5G, teknologi og samfundsudfordringer

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Issues to be discussed

- What 5G is (capacity and speed compared with 4G).
- Which possibilities in technical sense can be opened in industry, transport and the way cities are functioning with 5G.
- What means introduction of IoT?
- Has Industry 4,0 spread in practice?

HVAD ER 5G?

https://yousee.dk/5g:

- TDC NET har lanceret det nye 5G-netværk i Danmark
- 5G dækker 'nu' mere end 80% af alle, der bor i Danmark.

- **Hvor hurtigt er 5G?:**
  - 5G er meget hurtigere end det nuværende 4G-netværk. Det betyder, at du vil mærke markant forbedring på hastigheden i forhold til det nuværende 4G-netværk.
- !

5G karakteristika

- Hastighed: 500- 1000+ Mb/s (idag 100- 500 Mb/s) vs 4G: 10 – 40 Mb/s
- Hvad betyder det?
  - Tale ..
  - Google søgning ….
  - Blu-ray film 20- 40 sek
- Hvorfor?

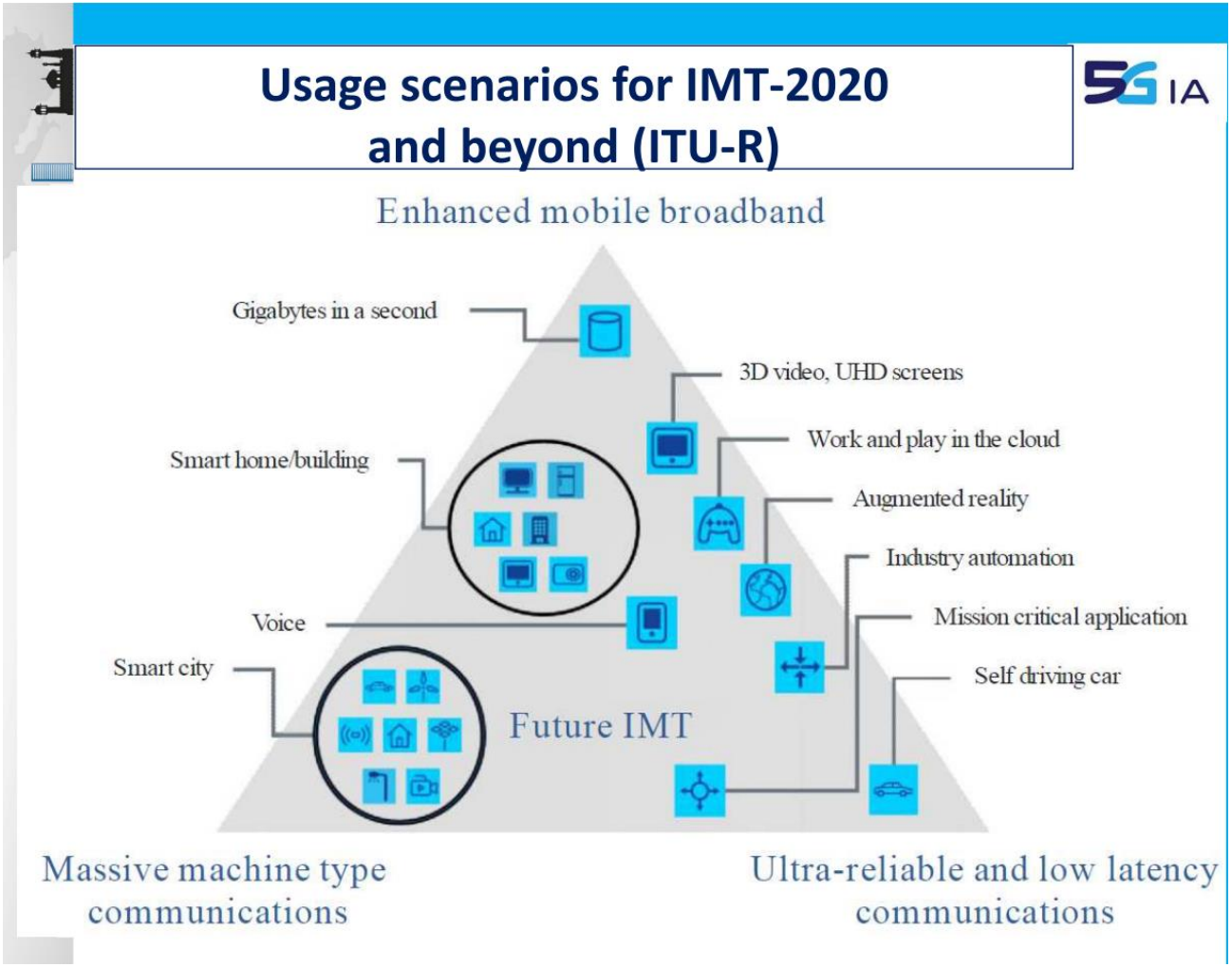
Mobile development/ evolution – through the 'Gs'

Industry view in 2010:

1G	2G	3G	4G	5G
1981	1992	2001	2010	2020(?)
2 Kbps	64 Kbps	2 Mbps	100 Mbps	10 Gbps
Basic voice service using analog protocols	Designed primarily for voice using the digital standards (GSM/CDMA)	First mobile broadband utilizing IP protocols (WCDMA / CDMA2000)	True mobile broadband on a unified standard (LTE)	'Tactile Internet' with service-aware devices and fiber-like speeds

- 2G – digital
- 3G – data possible -> 'euphoria'; in reality relieving 2G congestion
- 4G – diversified data a reality – but BM problems
- 5G –focus on usage, through
  - massively greater capacity/ speed
  - Machine-to-machine communication (IOT)
  - Low latency

Use Cases – 5G (ITU/ 3GPP) - 2015



5G - visioner

- Dagens 5G visioner bygger stadig på 'ITU- trekanten'

med disse specifikationer

  - More available
  - More dependable
  - More reliable
  - More flexible

- Byggende på
  - Increased Speed
  - Decreased Latency
  - Improved Device Connectivity (IoT)

Prominente Use Cases

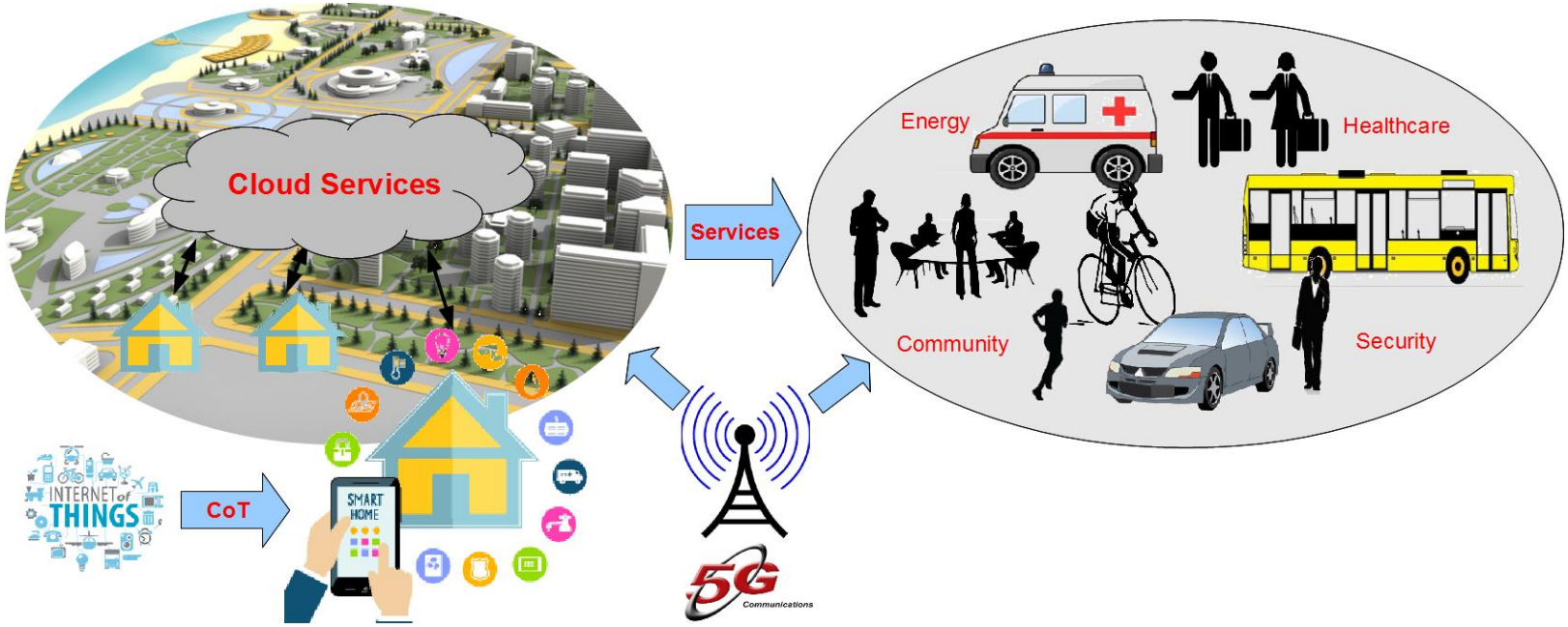
- Smart cities – var det første 'store' case
- Industry 4.0 – fremstår nu som det vigtigste

De kræver begge især

Machine-to-machine/ IoT communication based on network slicing

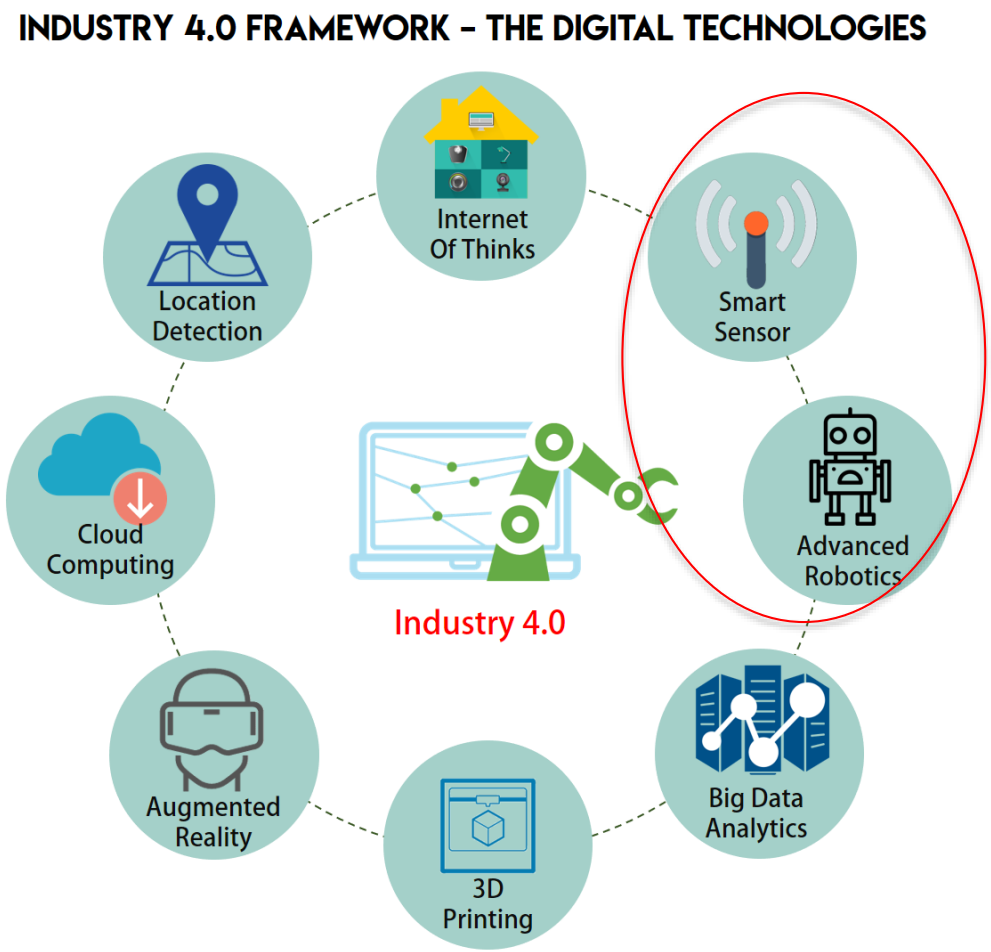
Low latency

Smart City and Smart Home solutions



- 5G technologies offers potentials to connect 'always on' the world from the largest megacities to the smallest internet of things
- The smart city is visioned to be an engine of social transformation where a modern ICT based infrastructure integrates the smart homes and IoT's into a smart city system
- Social transformation as response also to 'the other big societal challenges'

Industry 4.0 – 5G *markedet*



Idag wired connections/ Wi-fi
Wireless/ 5G billigere/ Mere fleksibelt

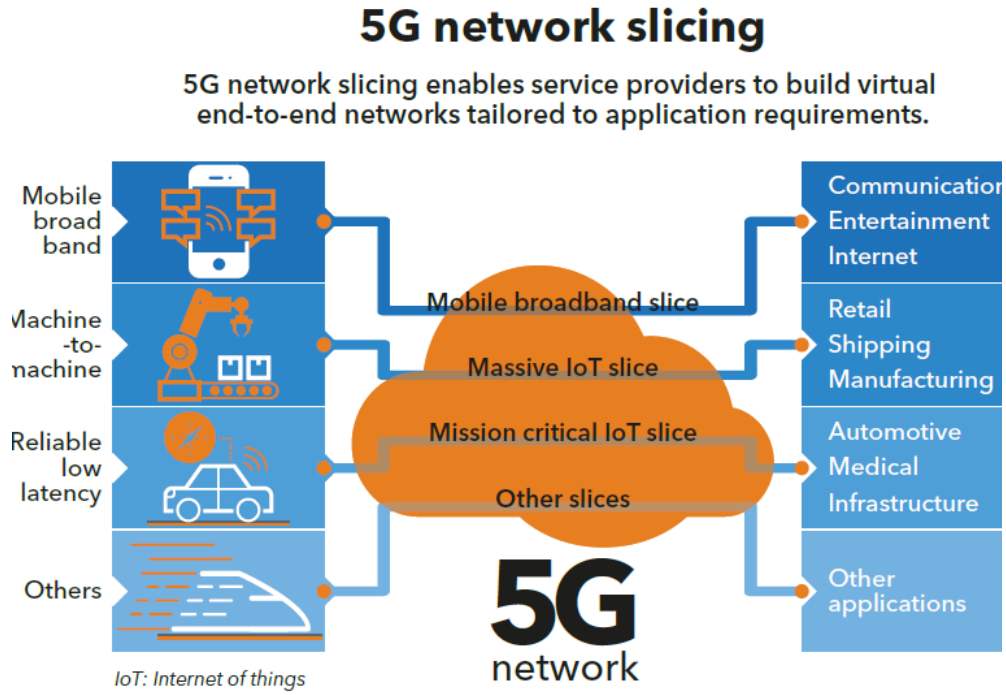
To vigtige 5G kvaliteter

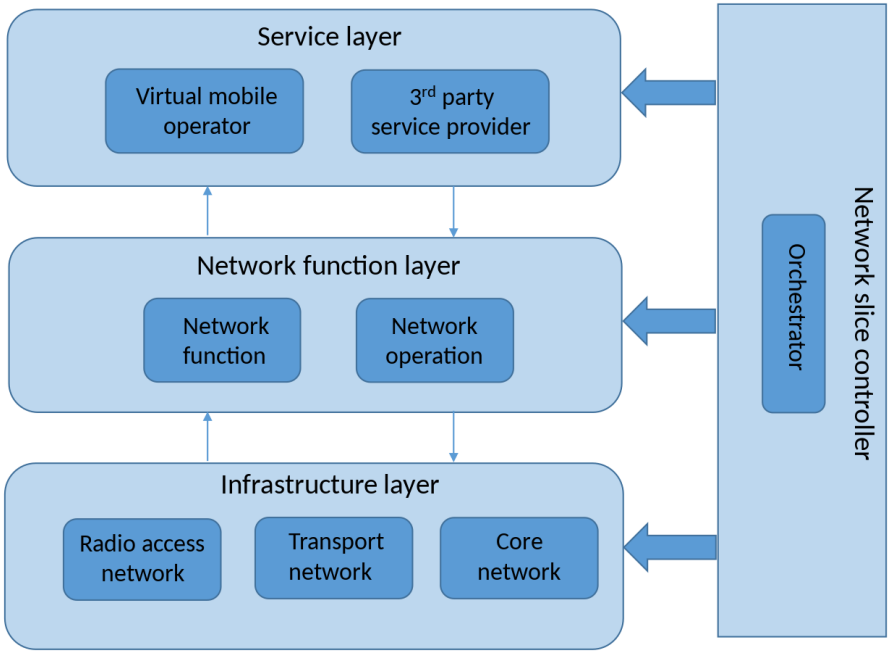
Latency; 5G: 1- 2 ms (4G: 50 ms)

Kontrol :
Network slicing – et virtuelt privat mobilnet

Network slicing - Tekniske & økonomiske udfordringer

Slicing muliggjort af Virtualisering & Software Defined Networks





Source WWRF Outlook28

Uløste tekniske problemer: standardisering af RAN & koordinerende control
Tekno-økonomisk: frekvenser

Tekno-økonomisk udfordring - frekvenser

- A private mobile network is suitable for, e.g., enterprise IoT services, smart city applications, and industry applications.
- To operate a mobile network you need frequencies/ a license
- Licenses for spectrum allocated to mobile networks have been reserved for Mobil Network Operators (MNOs)
- Many countries look likely to set aside mobile spectrum for private licensing in 5G
- MNOs can also deliver private networks (slices) to companies in coordination with their public networks

Frekvenser

- Det er staten, der regulerer, hvem der må sende signaler på hvilke radiofrekvenser og på hvilke vilkår
- I 2019 blev 20 frekvensblokke i 700-, 900- og 2300-MHz-frekvensbåndet tildelt i en auktion der indbragte staten 2,2 milliarder kroner
- I Europa er 700 MHz-, 3,5 GHz- og 26 GHz-frekvensbåndene identificeret som pionerbånd for 5G
- TDC anvender 700 MHz i den aktuelle udrulning – det begrænser hastigheden jf tidligere
- 3,5 GHz- og 26 GHz-frekvensbåndene forventes på auktion i efteråret 2020
- Energistyrelsen, om det skal være muligt for private virksomheder at købe frekvenser til dedikerede lokale 5G-net

TDC on Private 5G

- Background
  - "*TDC fully understands that private companies see opportunities in 5G technology and in how 5G can contribute to further efficiency and optimization in production.*"
  - But TDC hopes it will be in charge of deployment and maintenance of the networks for private customers
- Deployment scenarios
  - Scenario I: Network Slicing
  - Scenario II: Local 5 G network for companies connected to the public network
  - Both scenarios based on TDC's frequencies enabling them to plan the networks optimally concerning interference, security and availability

Source: TDC net

TDC on frequencies to Private 5G

- According to TDC giving the spectrum to companies have a number of drawbacks
  - Using the frequencies becomes sporadic and random - driven by the industrial need.
  - Use will be limited to indoor solutions due to the risk of interference, thus not contributing to macro coverage, which is why the utilization rate will be very low.
    - Less than 10% of use* of the reserved amount of spectrum, relative to if utilized effectively by a mobile operator.
  - Inadequate coordinated use may cause interference.
  - Interference can have serious consequences for reliability and stability, such as the control of robots.
  - Coordinating use of frequencies must be ensured and facilitated. More 'Guard bands' cause further inefficient frequency utilization.

*TDC NET's assessment, which is based on the reservation of 70-100 MHz of the 3.5 GHz band, and that 100-150 companies use the frequencies in several locations in Denmark.

Source: TDC net

Telecom operators concern

- Losing control over the network
- Traditional business models´s (BM's) unsustainable in 5G
  - Subscription as the core element are not likely to produce enough turnover and profit to cover these.
  - Turnover on subscription fees are going down and cost of business model innovation and implementing 5G will be extremely high.
  - It has been predicted that network-related capital expenditures will have to increase 60 percent from 2020 through 2025, roughly doubling total cost of ownership during that period (McKinsey 2018).

Case: 5G project at the Danish Grundfos

- Purpose of the project
  - Investigate if 5G technology in the future could replace wired ethernet connection in the production area.
- Devices/equipment used at the company:
  - Office PC's 15.000
  - Production PC's 1.500
  - Wireless clients 12.000
  - Security cameras 1.000
  - Various production equipment 8.000
  - Printers 2.500
- Cables and servers used in the company
  - Fiber 70 km
  - Data plugs 30.000 plugs
  - Ethernet cable 3.000 km
  - Server rooms 182 rooms
  - Data center racks 60 racks
- Yearly extension of cables and plugs
  - Fiber 2,5 km/year
  - Data plugs 400 pieces/year
  - Ethernet cable 20 km/year

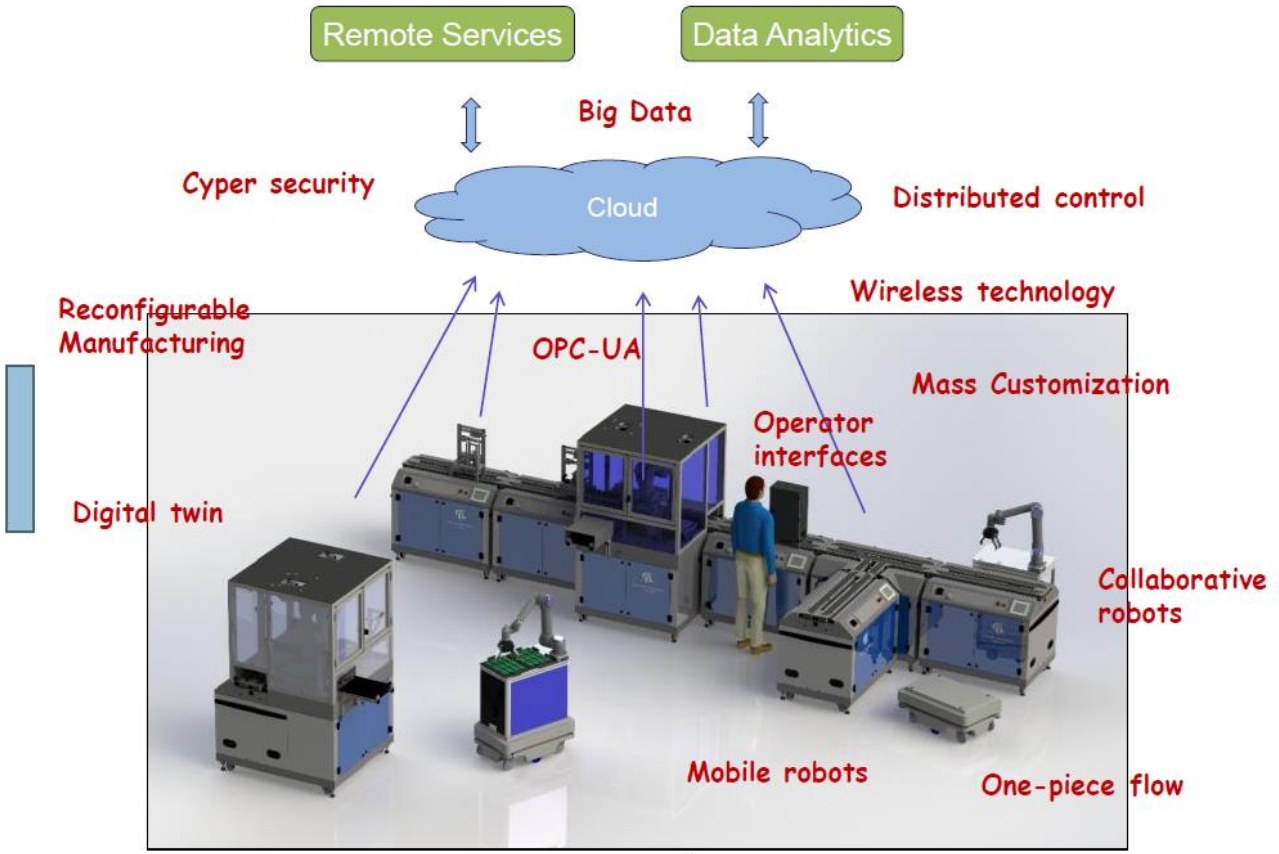
Source: Grundfos

Case: 5G project at the Danish Grundfos

- Factory of the future
  - Number of sensors will increase
  - Multiple Devices in the production
  - Positioning of pallets and equipment
  - AGV's
- What is important for Grundfos
  - Capacity and performance
  - Reliability
  - Security
  - Cost
  - In control of their network both wired and wireless
- What makes private 5G interesting for Grundfos
  - Scalability
  - Flexibility
  - Cost control
  - Same performance as cable

Source: Grundfos

Lego på AAU Industry 4.0 Lab



Source Ole Madsen, Materials & Production, AAU

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Konklusion/ sammenfatning

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- Which possibilities in technical sense can be opened in industry, transport and the way cities are functioning with 5G.
- What means introduction of IoT?
- Has Industry 4,0 spread in practice?

- Tekniske 5G løsninger er på vej – de kan potentielt etablere et 'nyt økosystem'
- Det er især Industry 4.0, der tegner sig som relevant marked med egentlig eftespørgsel efter 5G
  - Der er interesse for denne løsning I DK: Grundfos & LEGO
- Det generelle forbrugermarked, der har båret 4G er (måske?) mindre relevant
- Der er mange uafklarede tekniske/ økonomiske udfordringer for det ny økosystem
- '5G' kommer/ er her – men hvordan!
- 6G 'er på vej'