

UiO  Department of Technology Systems  
University of Oslo

**Vestre Bærum Medlemsmøte - 15Mar2021**

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

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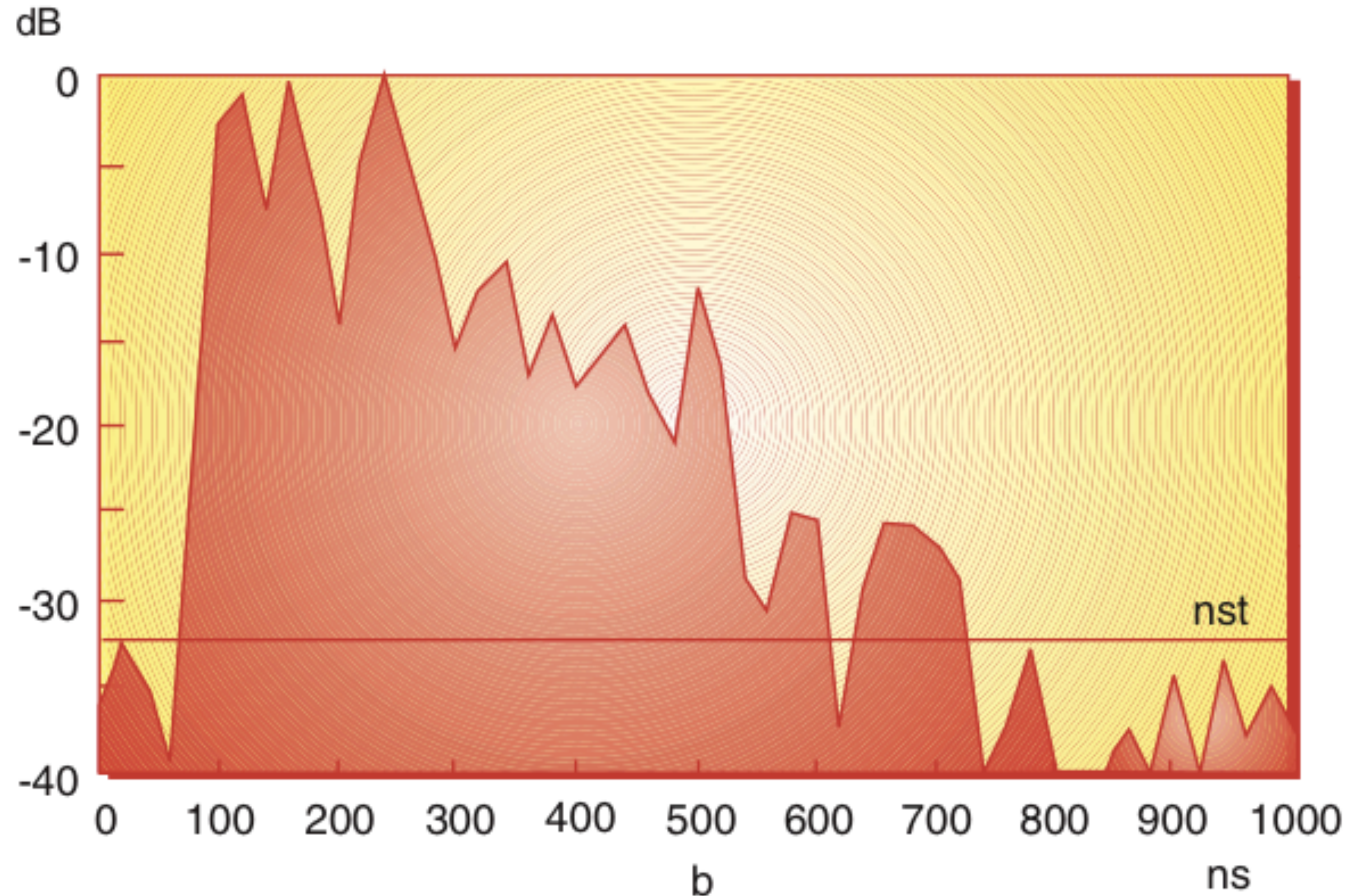
# How did we measure the quality of the mobile network





## Impulse Response, Urban Measurements

- 1950 MHz, Oslo.
- Output power 25 dBm
- Q (all impulse responses):
  - describe characteristics of reflection
  - from delay, calculate reflection factor and free space attenuation
  - why almost equal distribution?
  - Physical effects?



[Source: R Rækken, G. Løvnes, Telektronikk]





## Hovedspørsmål: Rekkevidde og kapasitet

- Coverage/Range (2G, 4G)

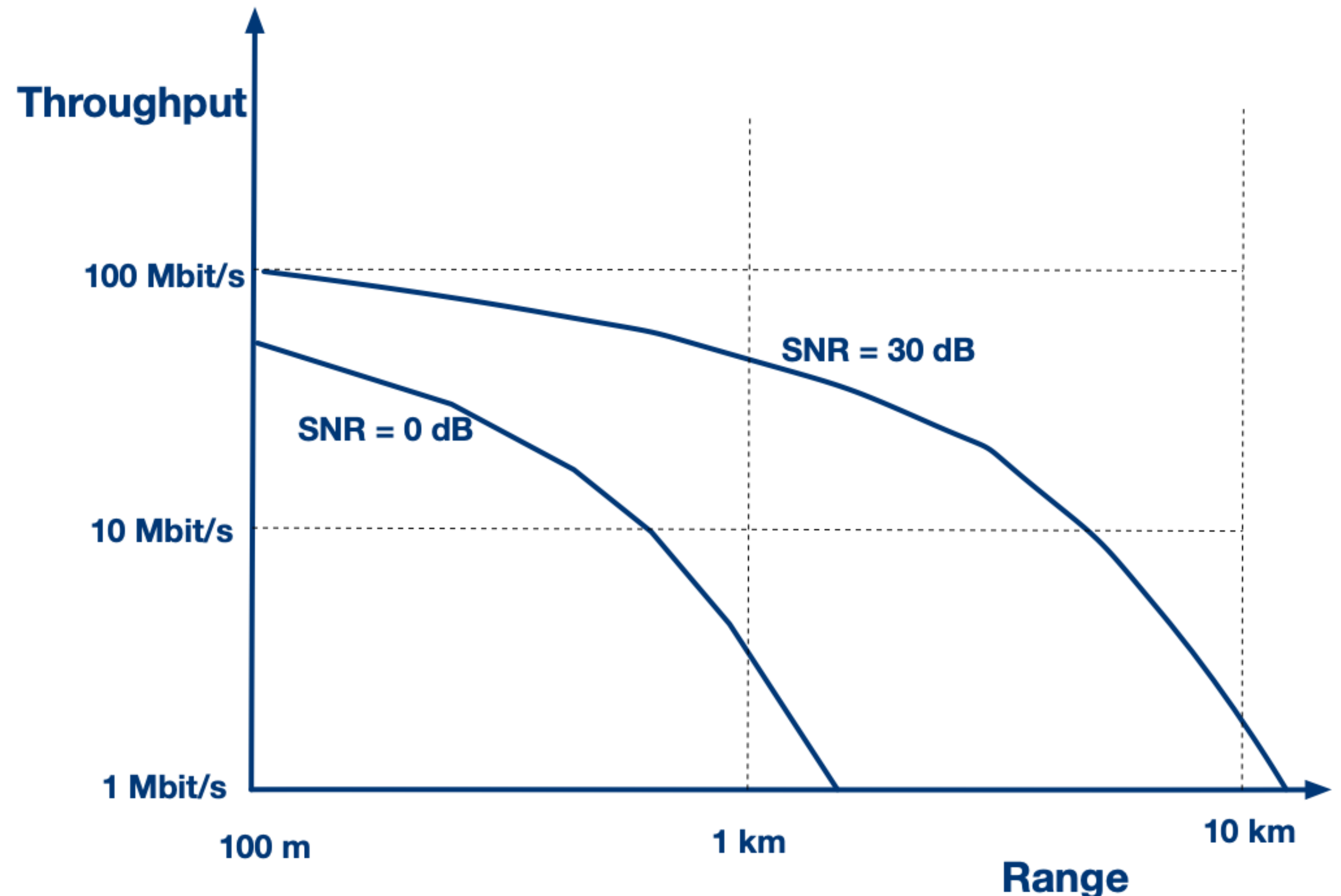
$$f \sim 1/R$$

- 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>



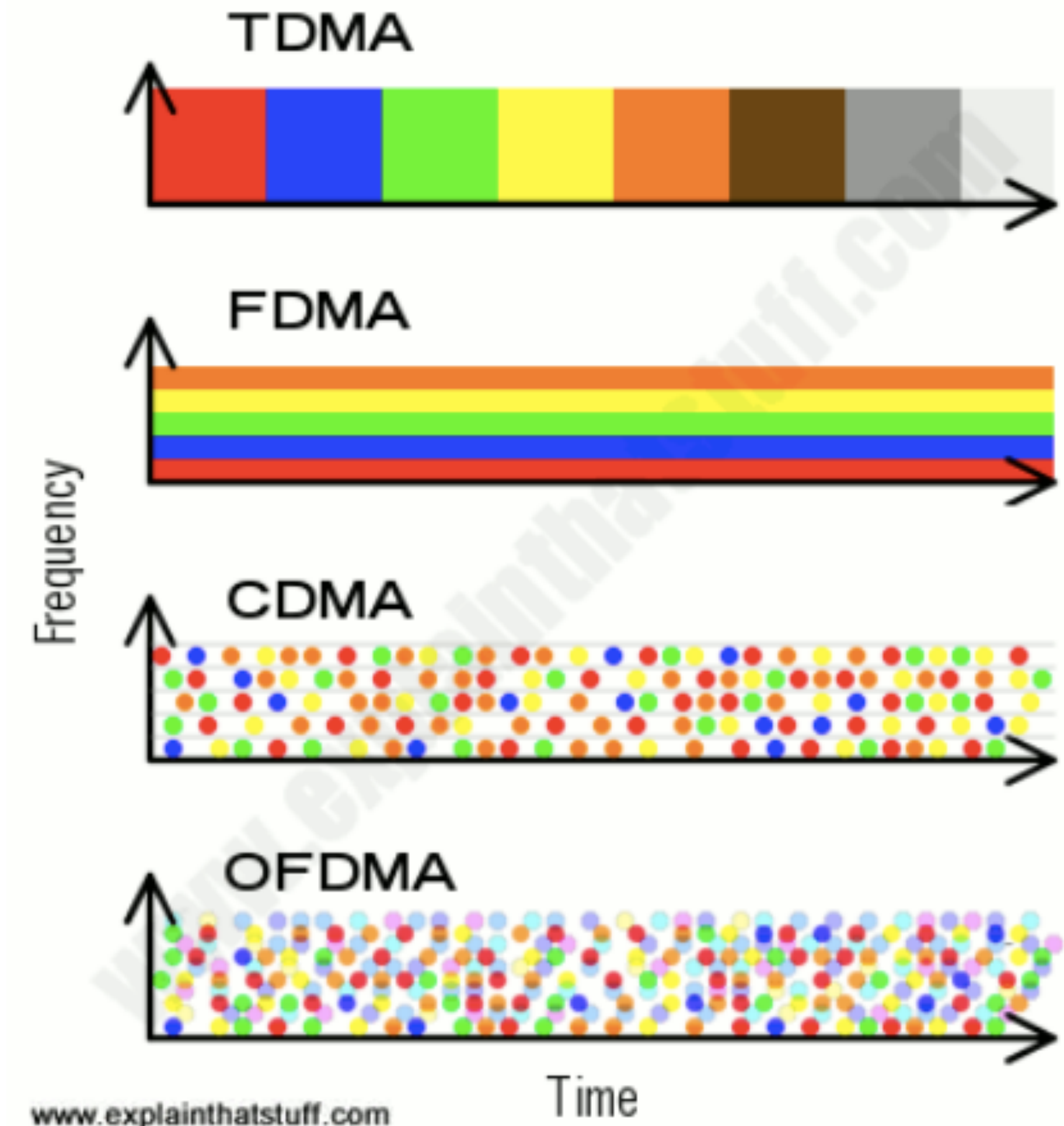
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## Principles 2G-5G

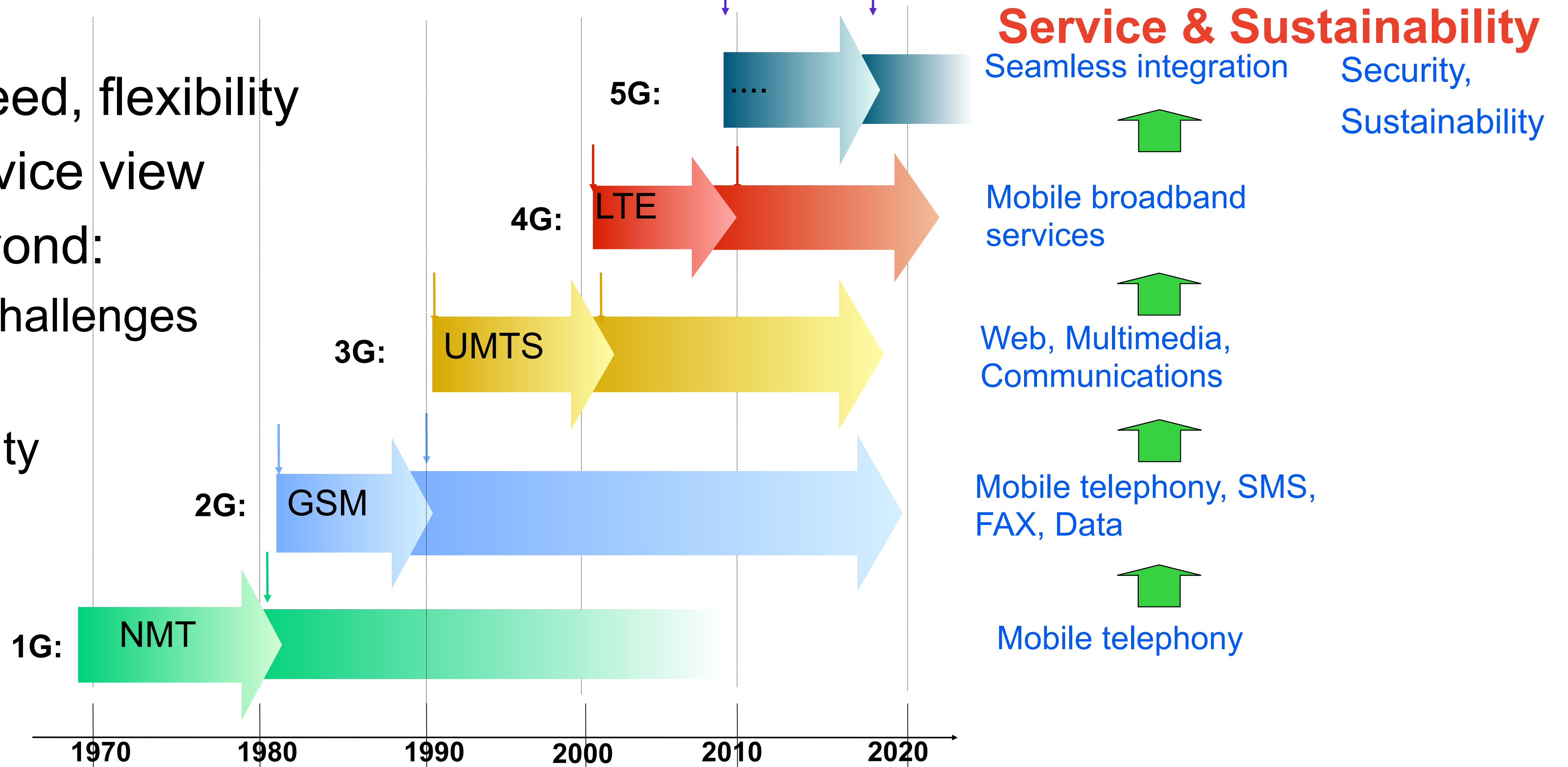
- Principles
  - ➔ frequency, time, code
  - ➔ allocation
- New applications
  - ➔ Internet of Things (4G, 5G)
  - ➔ Control systems (5G)
    - latency, reliability





## 5G: Speed, Bandwidth, latency and **much more**

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



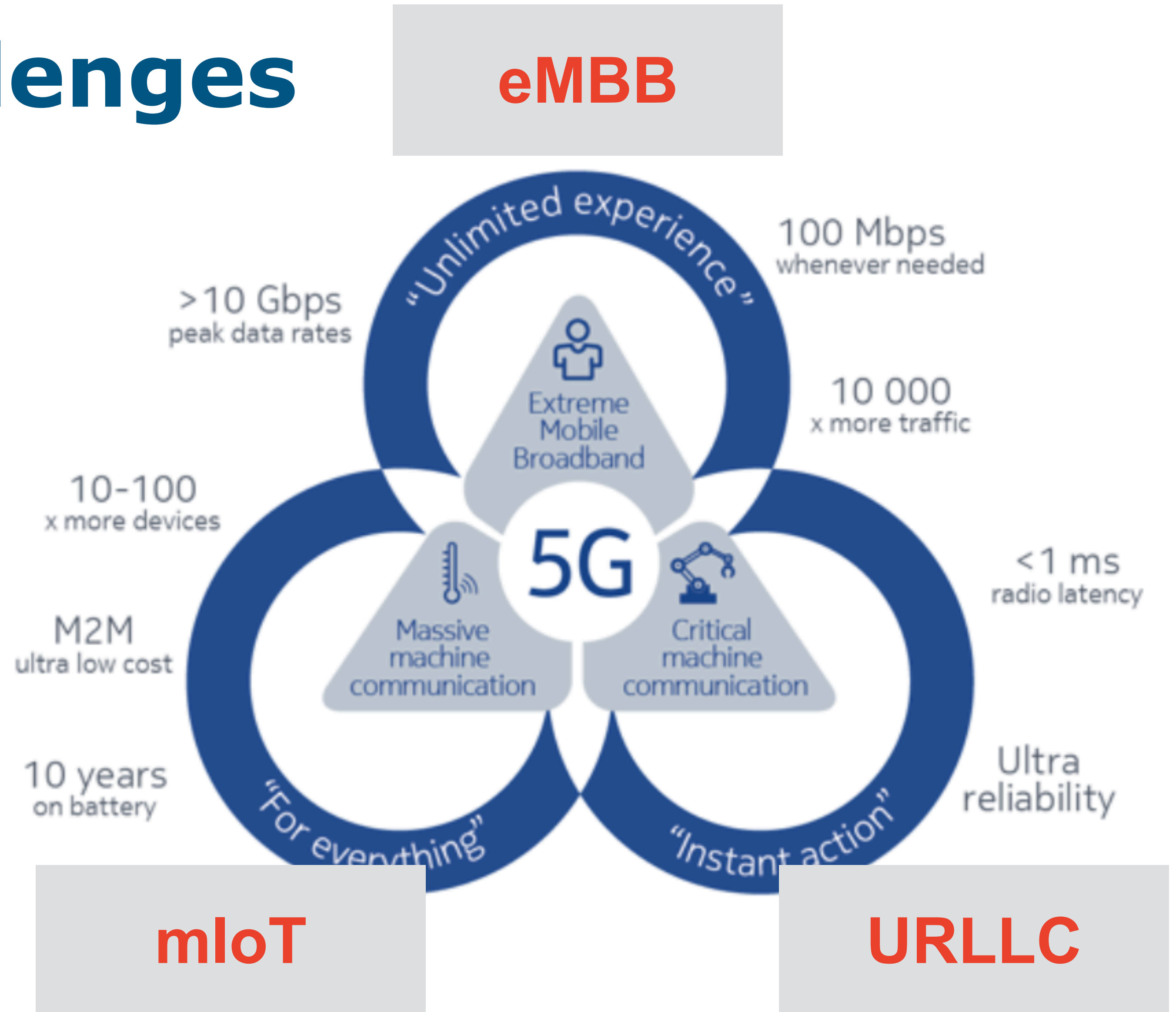
[adapted from Per Hjalmar Lehne, Telenor, 2000]





# 5G: Industrial Challenges

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

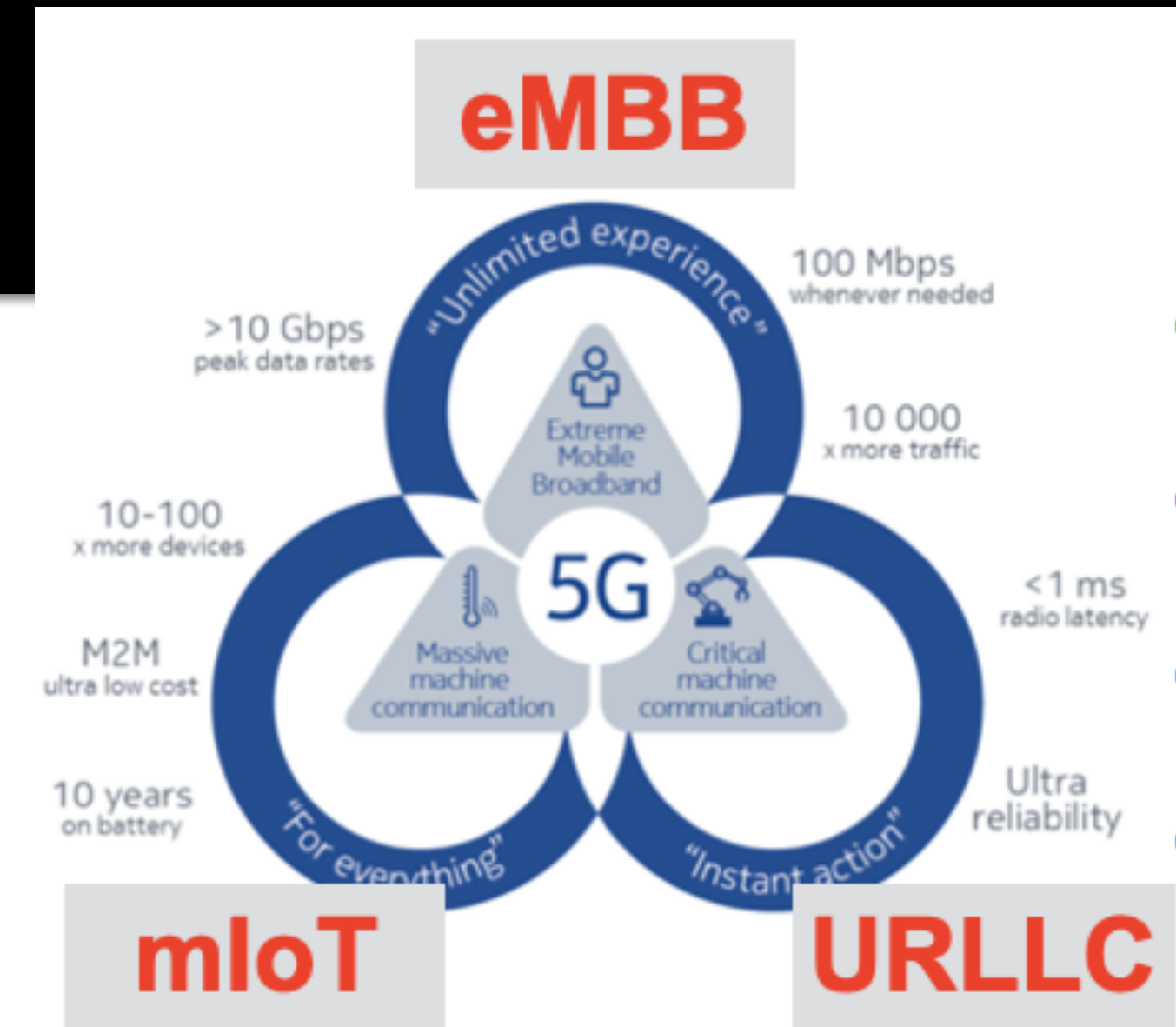


[source: Nokia <https://networks.nokia.com/5g/get-ready>]



## 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





## 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/>

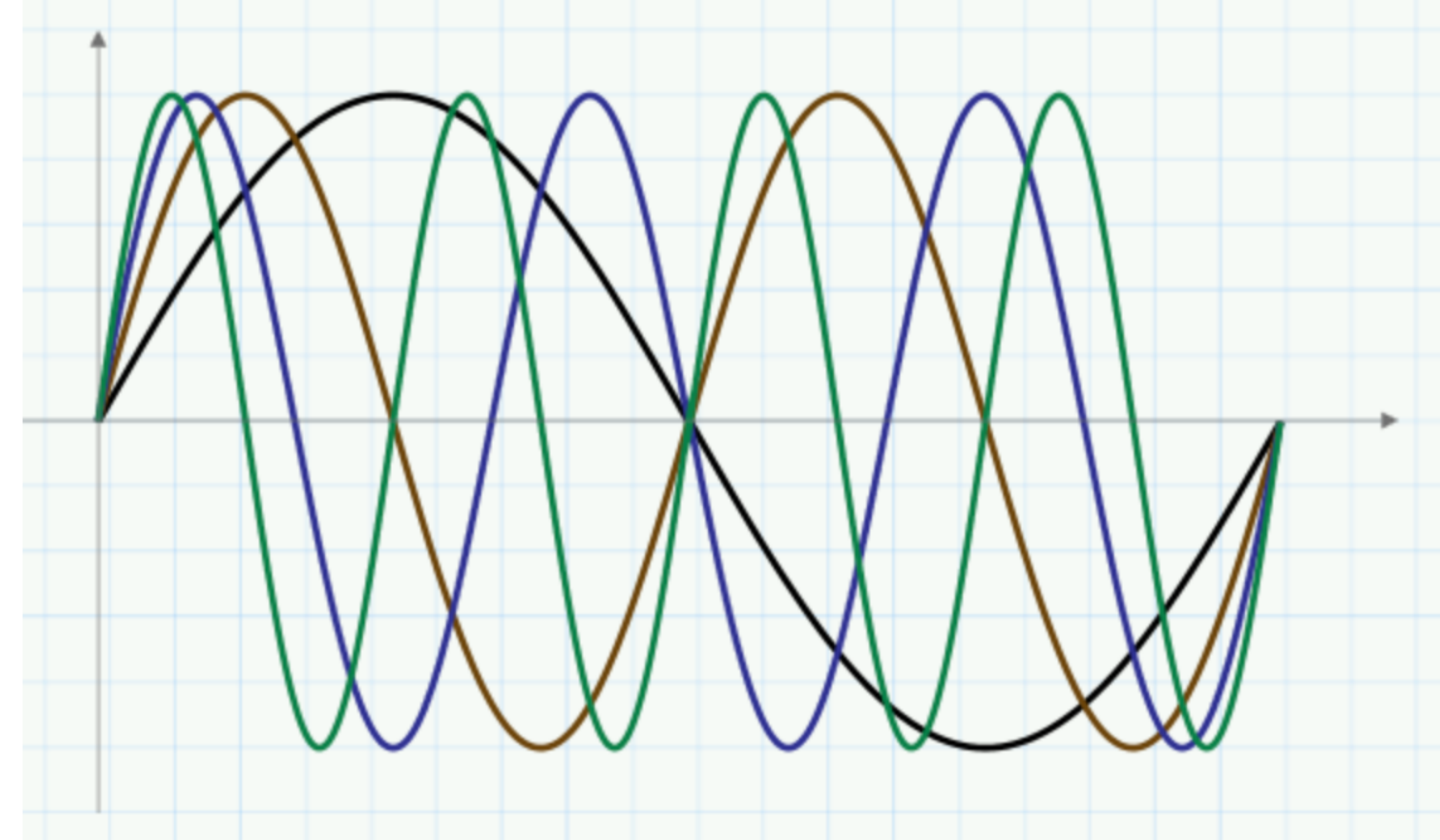


Figure 3. This OFDM signal contains four carriers spaced apart by  $\Delta f$  corresponding to  $f_0, f_1, f_2, f_3$ .

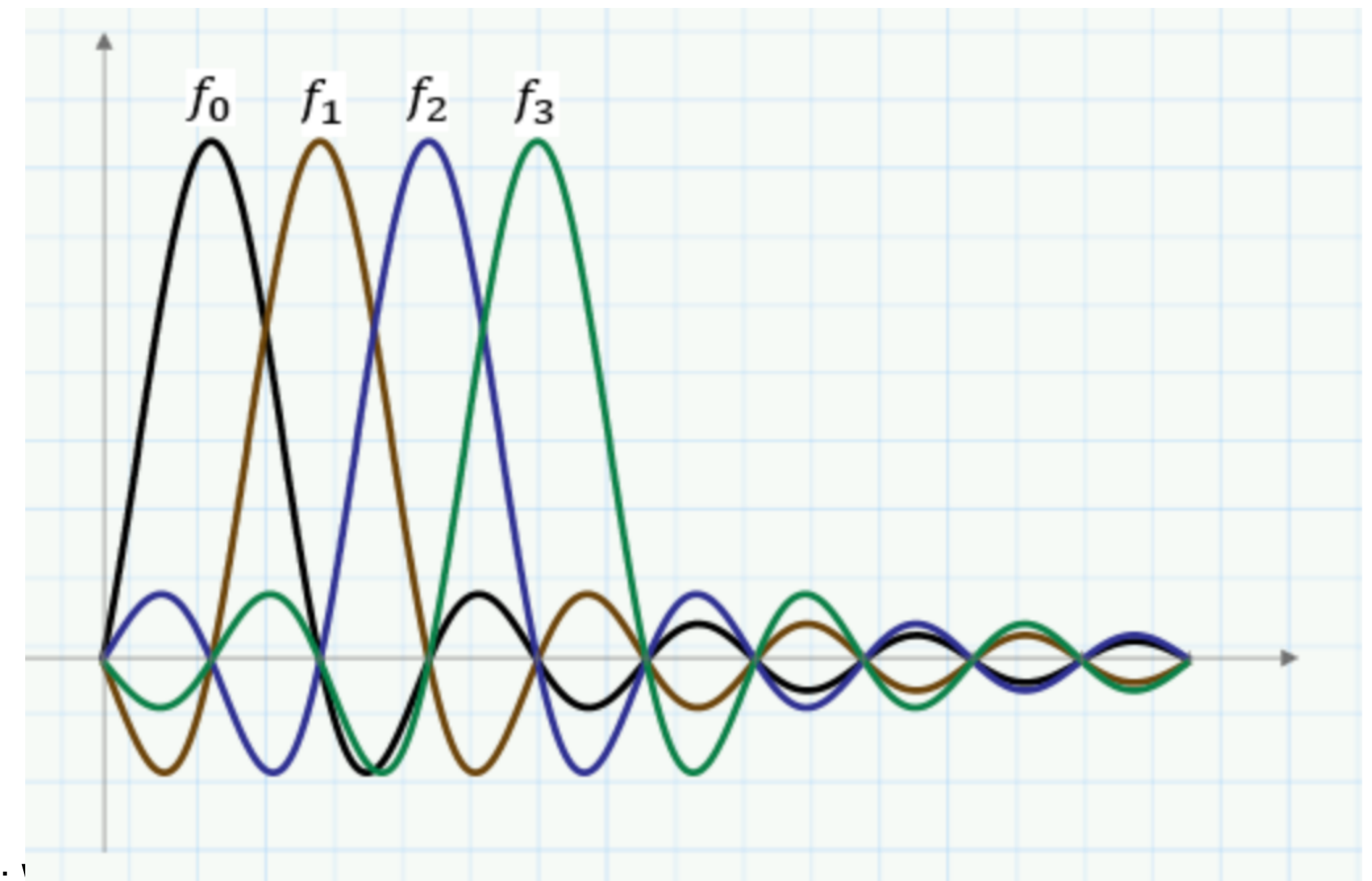


Figure 4. Frequency domain representation of a four-carrier OFDM signal





## Teknologier for 5G

MIMO = multiple input, multiple output

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





## 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

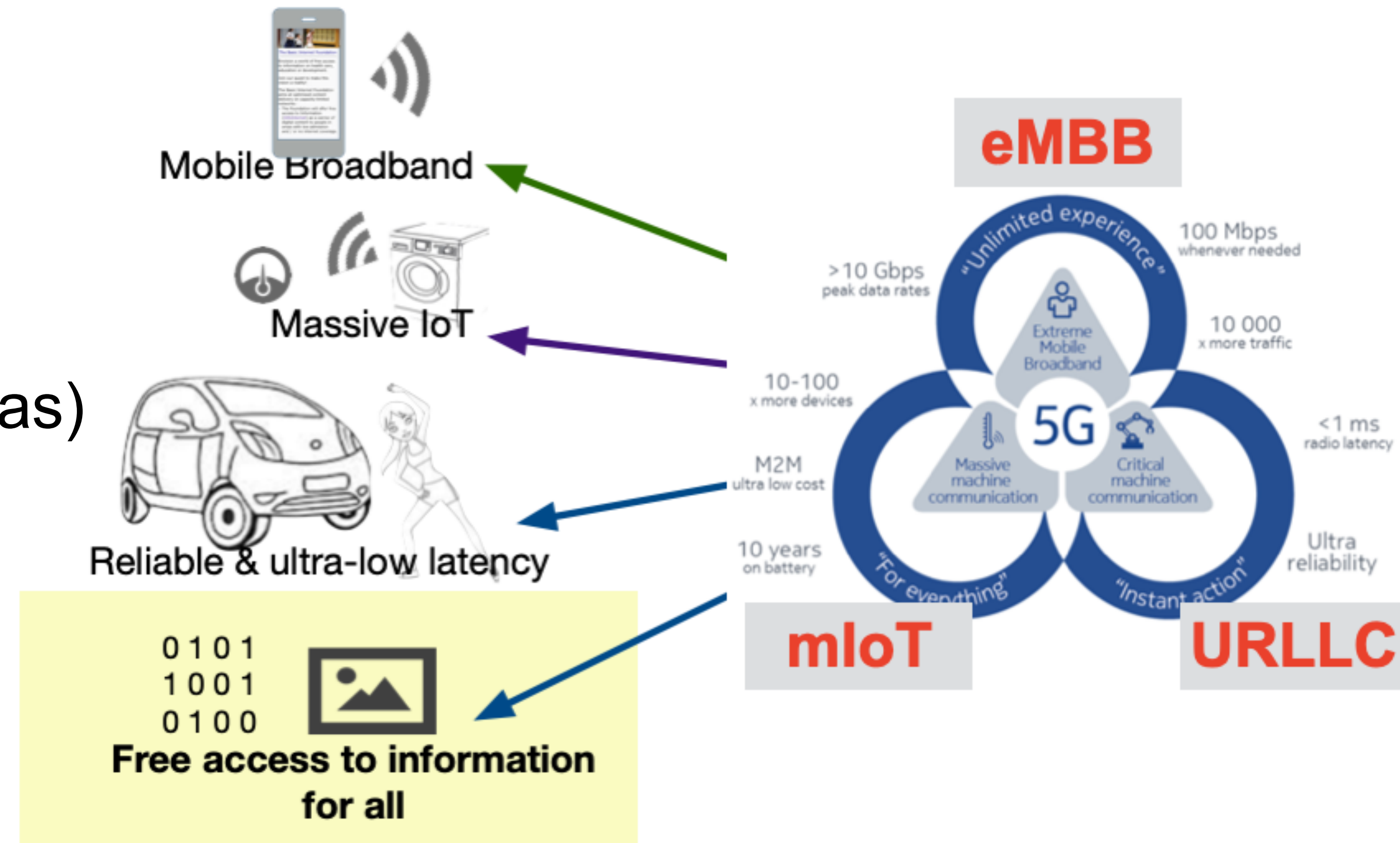
- require:
- overcome significant path loss in bands above 24 GHz
- robustness: innovation to overcome mmWave blockage from hand, body, walls, foliage - non-LOS is a problem
- Device size/power integration into a mobile
- Dense network topology and spatial reuse (150-250m distance)
- colocation of 28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

## 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



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round 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
  - ...





# 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

