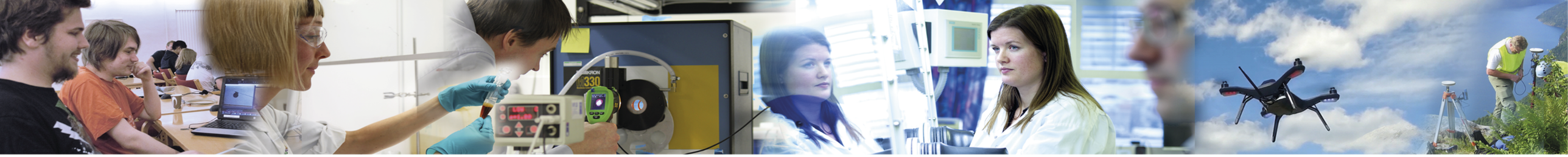


UiO : Department of Technology Systems
University of Oslo

Tanzania Initiative (DA4TI), 22-24Aug2022

Future Technologies for Sustainable Communications

Josef Noll,
Professor, University of Oslo, Department of Technology Systems
Kjeller, Norway, m: +47 9083 8066, e: josef@jnoll.net

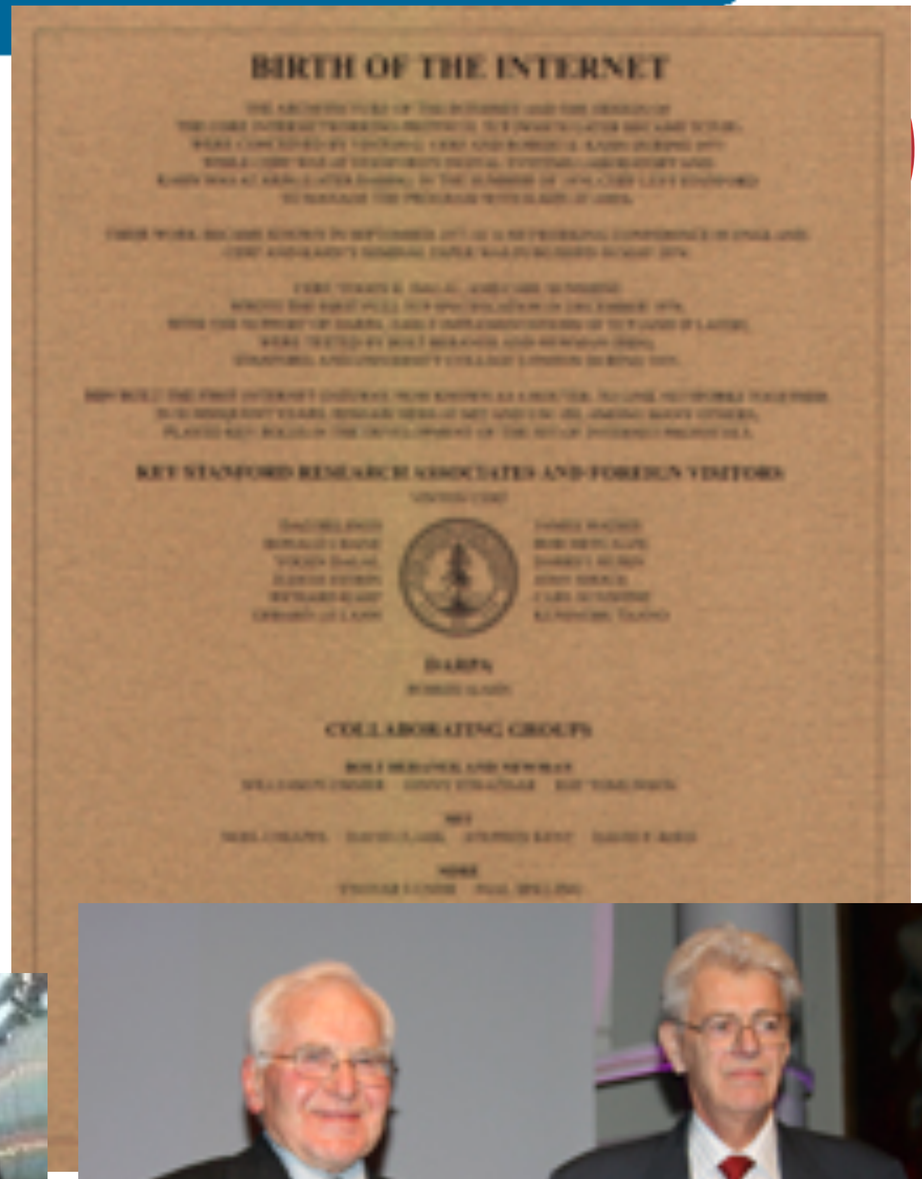
Outline

"The last time I was connected by wire was at birth"

- "It's fantastic to understand"
  - my way
  - Kjeller and the North
- Future communications
  - 5G challenges
  - IoT
  - (Cyber-, IoT-)sikkerhet,
  - Societal Security and SDGs
- Main challenges

Internet and the Nordics

- 1. Arpanet Connection to Kjeller (June 1973)
- List_of_Internet_pioneers [Wikipedia]
  - Yngvar Lundh, Paal Spilling
- Application development
  - .php, OpenSource, Linux, Skype, Spotify
  - OperaSoftware, FAST Search
  - Nokia, Ericsson
  - Telenor, TeliaSonera
- Mobile Internet:
  - GSM (Sintef, TF, NTNU)
  - Mobile Applications



Internet of Things (IoT)

5G (6G)

Cyber-, IoT-, Societal Security

Sustainable Development Goals (SDGs)

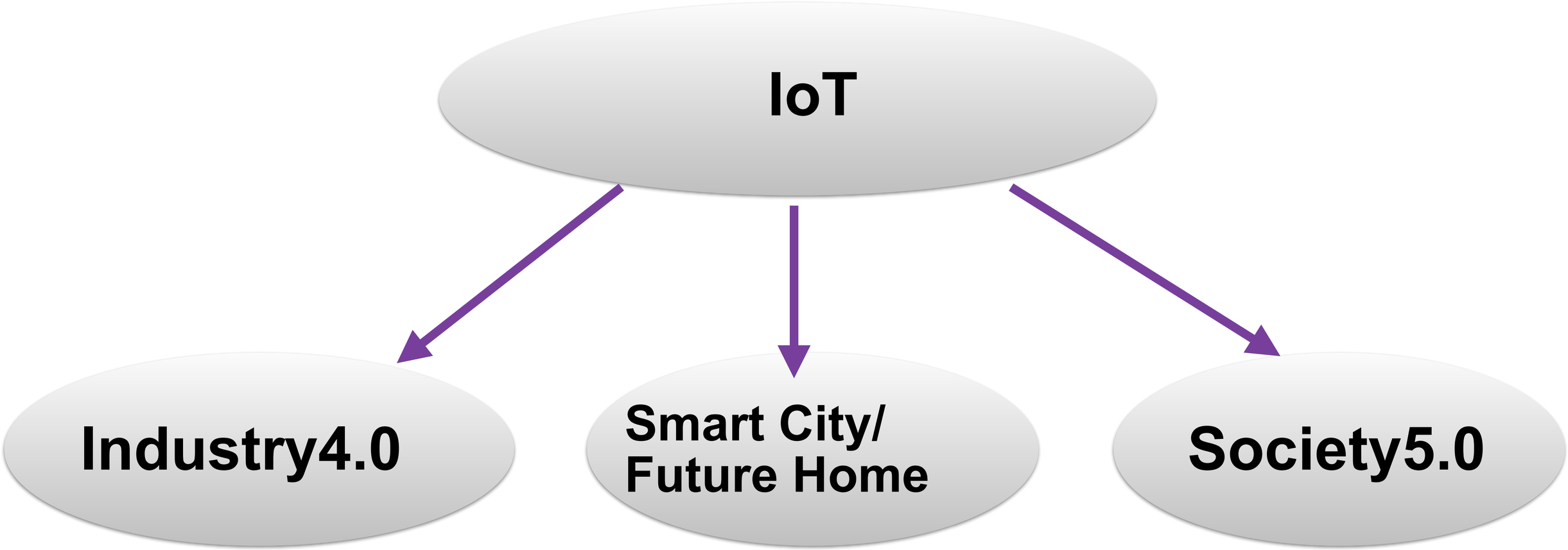
Internet of Things (IoT)

5G (6G)

Cyber-, IoT-, Societal Security

Sustainable Development Goals (SDGs)

Internet of Things (IoT)
Application driven communication

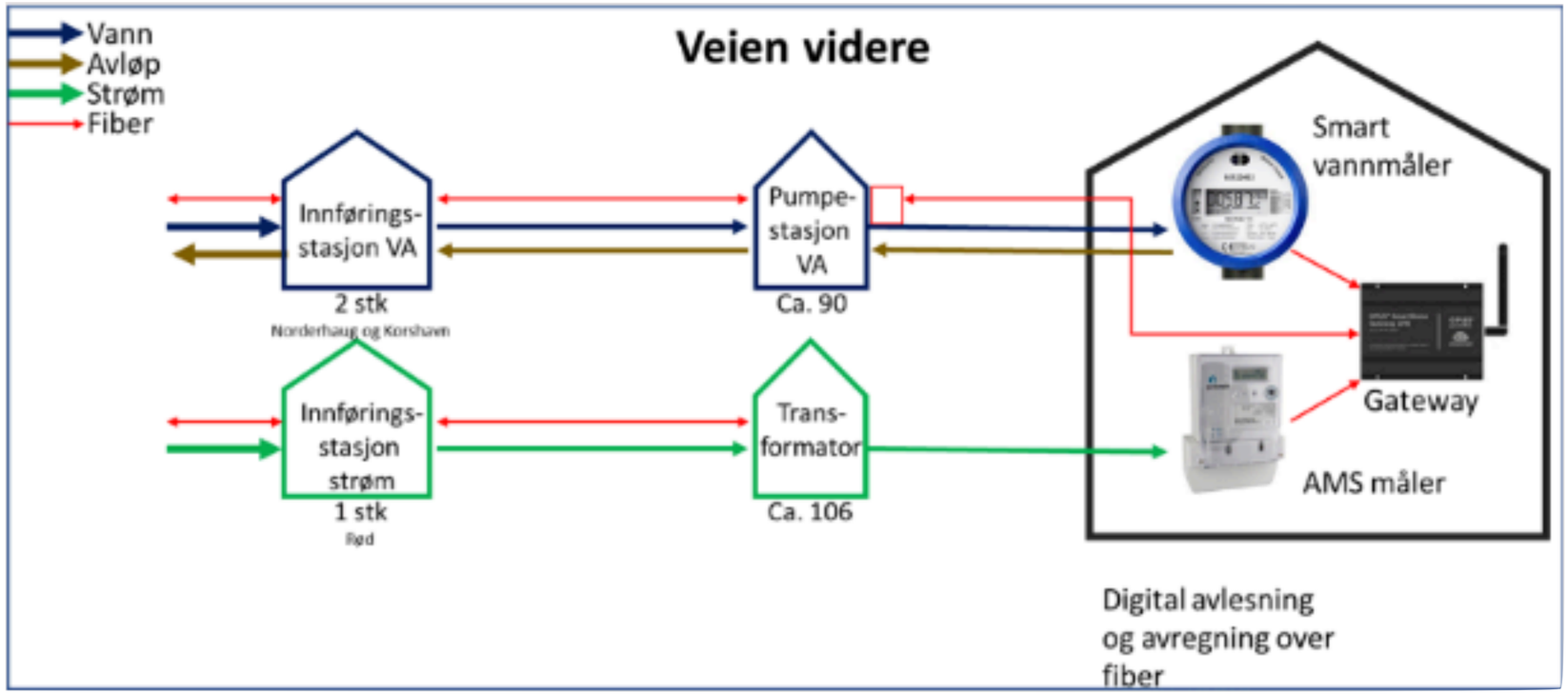


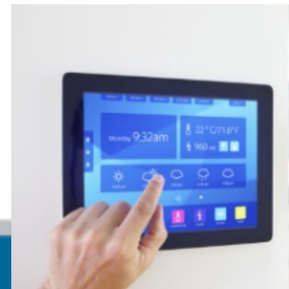
Societal Security
Trust

Hvaler kommune

[Kilde: Jan Richard Aspheim, Hvaler, Virksomhetsleder Kommunalteknikk og eiendom]

Utviklingen av VA, AMS og fiber

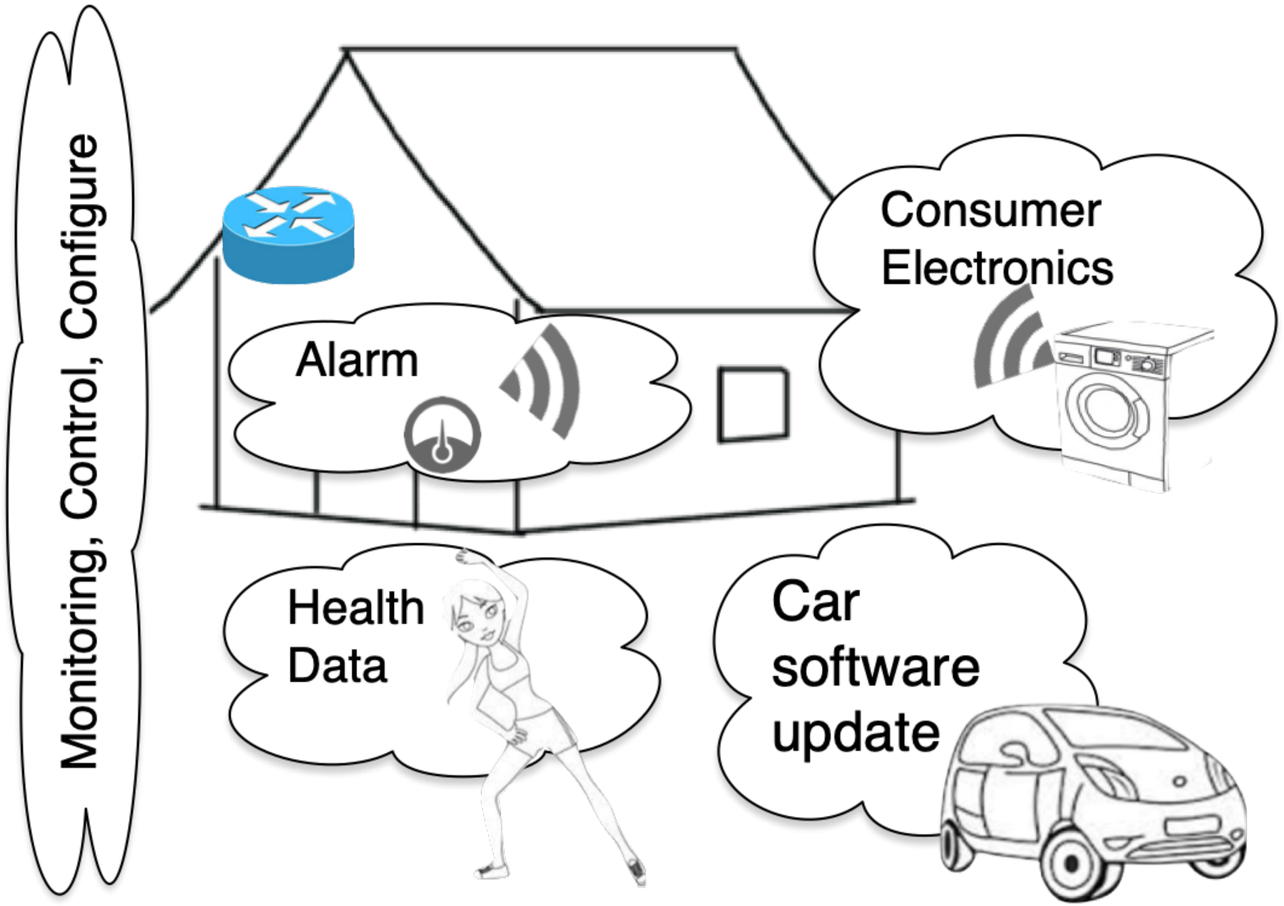




Internet of Things (IoT)

- Interconnected power systems
  - measure:
    - Voltage,
    - Frequency variation
  - automatic control

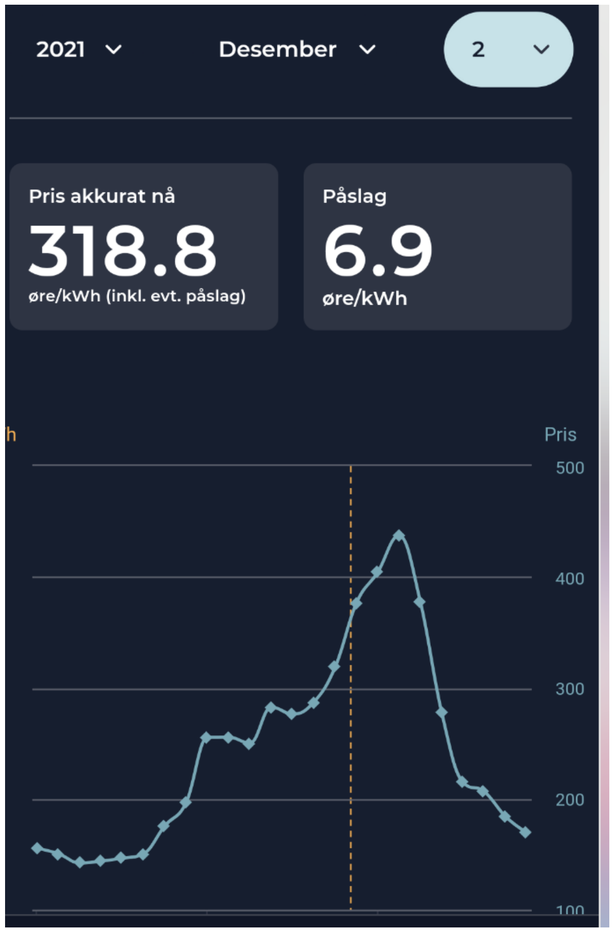
- Controlling home appliances
  - Power consumers:
    - heat pump, water heater
    - car charger
    - washing machine, dish washer
  - Convenience & Security



The “new normal”

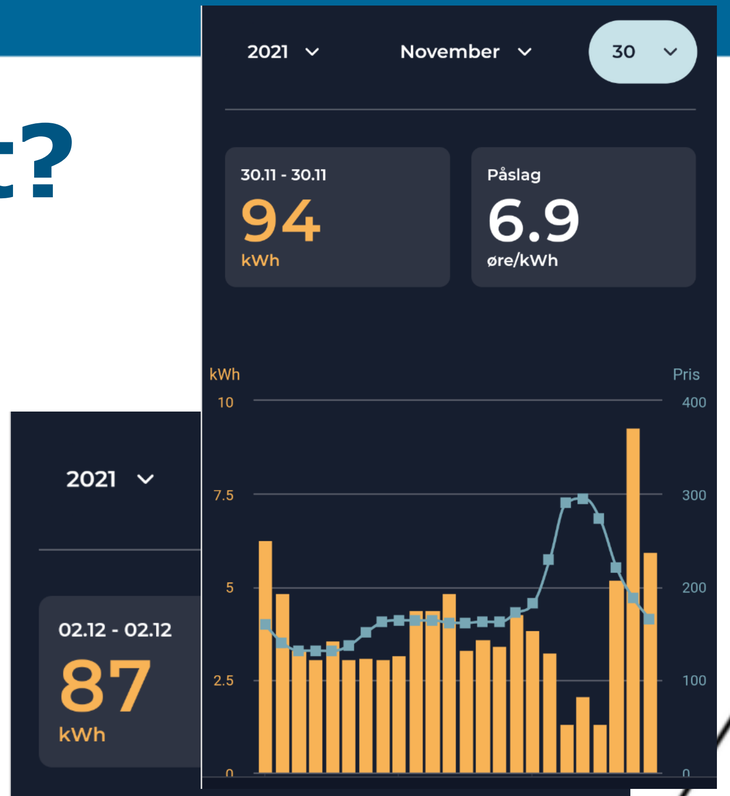
- Growth of Renewables
  - variability
- Gas prices
  - war, climate crisis
- Climate Crisis
  - unpredictable weather

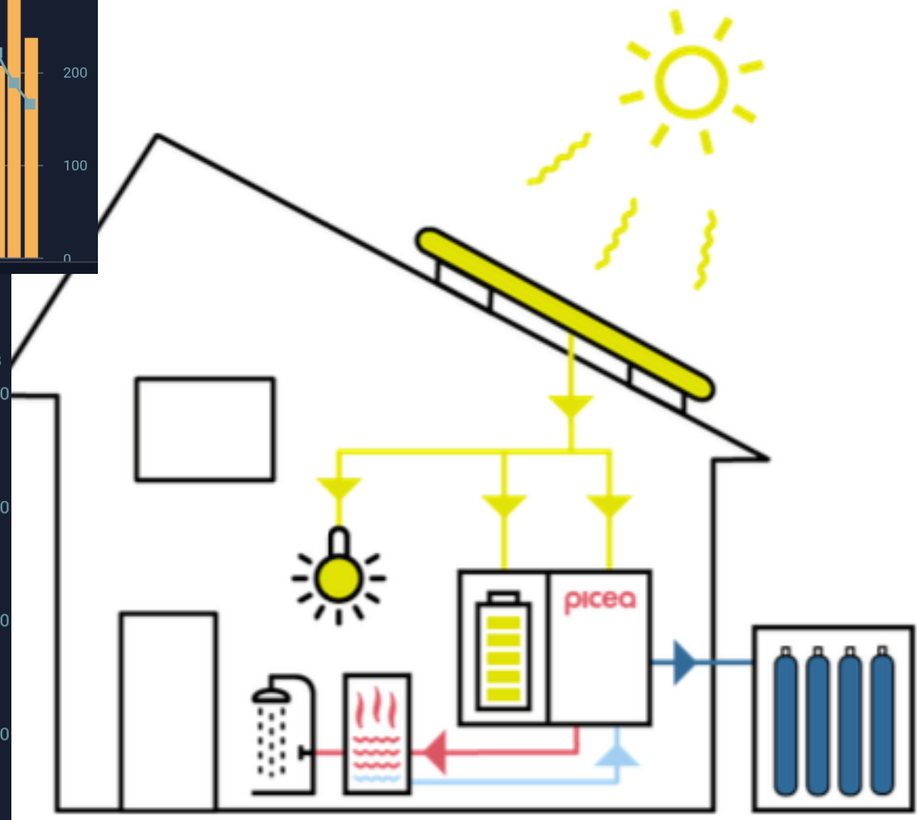
- **High variation of electricity prices**



How can we adapt?

- Empower the customer
  - capability to adapt
  - decentralised solutions
  - distributed grid
- Upgrade houses
- Neighbour-networks

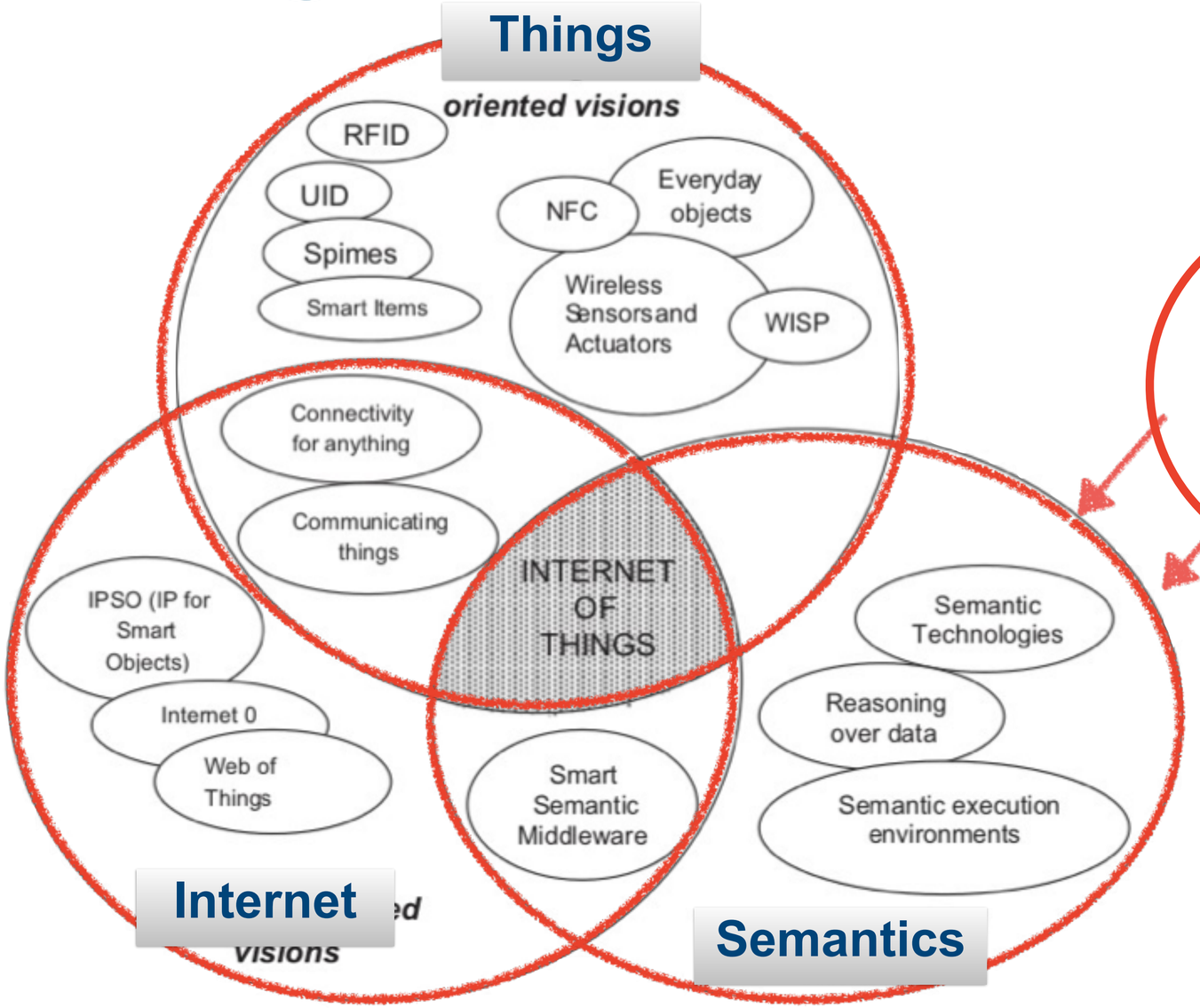


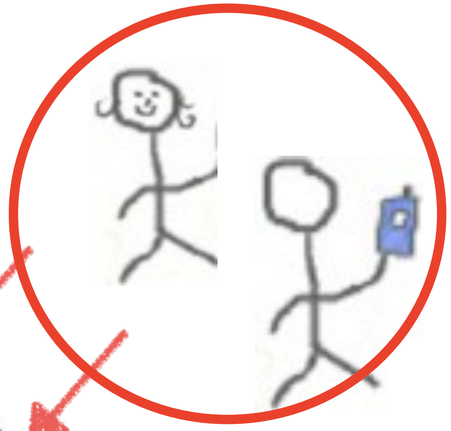


Source: L. Atzori et al., The Internet of Things: A survey, Comput. Netw. (2010), doi:10.1016/

The Internet of Things (IoT)

- IoT =
  - Things +
  - Internet +
  - **Semantics**
- Things that communicate
  - with Things: computer,
  - understand the meaning,
  - takes own decisions





* security
* privacy
* dependability
* context-aware
* personalised

Fig. 1. "Internet of Things" paradigm as a result of the convergence of different visions

Semantics in communications?

- What does optimum communication means?
  - Variety of radio interfaces
  - Optimum connectivity

- Multi-dimensional optimisation
  - Connectivity: price, security, latency, reliability, energy consumption

lunch (.no)


lunch (.es)

Internet of Things (IoT)

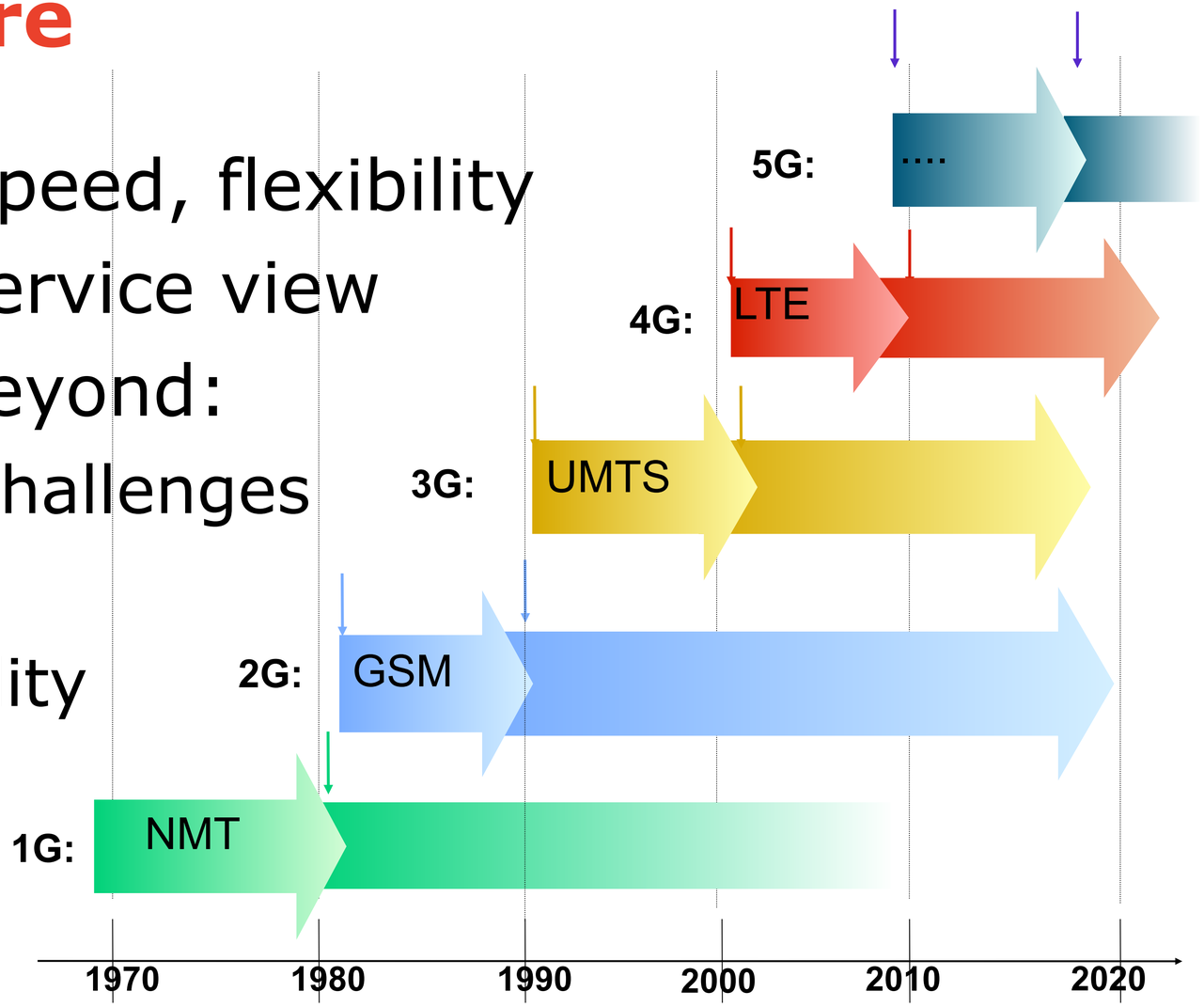
5G (6G)

Cyber-, IoT-, Societal Security

Sustainable Development Goals (SDGs)

5G: Speed, Bandwidth, latency and much more

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



Service & Sustainability

Seamless integration

Security,

Sustainability

Mobile broadband services

Web, Multimedia, Communications

Mobile telephony, SMS, FAX, Data

Mobile telephony

[adapted from Per Hjalmar Lehne, Telenor, 2000]

How did we measure the quality of the mobile network

1998

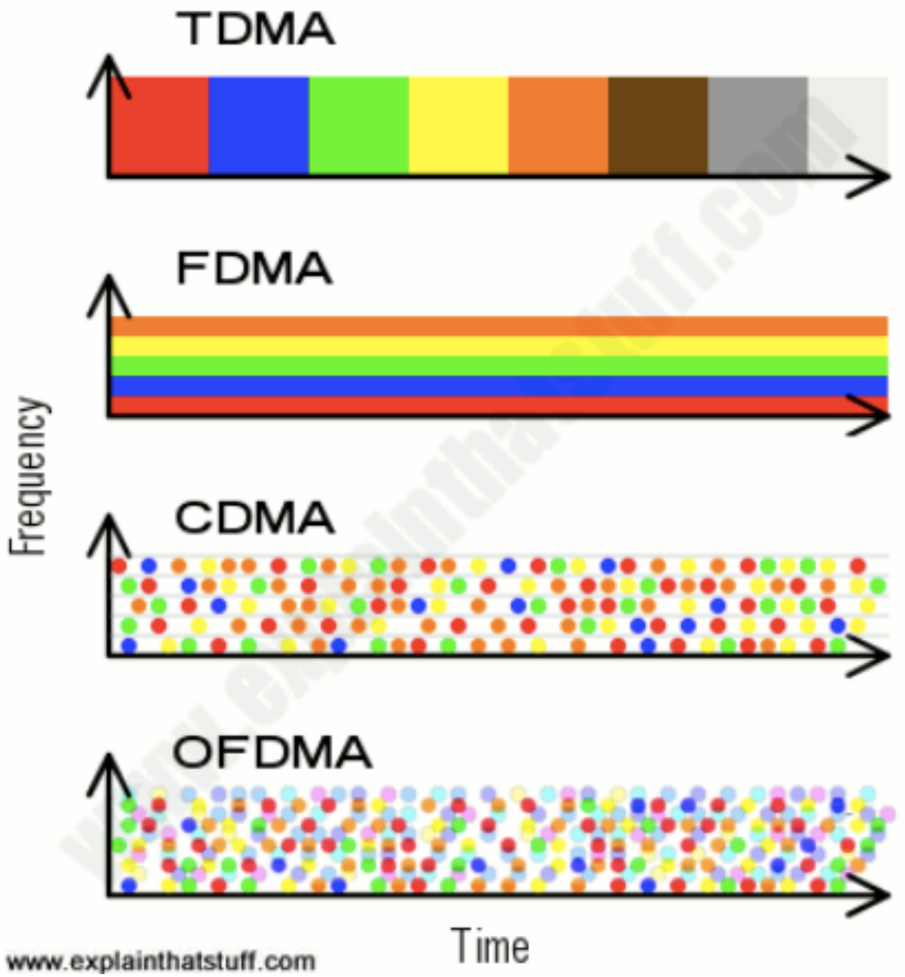
Mobile networks in Africa

and challenges for 5G:
https://basicinternet.org/5g-is-for-the-benefit-of-telecomm-operators-not-us-as-consumers/

Principles 2G-5G

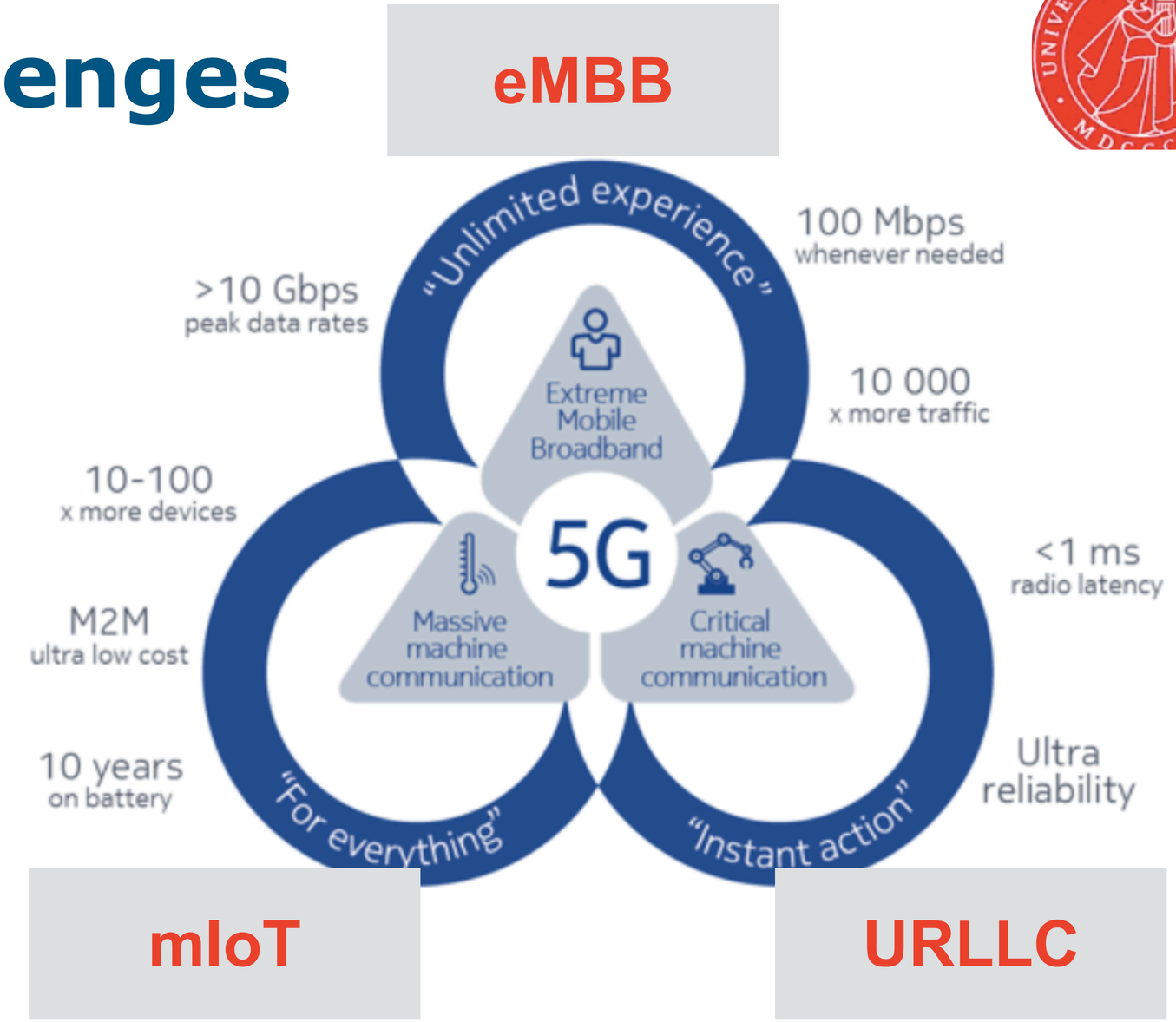
- Principles
  - frequency, time, code
  - allocation

- New applications
  - Internet of Things (4G, 5G)
  - Control systems (5G)
    - latency, reliability



5G: Industrial Challenges

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



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

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)

MIMO = multiple input, multiple output

Trust for IoT

2 Trains following each other - wireless!

Wireless Train Coupling
https://www.youtube.com/watch?v=pMQ0CWzOKTI

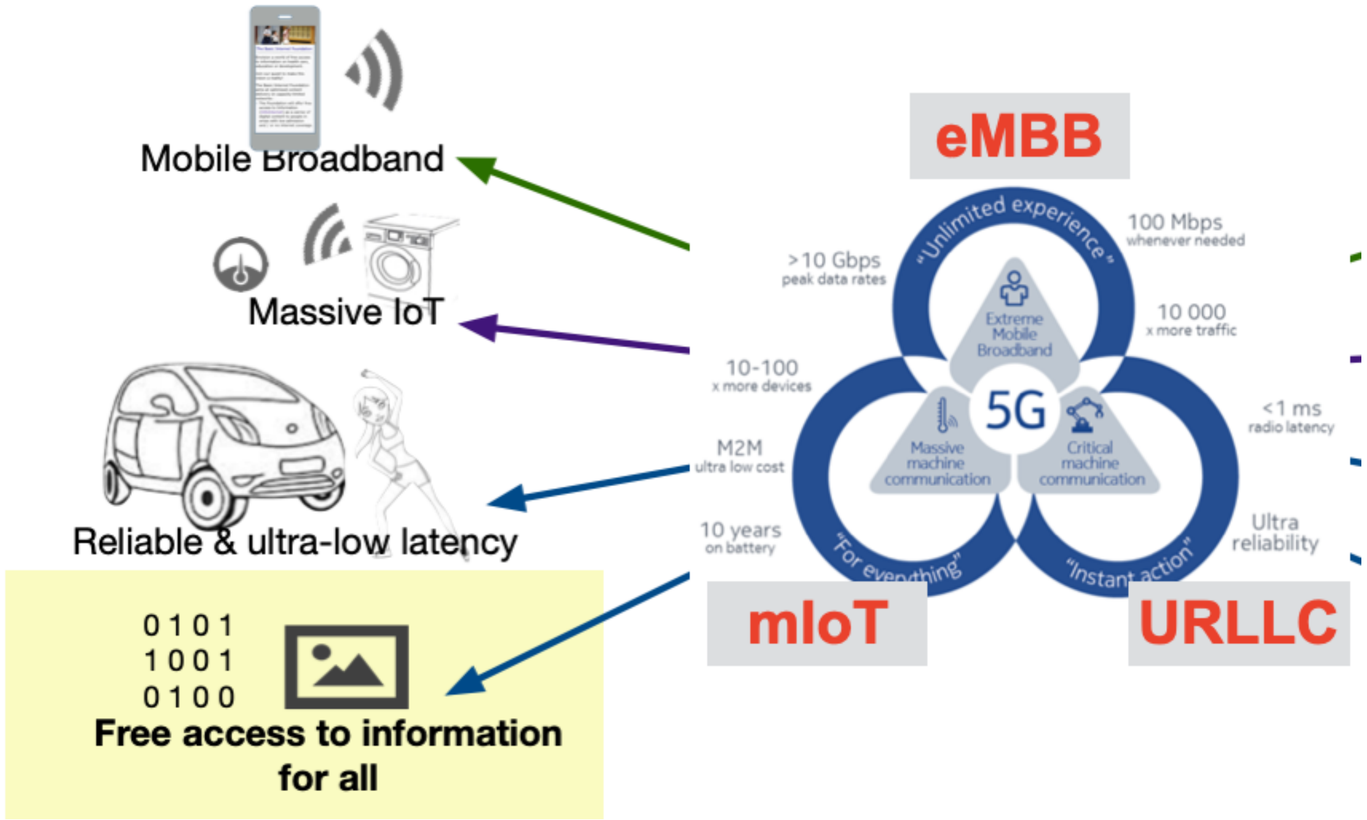
SCOTTproject.eu

5G Challenges

- 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

From 5G to 6G
societal aspects

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



From 5G to 6G
industrial aspects

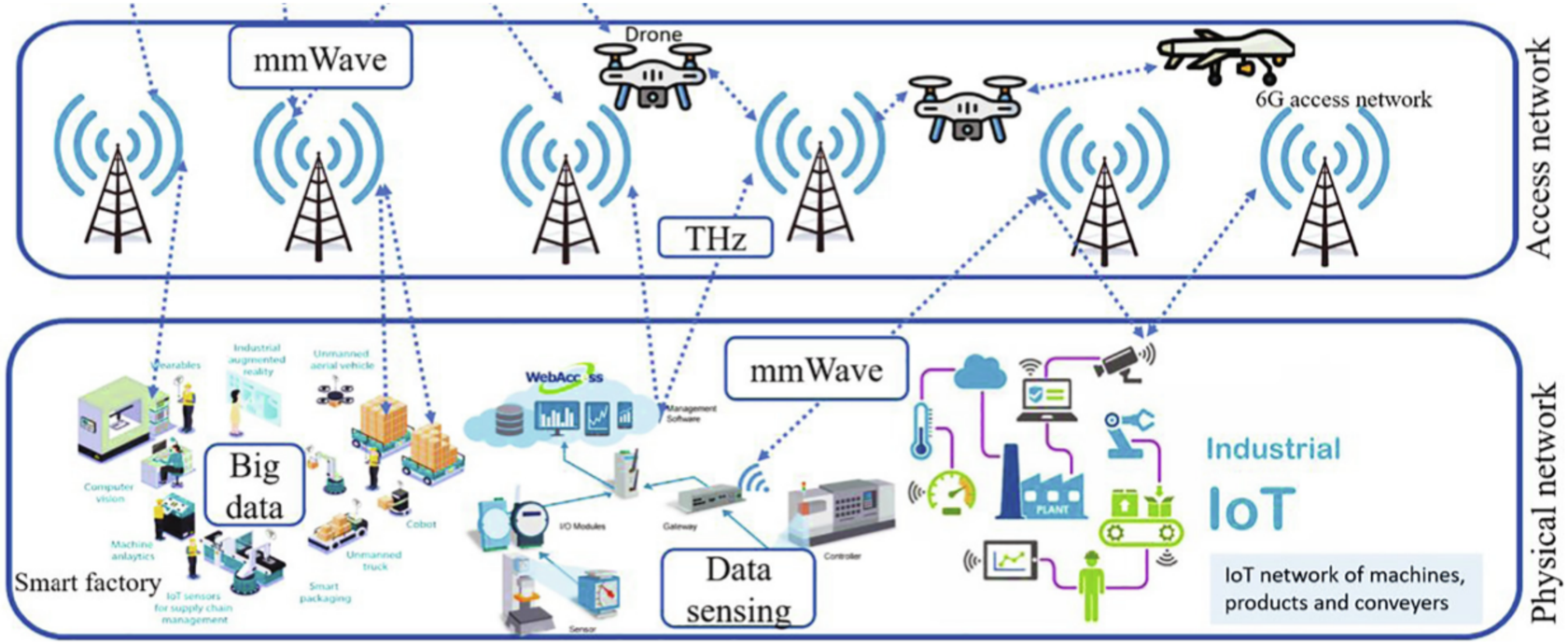


Fig. 13. Factory of the future technologies, requirements, and architecture within 6G.

- interface mobile-private network
  - we become network operators
- application-specific routing (service quality)
- interference with unlicensed technologies

Source: Shima. A. Abdel Hakeem et al. https://www.sciencedirect.com/science/article/pii/S1319157822001033

6G expectations

6G VISION REQUIREMENT AND ITS COMPARISON TO 5G

Constraint	5G	6G
Traffic Capacity	10 Mb/s/m2	∼1-10 Gb/s/m3
Throughput: downlink	20 Gb/s	>1 Tb/s (1000x)
Throughput: uplink	10 Gb/s	1 Tb/s
Uniform user experience	50Mb/s, 2D everywhere	10Gb/s. 3D everywhere
Latency (radio interface)	1ms	∼50ns
Latency (end to end)	10ms	1ms
Reliability (Block error rate)	1-10-5	1-10-9
Energy/bit	∼10mJ/b	1pJ/b
Localization precision	10 cm in 2D	1 cm in 3D
Network type	mmWave	THz Wave
Frequency band	3 GHz-100 GHz	mmwave, VLC, 300GHz-3 THz
Transmission Range	<1Km	<1Km
Application scenarios	Massive MIMO, Macro/pico cell	Tiny THz cells,
Device types	Smart Phones, Sensors, Drones, AR/VR devices, wearable devices	In addition with 5G, XR, smart implants, Brain Computer Interface (BCI) devices
Mobility	200 Km/h – 500 Km/h	500 Km/h (Bullet train) -1000 Km/h (plane)
Channel Codes	LDPC and Polar codes	NB-LDPC and Polar codes
Channel Bandwidth	100 MHz	500-1000 MHz
Jitter	$\sim 100ms$	1 μs

Source: Shima. A. Abdel Hakeem et al. https://www.sciencedirect.com/science/article/pii/S1319157822001033

6G Technologies

- Enhance reliable (ERLLC, eURLLC)
- AI on the radio
- Timing in co-ordinated networks
  - private/public 6G network
- Positioning without GPS
- Device (energy) efficiency
- 6G as backbone

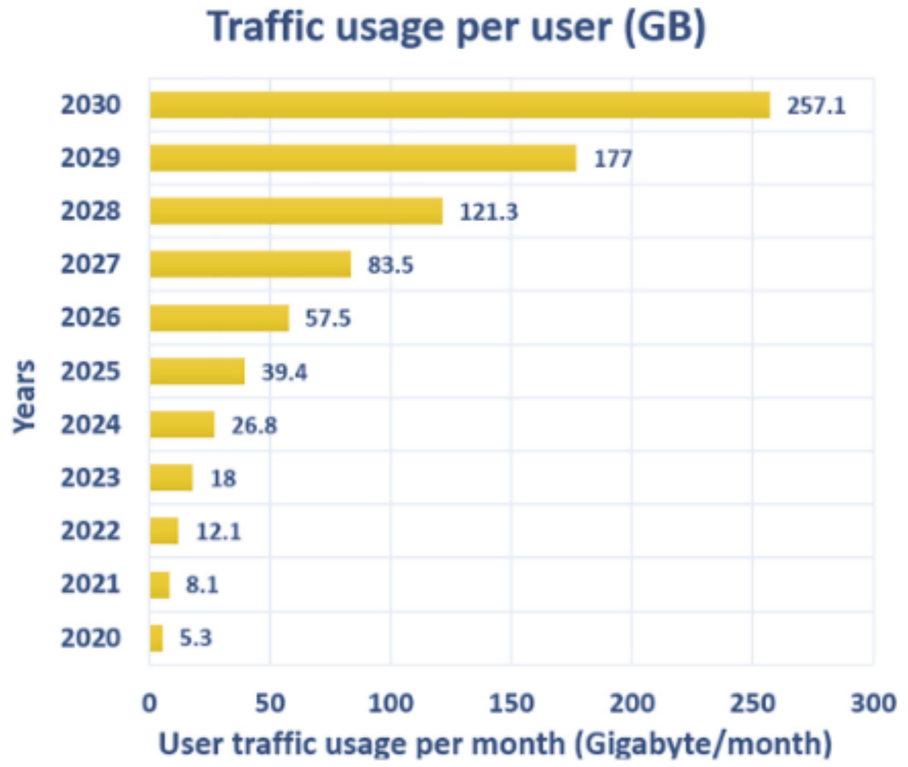


Fig. 4. Estimated user traffic per month according to ITU-R Report M.2370-0 from 2020 to 2030 (1 exabyte (EB) = 10^6 terabytes (TB), 1 TB = 10^3 gigabytes (GB)).

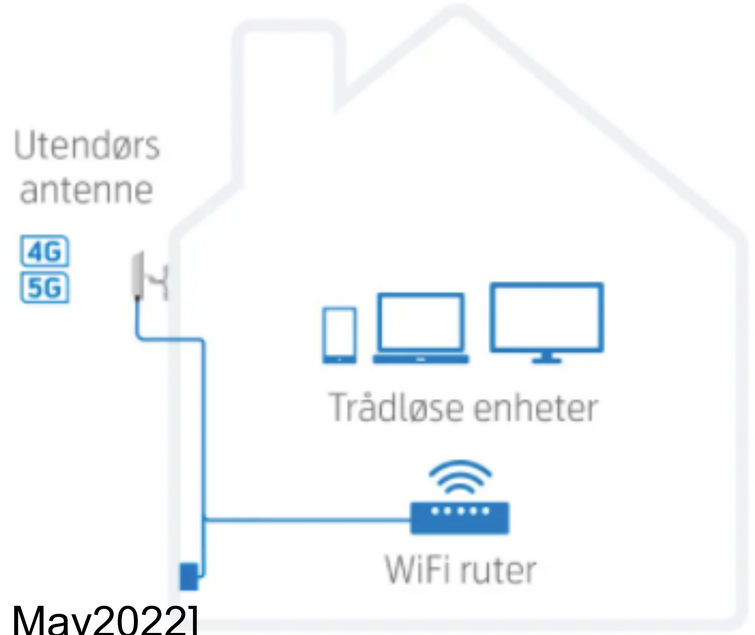
Source: Shima. A. Abdel Hakeem et al. https://www.sciencedirect.com/science/article/pii/S1319157822001033

1) Fixed-Wireless Access & autonomous networks

My assumptions for 6G

- 6g as backbone/fiber replacement
  - 10-100 Mbps for 499-699 NOK/mnd
  - 100 Gbit/s for fibre extension

- 5G industry forum
  - process industry
  - private network in a public network



[Source: Telenor.no, May2022]

Internet of Things (IoT)

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Addressing the Threat Dimension for IoT and 6G

- Trusted radio? Hidden radio?
- Will we recognise “hacking” of communications?
- Artificial intelligence on our radio chip

[source: www.rediff.com]

18. Dezember 2014, 18:14 Uhr Abhören von Handys

So lässt sich das UMTS-Netz knacken

[source: Süddeutsche Zeitung, 18Dec2014]

Zwei Hacker zeigen
UMTS-Antenne lassen

Significance

Spamming from / of IoT networks

IoT security challenges

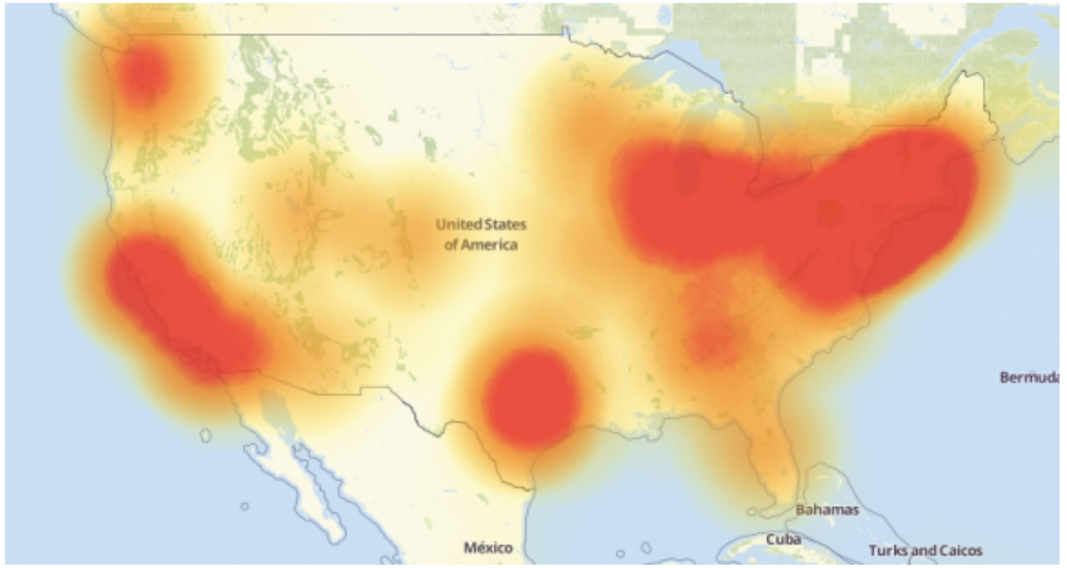
- Mirai attack
  - "security by obscurity"
  - different security viewpoint

- "it is just the beginning"
  - 4x increase in capability in 2018

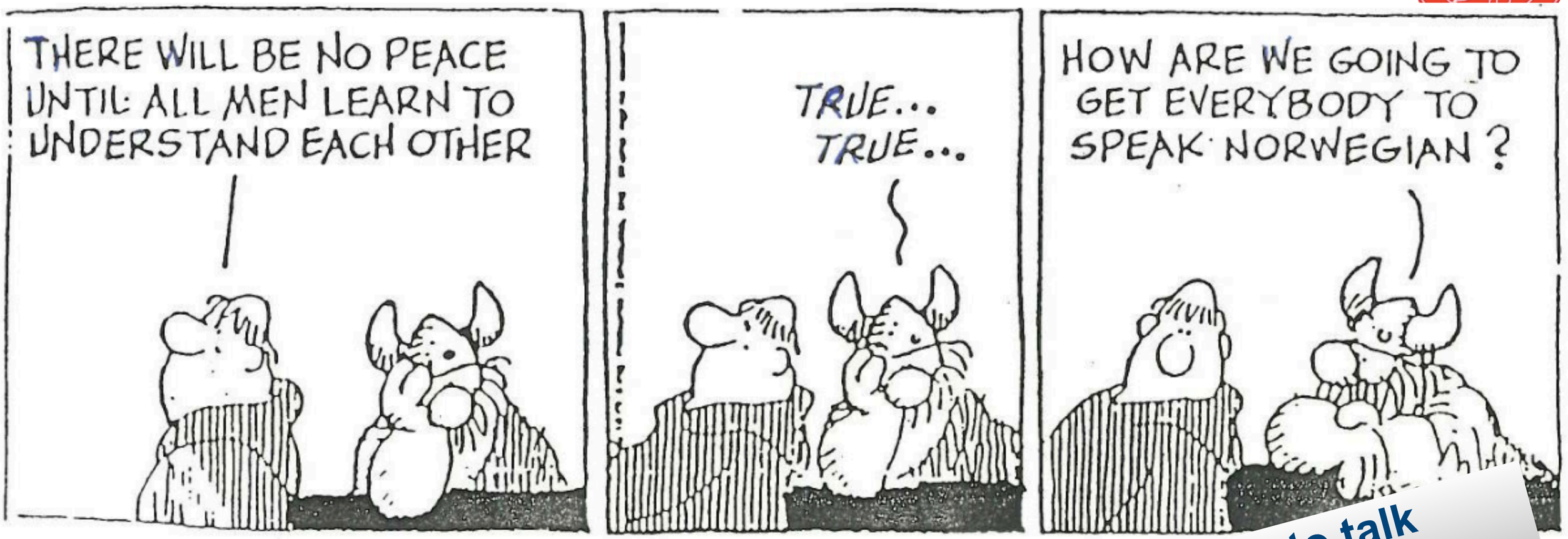
21 OCT 16 Hacked Cameras, DVRs Powered Today's Massive Internet Outage *16Oct2016*

A massive and sustained Internet attack that has caused outages and network congestion today for a large number of Web sites was launched with the help of hacked "Internet of Things" (IoT) devices, such as CCTV video cameras and digital video recorders, new data suggests.

Earlier today cyber criminals began training their attack cannons on **Dyn**, an Internet infrastructure company that provides critical technology services to some of the Internet's top destinations. The attack began creating problems for Internet users reaching an array of sites, including Twitter, Amazon, Tumblr, Reddit, Spotify and Netflix.



[Source: https://krebsonsecurity.com/2016/10/hacked-cameras-dvrs-powered-todays-massive-internet-outage/]



teach our sensors to talk Norwegian

Who pays if IoT connectivity fails? how to prove?

Confidential computing & hidden communications

Volvo to 'accept full liability' for crashes with its driverless cars

But decide on rules so we can make the dang vehicles

13 Oct 2015 at 06:04, OUT-LAW.COM

68 22 78

Volvo will "accept full liability" for collisions involving its autonomous vehicles, the company has confirmed.

Internet of Things (IoT)

5G (6G)

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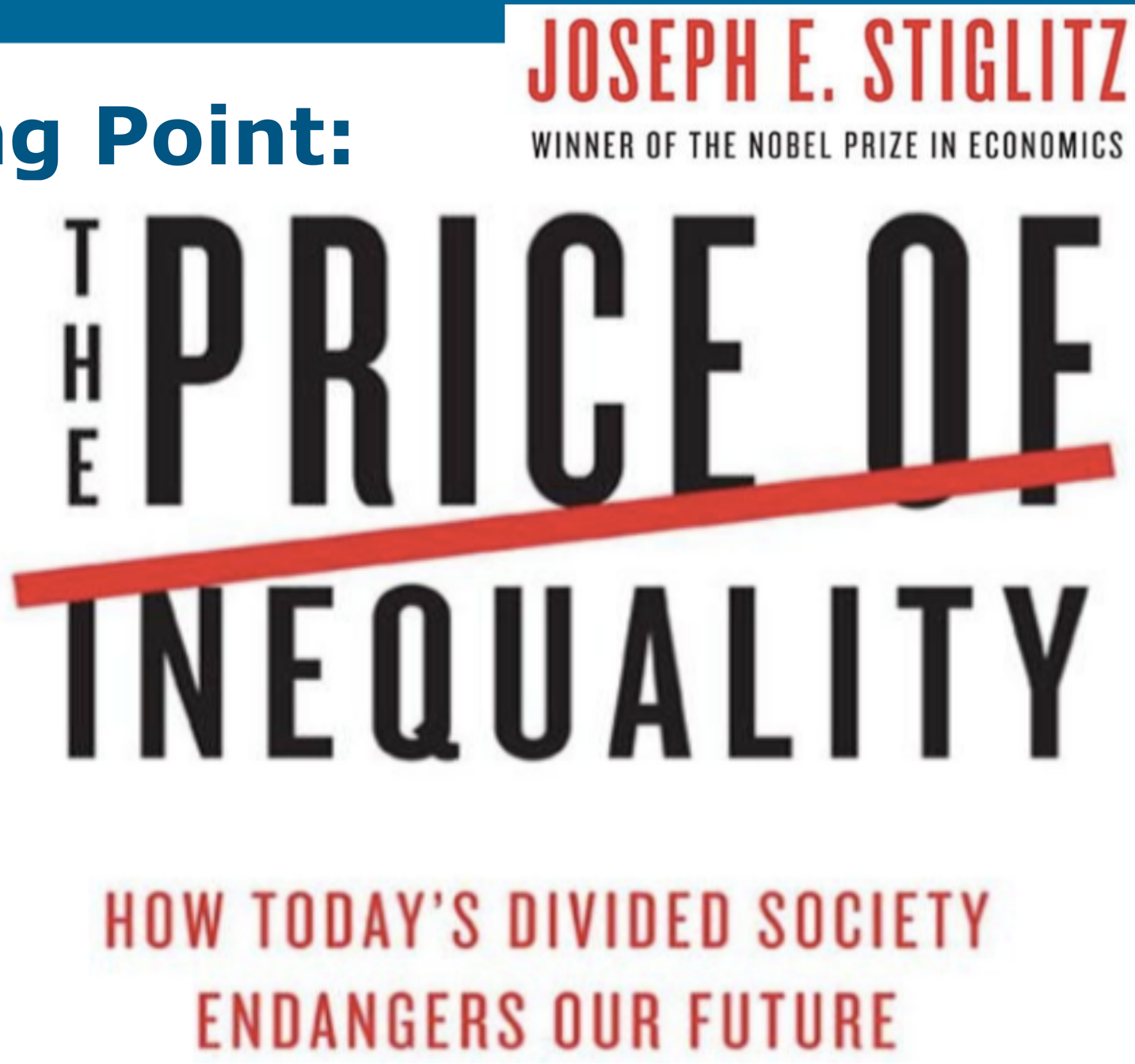
Sustainable Development Goals (SDGs)

Starting Point:



“Connect the Unconnected”

Izazi

Basic Internet Foundation

Installation time: 1,5 h

catching the signal from the Vodacom tower in Migoli (~10km away)

The mobile phone has replaced the machete (even in places without Mobile Broadband)

Solving the challenge of access

- Large range
  - cell size 60-100 km
- Multi-MIMO for distribution
  - spatial filtering
  - spectrum efficiency
  - extrem high bandwidth (100 Gbit/s)
- Affordable solution
  - OPEX <20 USD/month

Summary
"feels good to understand who things work"

- Technology *meets* global challenges
  - ➡ Billions of sensors <=> electronic waste
  - ➡ Cyber-/IoT-security <=> Trust and societal security
  - ➡ Automatisation, Industry4.0 <=> Trust and transparency

- Main drivers for 6G
  - Societal: free access to information
    - large cells, digital inclusion
  - Internet of Things
    - Social networks of things
  - Security in communications
    - Trustworthy communication
    - Intrusion detection

teach sensors to speak Norwegian