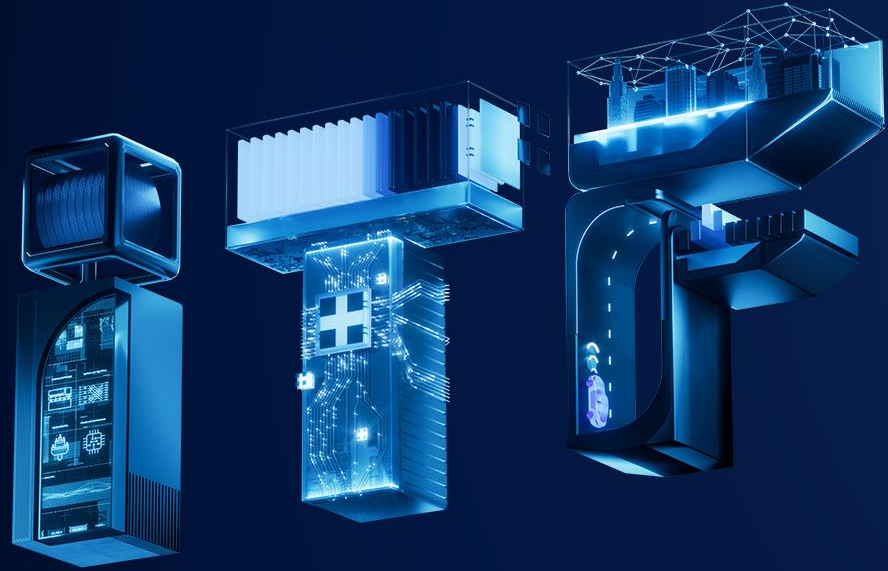




ITFBEYOND5G
powered by imec



Explore
next-gen mobile **connectivity**

imec

semi



ITFBEYOND5G
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+ From applications to semiconductors or the other way around: the case for technology-push

Michael Peeters, VP R&D Connectivity (with the generous help of the speakers)



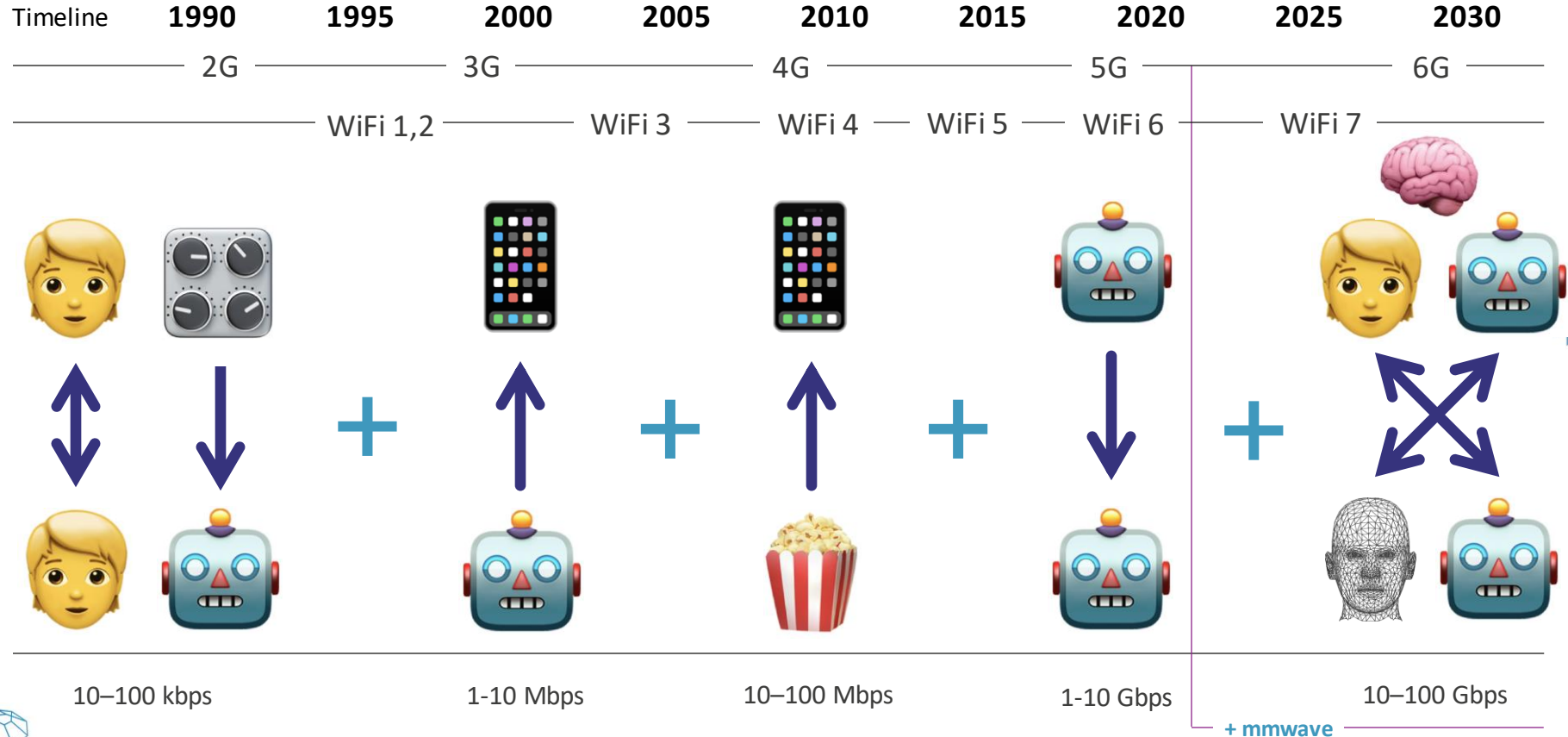
And you will read this last.

You will read this first.

And then you will read this.

Then this one.

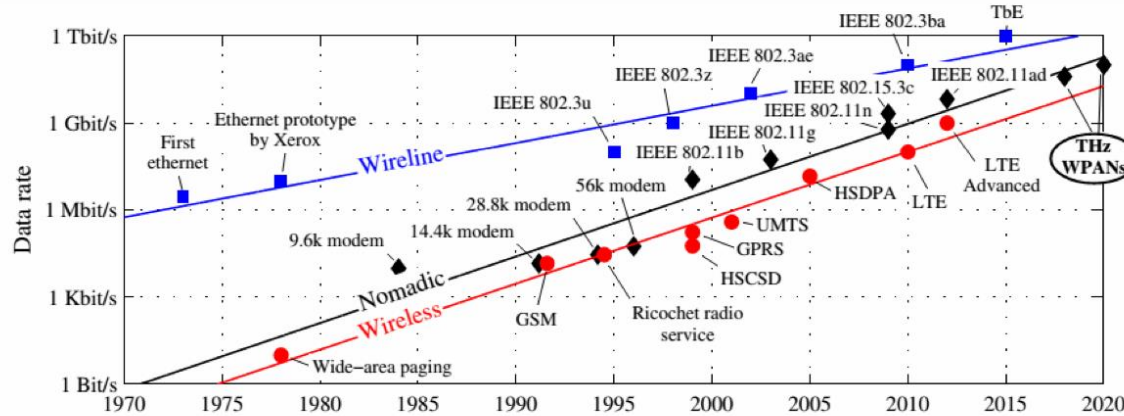
The (cumulated) evolution of connectivity



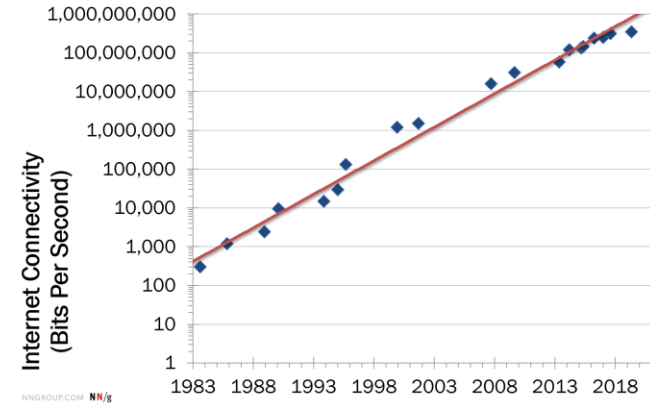
(Sleep) No Moore

But Edholm and Nielsen are our product managers

Moore's law: the number of transistors in a dense integrated circuit (IC) doubles about every 24 months.



Edholm's law: data rates are doubling every 18 months.
Wireline, Wireless and Mobile are converging.

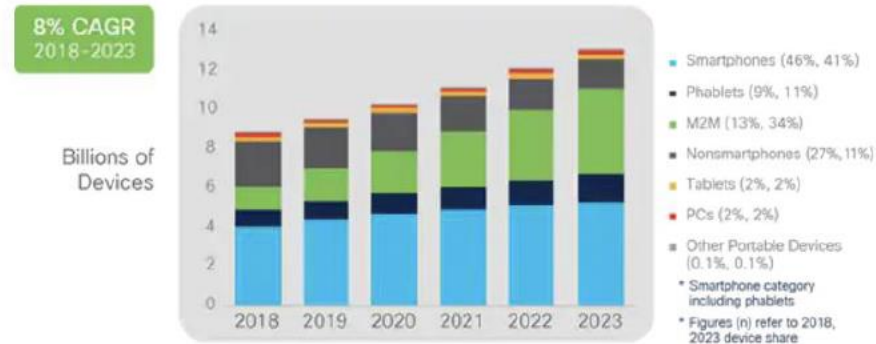


Nielsen's law: a high-end user's connection speed doubles every 21 months.

General trends

- › Number of users and number of connections continues a steady expansion
 - We increasingly live within a connected world – 2/3 of population connected by 2023
 - 3 times connected devices as people (!)
- › New use cases on the horizon

Figure 7. Global mobile device and connection growth



Reference: Cisco Annual Internet Report (2018–2023) White Paper

Advancing 5G to fulfill its full promise

Enhanced mobile experiences, new capabilities,
and expansion to diverse verticals



Communication saturation

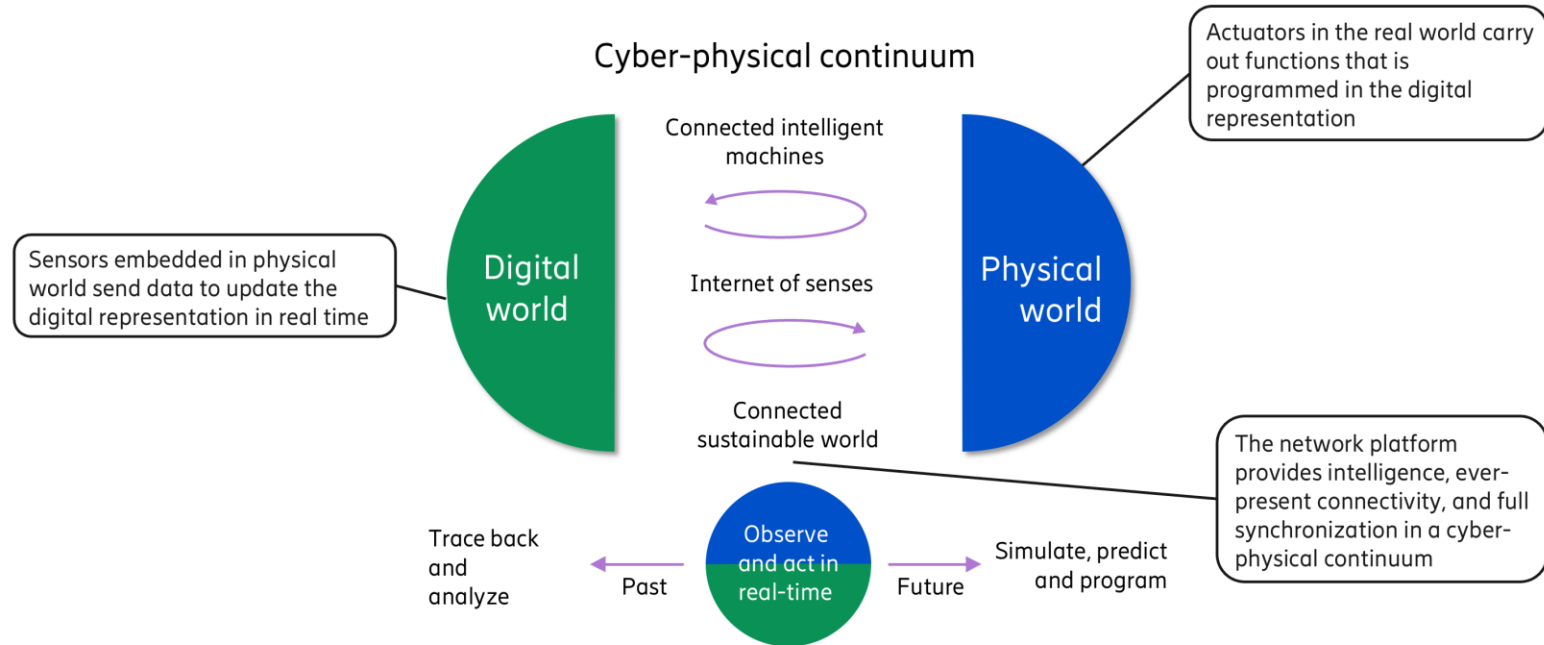
Usecases that will (always) drive the market



communication at a distance	People	Pretend-People	Machines
People	voice, video calls	entertainment, gaming, Xbots	body-machine interfaces
		XR	
Pretend-People		conversation bots, training	neural network training
Machines			automation
			agent-2-agent

+

Connecting a cyber-physical world



Fredrik Tillman | 2022-11-15

What do we read today...

"6G needs to be different."

6GIC white paper

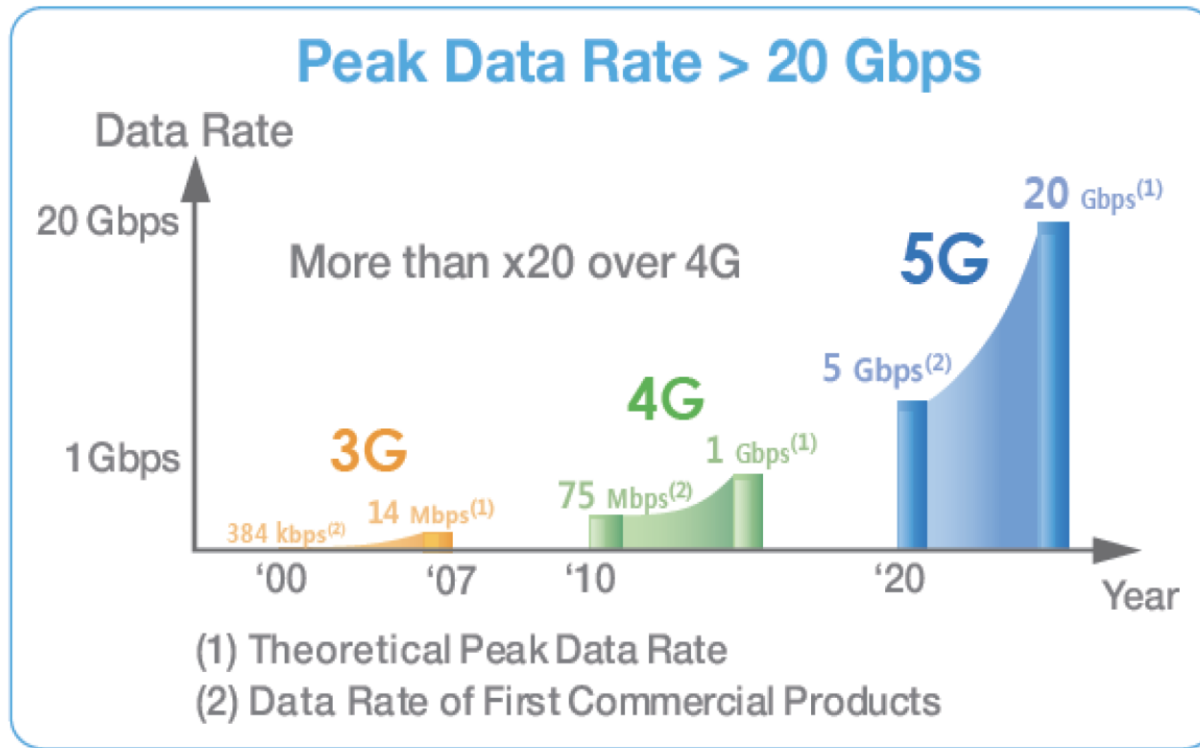
**The traditional approach to
next generation wireless is not
sustainable. A new approach
is needed that is inspired
by the great societal and
economic challenges ahead.**



Really?

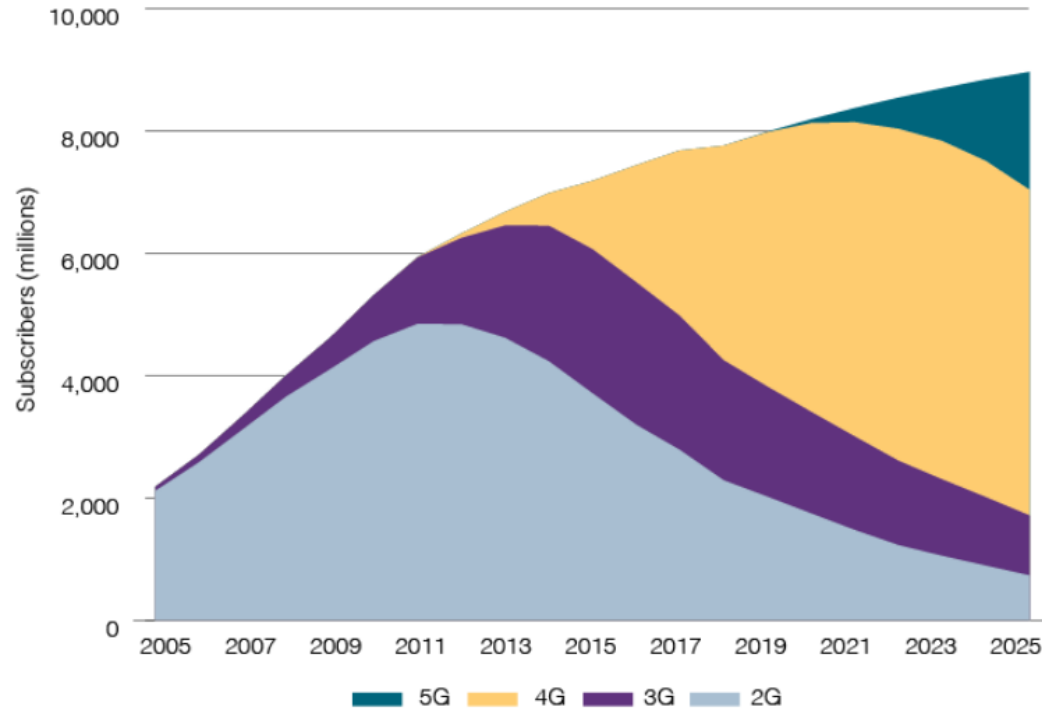
Bitrates

https://www.arcep.fr/uploads/tx_gspublication/Report-5G-issues-challenges-march2017.pdf



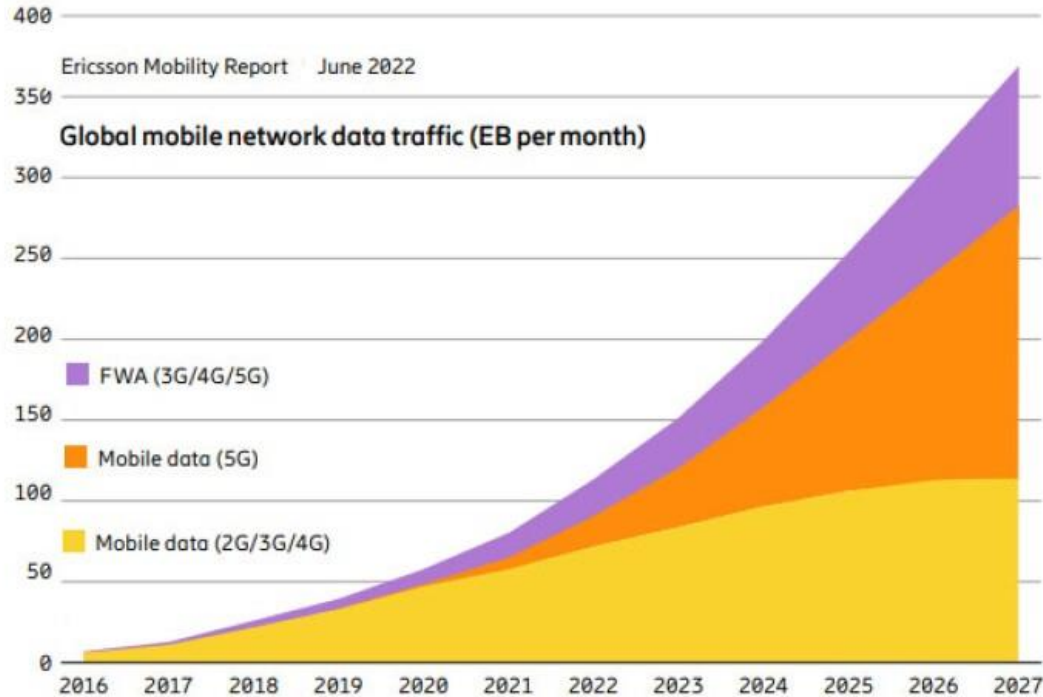
Really?

Subscribers



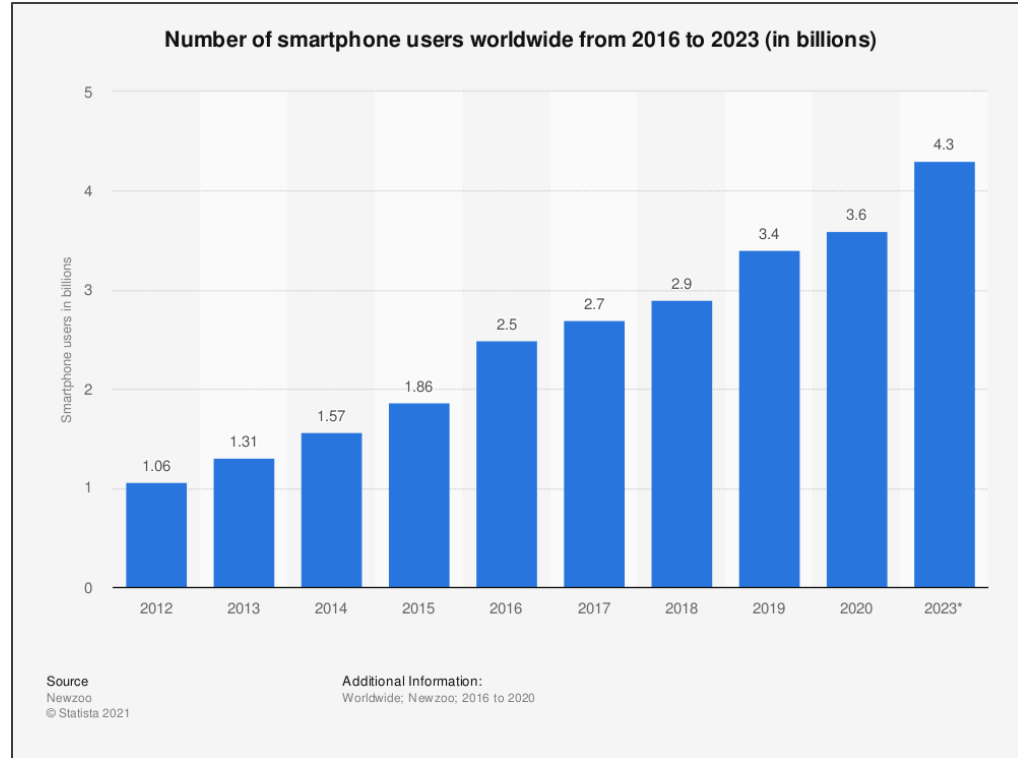
Really?

Total data carried



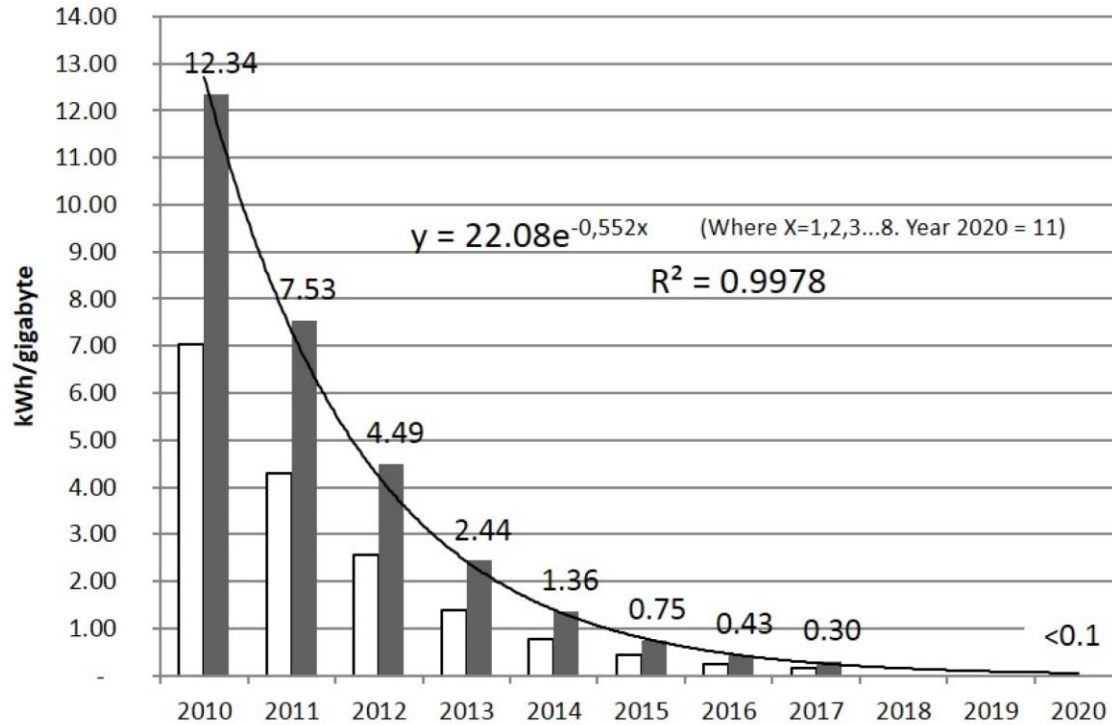
Really?

Smartphone users



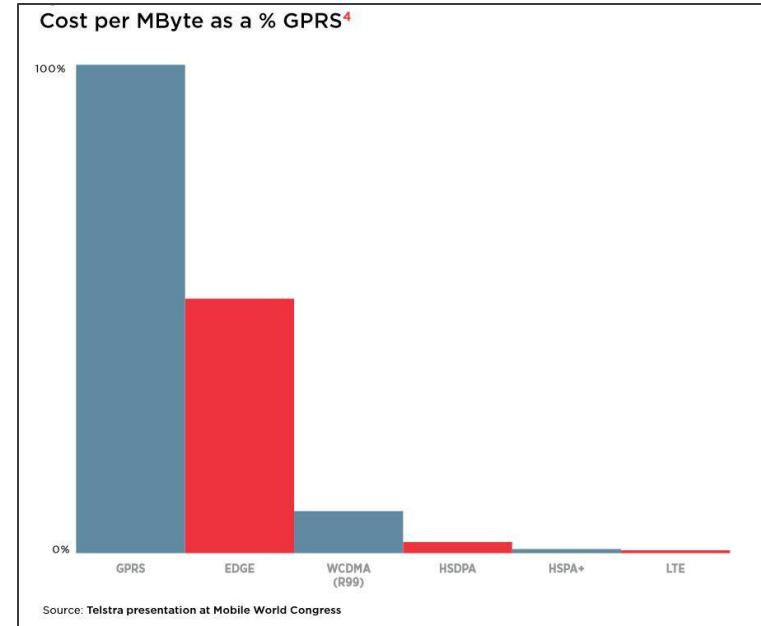
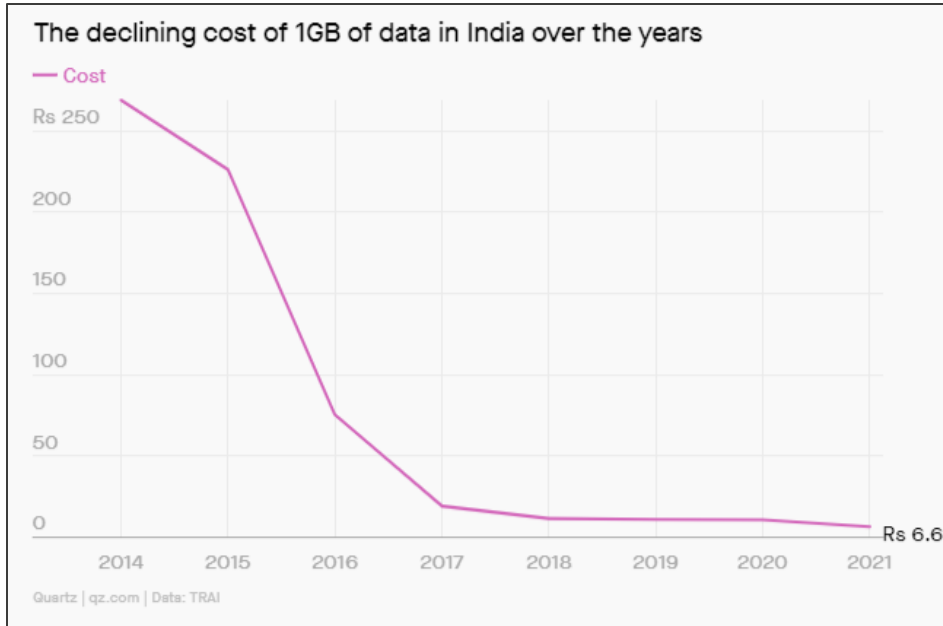
Really

Power consumption of network (Finland)



Really?

Mobile data price & cost



What we should say...

"6G needs to be as successful as the previous generations"

paraphrased

The traditional approach to
next generation wireless has
sustained exponential growth.
The approach needed for the
great societal and economic
challenges ahead can only
be inspired by this.



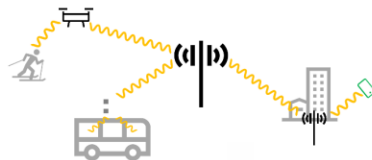
Pushing network performance



- Extreme data rates in specific scenarios
- Wide-area coverage of future 6G services
- Spectrum co-existence with legacy 5G systems



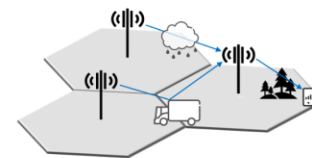
Multi-point
connectivity



Multi-hop
connectivity



Complementary
satellite component

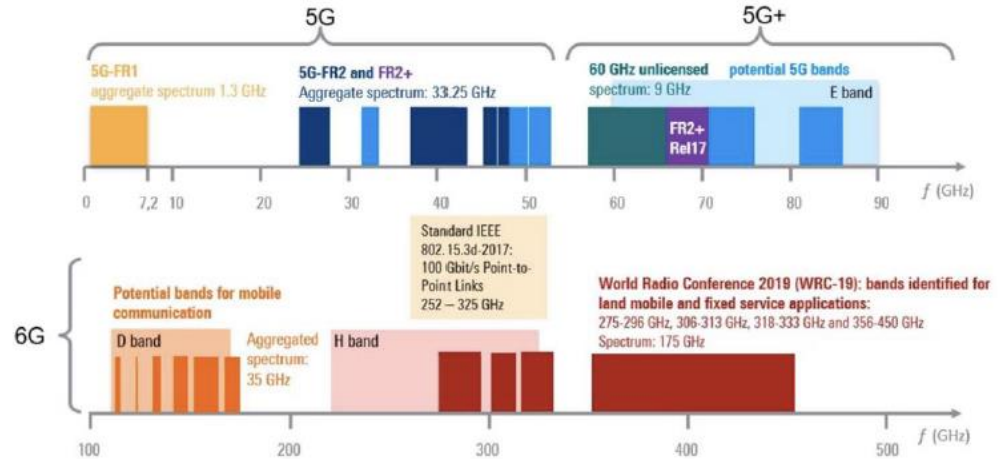


Joint communication
and sensing

Fredrik Tillman | 2022-11-15

Moving to mmW

- > Large, continuous, and available spectrum is available in mmW
- > mmW expected to play an important role within the advancement of future commercial communications systems



Reference: T. Eichler, Millimeterwave and THz Technology for 5G and Beyond, Rohde & Schwarz

Larger bandwidths and data-rates at higher frequencies

COMMUNICATION PERSPECTIVE	FR1	“FR3”	FR2	“FR4”	“FR5”
TYPICAL RANGE	0.1-6 GHz	7-24 GHz	24-52 GHz	52-71 GHz	95-325 GHz
EXAMPLE CARRIER FREQUENCY	3.5 GHz	10 GHz	30 GHz	60 GHz	140 GHz
TYPICAL BANDWIDTH	100 MHz	200 MHz	400 MHz	2 GHz	10 GHz
WAVELENGTH	8.6 cm	3 cm	1 cm	5 mm	2.1 mm
NUMBER OF ANTENNAS ON 1.5cm x 1.5cm	0	1	9	36	196
	RF sampling (m)MIMO	Efficiency @ Cost	Beamforming	P _{OUT} & PAE drop	Baseband $\equiv$ RF Packaging III-V RF-FE

NextG Alliance: Component Technologies

A first?



1. Semiconductor technology
 - Silicon and III-V, DTCO and STCO
2. Circuits and sub-systems
 - New architectures, topologies, design methodologies for CMOS and non-CMOS
3. Antenna, packaging and testing
 - Novel packaging and interconnect technology, including underlying substrate materials

What should keep us awake at night?

Approach

- + To drive technical leadership, focus is needed.
- + For 6G, where standardization is expected to start around 2025, and where regulation is contingent on WRC-2023 and WRC-2027, this means that it is important to distinguish between 3 types of candidate technologies
 1. Those that will already show up in 5G++, and continue to exist into 6G
 2. Those that need to be mature by 2025 for them to even be considered for 6G
 3. Those that will be considered during the development of the 6G standard
- For imec, this selection is made by distinguishing between
 - Technologies that are **time-constrained (duration)** vs. those that are work-constrained (effort)
 - e.g. **technology development, spectrum regulation & auctions**, infrastructure & competition, ...
 - Technologies where we have asymptotic/diminishing gains vs. those where that are still proportional
 - e.g. air interface optimizations, interference cancellation, baseband dsp using current paradigms
 - note: KPI can be technical, economic or mixed

But we need to start today.

Beyond 5G is here.

6G should not be different.

The technology options are understood.



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Thank you

