fast wireless network will require policy tradeoffs, from convenience to national security. In a new survey, we asked citizens what they really value.

Illustration by Sam Chivers | Graphics by Andrew McGill

By JOHN HENDEL
02/25/2020 04:30 AM EST

Around the world, 5G is a buzzword, a sales pitch—and, increasingly, a policy challenge.

Public Opinion on SDGs (afrobarometer.org)

- Priorities by people in Africa
  - decent work
  - zero hunger
  - good health
  - …

https://blogs.worldbank.org/africacan/how-do-africans-priorities-align-with-the-sdgs-and-government-performance-new-results-from

Oppsummert

- 5G har tre hovedfokusområder
  - mer bredbånd, opp til 1 Gbit/s
  - stor antall dingser
  - pålitelig nett med liten forsinkelse
- nye forretningskonsepter & kunder
  - prosessindustri
  - hver dings har en (elektronisk) SIM
- 5G mangler samfunnsaspekter
  - digitalisering og fri tilgang til informasjon