Secure and Reliable ICT Systems for Telemedicine Applications

**Lars Dittmann, Technical University of Denmark**

$C = B\log(1 + \frac{S}{N})$
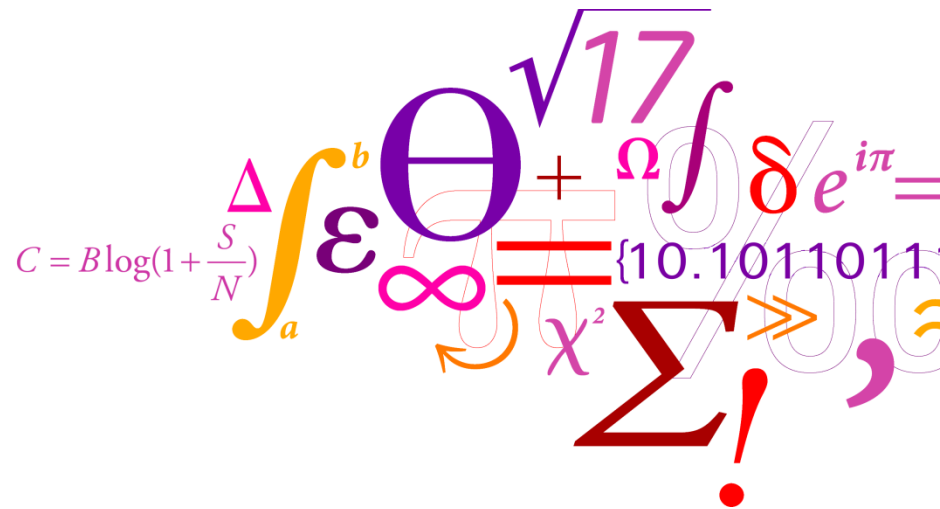
About me

- MSc and PhD in engineering – specialized in Telecom (network and protocol design, network optimisation, network performance and QoS.
- More than 30 years experience from academia – but also 30 years of experience in collaborating with industry.
- Head of communication technology section at DTU – Technical University of Denmark – with a staff of about 85 (including PhD student)
- Has been main supervisor for 36 PhD student
- Current focus in research – secure and reliable support of demanding application
- Strong interest in experimental and applied research.
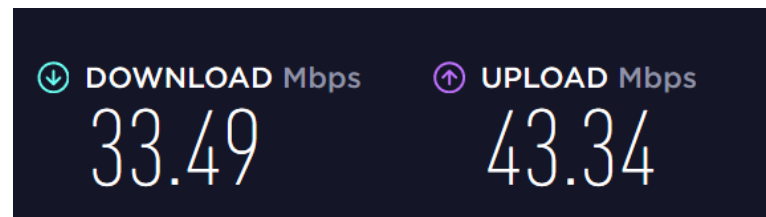- Have worked with telemedicin for the last 6-7 years

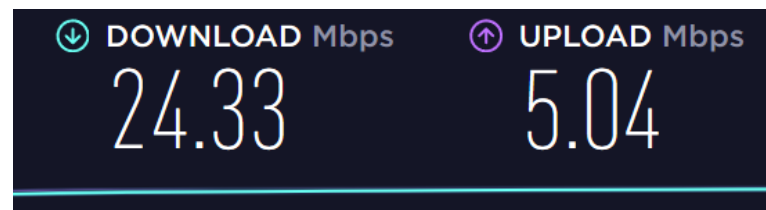# The Internet is not a given thing – but often taken for granted

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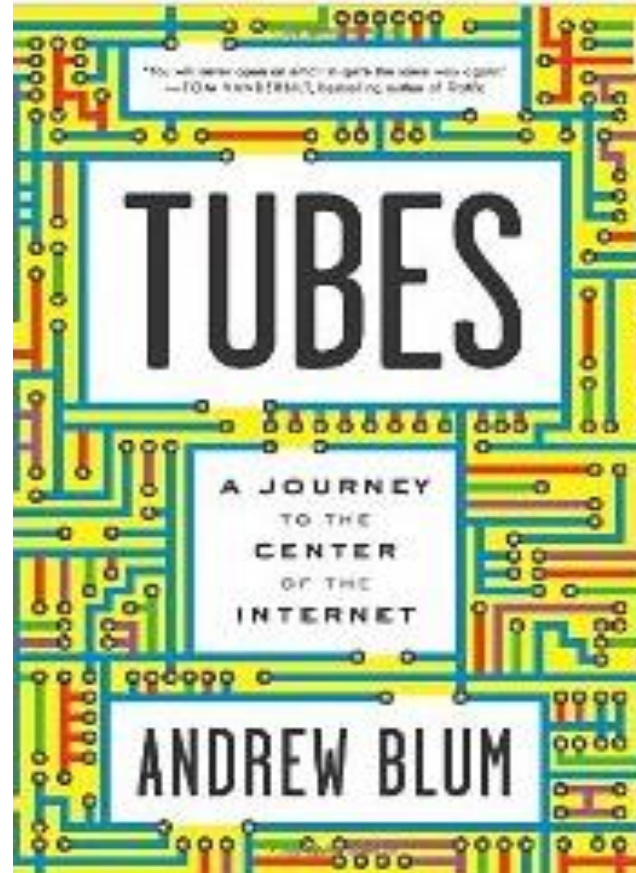
What is a fast Internet
(3 different connections on same laptop)?
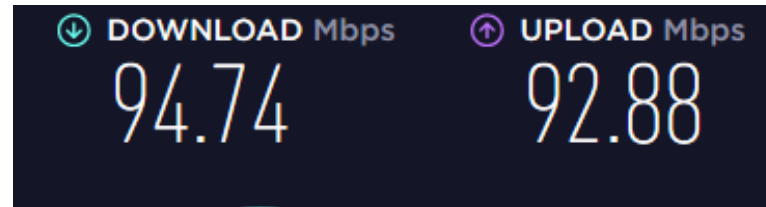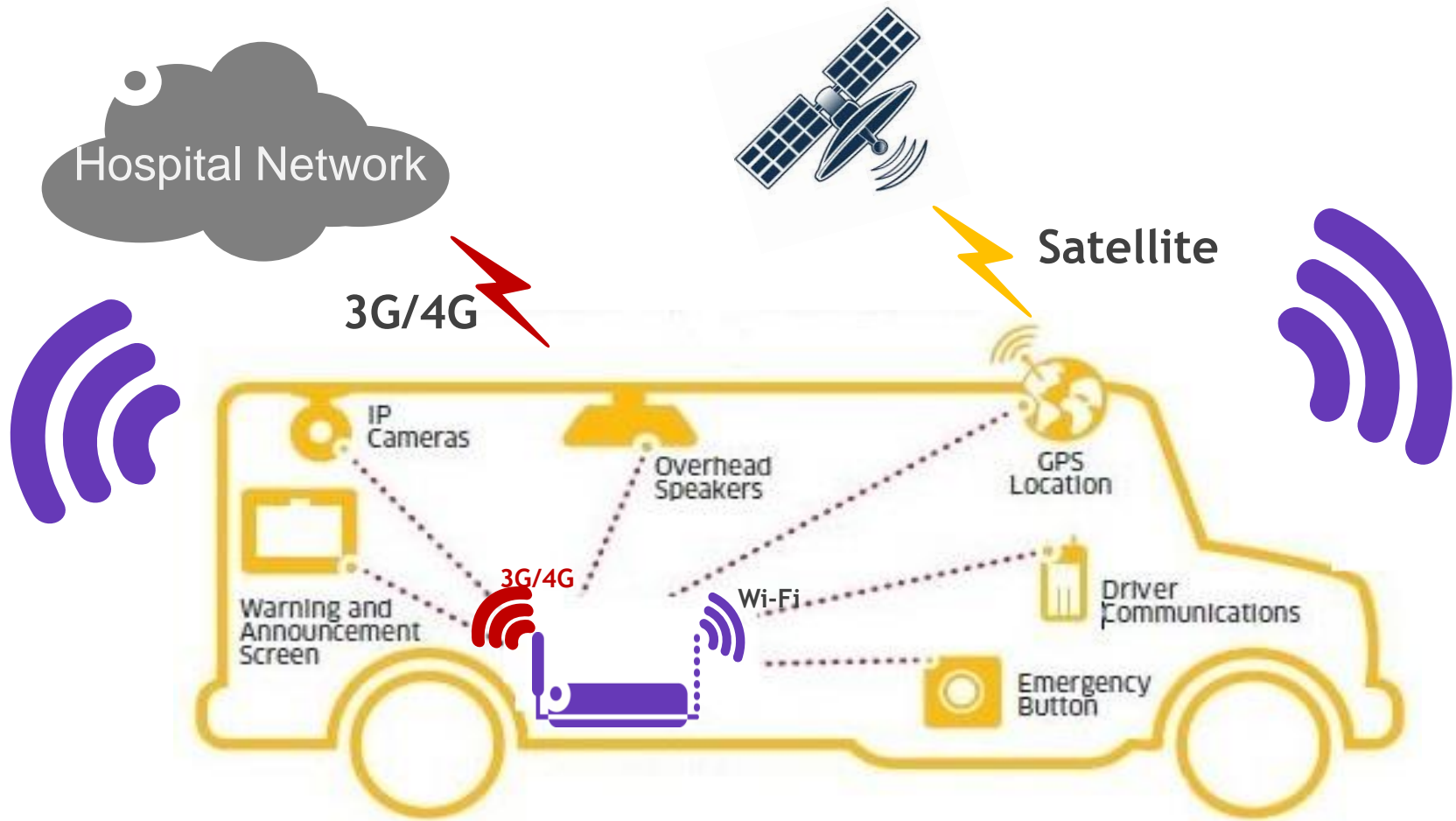

Ethernet

4G/LTE

WiFi

Outline

- What is telemedicine (- probably going to be)? Case-stories.
  - OCPD
  - Atrial fibrillation
- Why is security extremely important for telemedicine – do we care when we are ill and just want to be cured?
- The role of the network in ensuring secure and reliable telemedical services and current trends in network design and implementation
- Network security and availability
  - How to hack the network and hijack data
  - Legal aspects of a global network
  - How to get illegal access to information in a non-classical way.
- Solutions from a network perspective e.g. 5G and IT perspective e.g. CONTINUA

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What is telemedicin

- Medical treatment over distance
- Driver is typical cost savings or improved quality of life
- Can be anything from remote analysis of x-ray pictures to hospital-at-home
- Can be user driven (self-monitoring of health) of requested by healthcare system for people in certain risk-groups, people that might get re-hopitalized, people that can recover faster in own home etc.
- Not the same drivers in public healthcare and insurance-based healthcare
- Personal health is a personal matter – but of strong public interest for insurance companies, companies selling information (e.g. GOOGLE)
- AI can transform a large amount of apparently irrelevant information into conclusions and phenotyping that can have strong impact on the future of a person.

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Telemedicin is both before and after hospital treatement

Hospital Network

3G/4G

Satellite

IP Cameras

Overhead Speakers

GPS Location

Warning and Announcement Screen

3G/4G

Wi-Fi

Driver Communications

Emergency Button

Connected Ambulance as extended Clinic or Hospital

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.. and in between hospital (next step for robot surgery)

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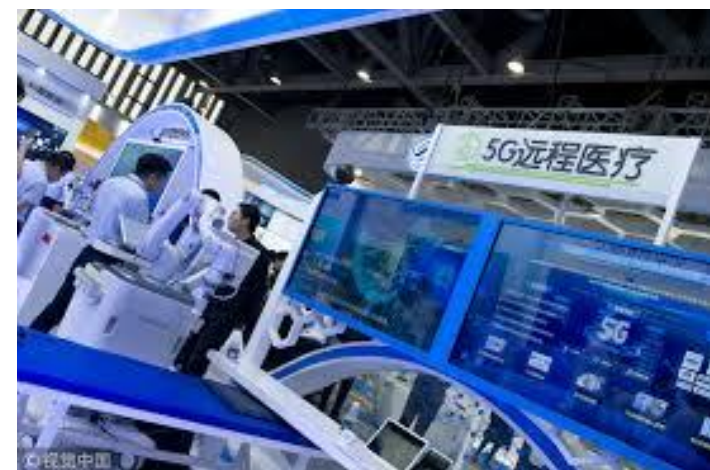
Telemedicin in real-time requires a very stable and reliable ICT platform

Robot:
System immanent latency currently 180 ms
Human:
Maximum latency tolerance 250 ms

Up to 10 Mbps, 5-10 msec E2E

Negotiation and exchange of information with team members / objects

Surgeon

Information basis
- Team members
- EHR (incl. video and Images)
- Supply Chain Management
- Patient flow management
- Billing

Team-members
- Remote surgeons
- Remote Anesthetist
- On-site surgeons
- On-site Nurses
- Radiologist (Digital Images)
- Pathologist (Biopsies)
- Blood-bank
- Pharmacy
- Intensive Care Unit
- Objects, sensors, CPS

Cooperative maneuver and trajectory planning

100 Mbps, 10 msec E2E

Robot Internal
Network

Interpretation and Plausibility Check

Prediction of situation and of intention

Exchange with other Team members / objects

Up to 50 Mbps, 10 msec E2E

Cooperative recognition

Information to other team members

Sensor input from different locations and other team members

Up to 10 Mbps, 10-20 msec E2E

Network Specifications:
- Reliability: 99.99x %
- Availability: 99.99x %
- Interference 0
- Indoor penetration 20 – 100 meters
- Outdoor range 1000 meters

Up to 100 Mbps, 10 -50 msec E2E

Own sensors

e.g. Longitudinal & Lateral tool Accelerations (minimum 5 degrees of freedom), in situ navigation, pressure, temperature, object tracking, etc., video (HD or pre-processed), Sensors for proximity measurements (device-to-device), vital parameters (heart rate, blood pressure, SPO2, CO_2, etc.)

eHealth - eLiving

- Telemedicine – a strategic goal for Denmark and Europe (with significant investment).
  - 1/3 less beds in future hospitals – more people being treated @home.
  - Ensure reliable communication and home network infrastructure.
  - Current Internet is NOT good enough for eHealth – due to reliability/availability/security
  - Ehealth should enabling benefit for both patients/elderly people and society.

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COPD

COPD is a cronical lung dicease that cannot be cured,
but lifequality can be improved from selfmonitoring and
video consultancy with GP or lung clinique

Atrial Fibrillation

Project "Future patient" collaboration with:
- universities
- hospital,
- healthcare centers,
- user communities
- etc

A fast-growing decease globally (and no good explanation why)
Usually a disease for elderly – but younger and younger people gets the diagnosis
Main consequence is stroke and death
Some people can sense it – but many not
Not necessarily a permanent condition

LPWA transmission

The patient's device

The doctor's computer
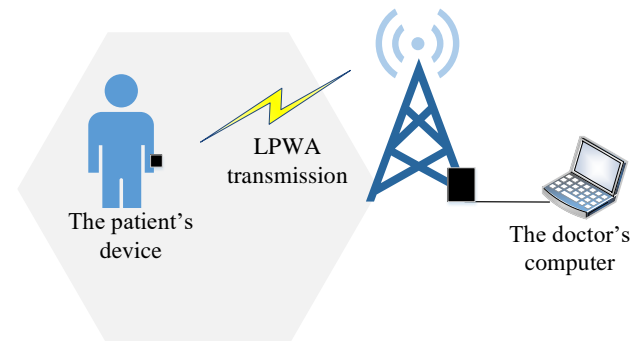
Small brainstorming exercise (10-15 min)

- Create groups of 4-5 people and discuss potential telemedical application.
- Discuss potential timeline for the applications.
- Discuss potential advantages and risk in general.
- Discuss issues related to datamanegement and datasecurity.

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Data security aspects (in general)

- Voluntarily or non-voluntarily generation of data
- Legal aspects of data ownership – user generated or system requested/recorded.
- Storage solutions applied – where, how, by whom
- Validation of content – and authentication of source
- Data availability – to you, your devices and others
- Data availability in real-time – and all the time
- Data structure applied in different scenarios

- Data is highly sensitive and can be misused – cryptography can/might prevent unauthorized persons (or algorithms) to access data.
- Network attacks can prevent authorized person to access data (at time needed or at all)
- Data availability is also a data security issues.
- Data location is a security issues as it is changing the possibility and legal issues regarding access to data.

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Potential misuse of data

Sweden scrambles to tighten data security as scandal claims two ministers

Six state agencies being checked after leak of sensitive data potentially including information on people in witness protection

Interior minister Anders Ygeman faces the media as he comments on his resignation. Photograph: Ari Luostarinen/AFP/Getty Images

Sweden's government has sought urgent assurances on data security from national agencies including the health, education and pensions services after a huge leak of private and sensitive information that has cost two ministers their jobs.

Availability is also security

DTU

🔖 LÆS ARTIKLEN SENERE

👁 **INDLAND**

Telia-kunder kan ikke komme igennem til akuttelefonen: Lån din ven eller nabos telefon

Der har morgenen igennem været problemer med at få fat i hovedstadens akuttelefon.

ANNA SOL JØRGENSEN
KL. 10.31

Der er tekniske problemer med Akuttelefonen 1813 i Region Hovedstaden, der betyder, at nogle bliver mødt af en optaget-tone.

Det oplyser hovedstadens akutberedskab på Twitter.

- Problemet er nu fundet. Borgere, der har telefonabonnement hos Telia, har problemer med at komme igennem til 1813. Vi er i kontakt med Telia for at få løst problemet hurtigst muligt, lyder beskeden.

Tidligere i dag anbefalede Hovedstadens Akutberedskab, at man forsøgte at ringe igen, hvis man blev mødt af en optaget-tone, når man ringer 1813.

Den anbefaling er nu justeret.

- Lån din ven eller nabos telefon, hvis du har brug for at tale med 1813, skriver beredskabet på Twitter.

■

f FACEBOOK   **t** TWITTER   🔗 KOPIER LINK

TDC-kunder er ramt af nedbrud på mobilnetværk

Endnu ved TDC ikke, hvornår deres mobilnetværk vil fungere igen. Kunder melder om problemer på Facebook.

Et nedbrud rammer en række mobilkunder på TDC's netværk, som søndag formiddag ikke kan foretage eller modtage opkald.

Det oplyser TDC til Ritzau.

Endnu kender selskabet ikke omfanget, men man har konstateret, at nogle kunder kan bruge netværket, og andre kan ikke.

TDC er ved at undersøge årsagen og kan endnu ikke melde noget om, hvornår netværket vil fungere igen.

→ **Læs også:** **Det er en ny dag for TDC. En nuuday: TDC får nyt navn og sikrer sig rettigheder til engelsk fodbold**

På selskaberne YouSee og Telmores Facebook-sider er der søndag formiddag opdateringer om nedbruddet.

»Vi har i øjeblikket en fejl med vores mobilnetværk, så man kan opleve ikke at kunne ringe eller modtage opkald«, skriver YouSee på Facebook.

Flere hundrede personer har skrevet i kommentarfeltet, og mange melder om problemer.

Københavns Politi skriver på Twitter, at der er problemer med at modtage opkald på 112 fra flere selskaber.

Problemet er ifølge politiet ved at blive løst.

ritzau

EMNER: Telia | Lægevagt | Twitter | Region Hovedstaden

The challange of network coverage

Landsby uden mobildækning – og så kom ministeren på besøg

AF JOHNNY K. OLESEN – UDGIVET D. 9. NOVEMBER 2017 – 11:18
KATEGORI: NYHEDER

Den lille landsby Javngyde nær Ry har elendig mobildækning, og nu skal ministeren med egne øjne se på sagen.

Den lille landsby Javngyde nær Ry har i årevis oplevet store problemer med mobildækningen. Problemerne er så alvorlige, i den lille landsby, at ambulancer ikke kan kommunikere med hospitalet i Skejby. Ifølge TV 2 Østjylland bliver ambulancer simpelthen nødt til at køre op til en bakketop for at kunne ringe til hospitalet.

I andre situationer har folk været nødsaget til et bruge fastnettelefoner ved alarmopkald til 112, og vagtlægerne har en chauffør holdende tre kilometer fra landsbyen for at kunne modtage nødopkald fra patienter.

Nu er dækningsproblemet så landet på ministerens bord. Ministeren for Energi-, Forsynings- og Klimaministeriet, Lars Christian Lilleholt (V), besøgte i mandags selv landsbyen for at se på problemerne. Det skriver TV 2 Østjylland

– Unik kommunal teleaftale fjerner mobilhul i en lille by

Landsbyen ligger i et hul mellem høje bakker og høje træer, hvilket betyder, at radiosignaler fra de nærliggende mobilmaster har overordtligt svært ved at nå frem. Ministeren udtrykte forståelse for problemerne med mobildækning, og til TV 2 Østjylland udtalte han:

– "Mobiltelefonen er så vigtigt et omdrejningspunkt i vores tilværelse. Derfor er forholdene i Javngyde uacceptable".

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POLITIK VELFÆRD LEDELSE INFRASTRUKTUR BÆREDYGTIGHED

Pilotprojekt åbner ladeport for skandaler om sundhedsdata

Blogindlæg | Thomas Birk Kristiansen 31.07.17 | af Thomas Birk Kristiansen | 3

INFRASTRUKTUR

COMPUTERWORLD

CIO | CHANNELWORLD | COMON | JOB & KARRI

FORSIDE DIGITALISERING FORRETNINGSSOFTWARE INTERNET TELE & MOBIL PC'ER & HARDWARE

Derfor har danske kommuner elendig data-sikkerhed: Kompetencerne forsvandt for 10 år siden

Danske kommuner bryder igen og igen persondataloven ved ikke at kontrollere sikkerheden hos deres databehandlere. Og der er en god grund til, at datasikkerheden halter, mener højtplaceret programleder i KL.

31. januar 2018 kl. 14.16

ADAM
FRIBO
Sikkerhedsjournalist

Det er efterhånden en kendt sag, at danske kommuner har problemer med datasikkerheden.

Særligt ondt gør det på et enkelt punkt - nemlig

Tale-opkaldstest - Resultaterne

Tre problematiske områder:

- Lammestrup, Nordvest
- Nyvang, Sydvest
- Lidemark, Syd
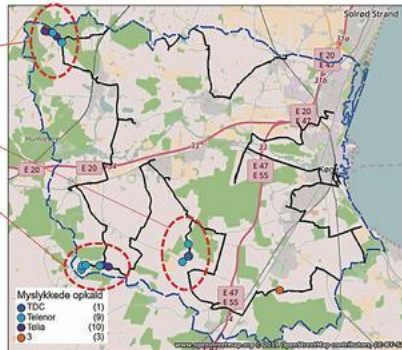
Mobile network hijacking equipment

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Integrating Health&Care in the future Intelligent home

- Our future home will be connected to an extend that is hard to understand (and accept !?)
- Telemedical application is one of many new things to be integrated into the future connected home and living environment.
- Other applications relates to for example climate control (temperature, humidity, dust, chemicals etc.)
- Many parameters can/will be recorded for cognitive control of the home (and can be store and used for research purposed in order to understand impact and relevance).

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eHealth a part of a larger transformation of the Internet?

- Internet of Things – new services on the existing infrastruture or a new infrastructure as well?
- IoT – challange: volume or type of application?

From many networks to a few networks – and maybe just one.

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IoT is many different things

Five-Year NB-IoT Connectivity Revenue Forecast / MUSD

Overall Revenues: 1.67 bn USD

Agriculture: 159
Automotive & Logistics: 225
Energy & Utilities: 180
Healthcare: 117
Manufacturing: 78
Retail: 175
Safety & Security: 227
Smart City: 276
Smart Home: 233

Source: Huawei
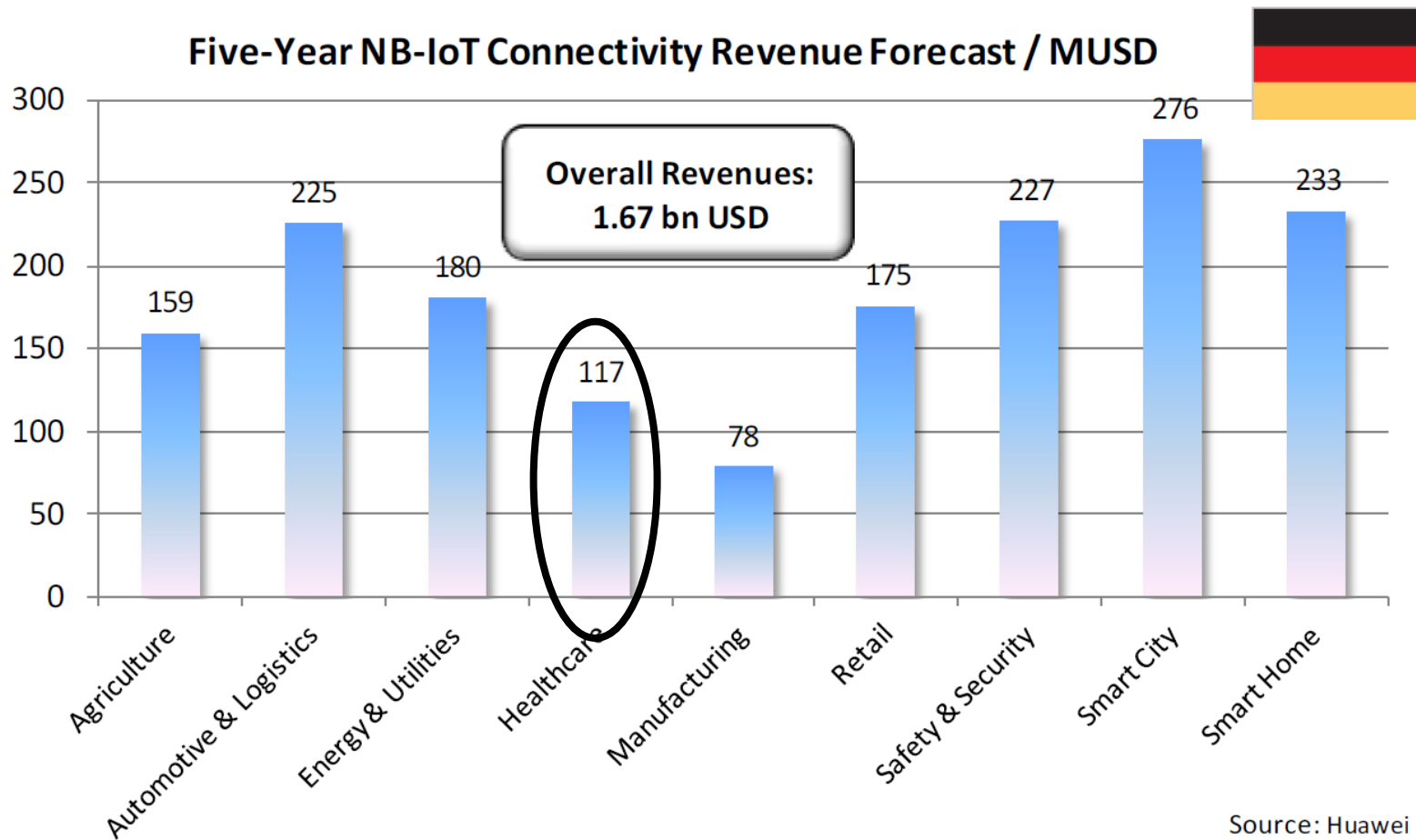
Improved reach

Improved value – consumer lifestyle

Improved process efficiency

Improved human efficiency

the internet of things

Third wave

Networked industries

Networked everything
Networked society

Second wave

Networked consumer electronics

50 billion units

(in 2025)

First wave

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Source: Ericsson

HOW DO WE GET ALL THESE DEVICES CONNECTED?
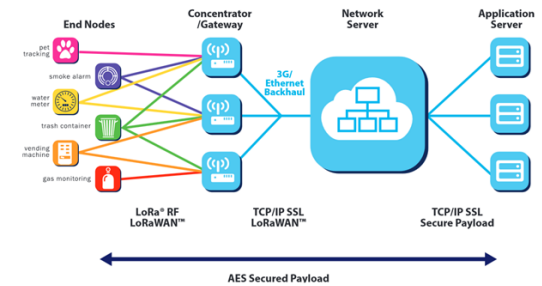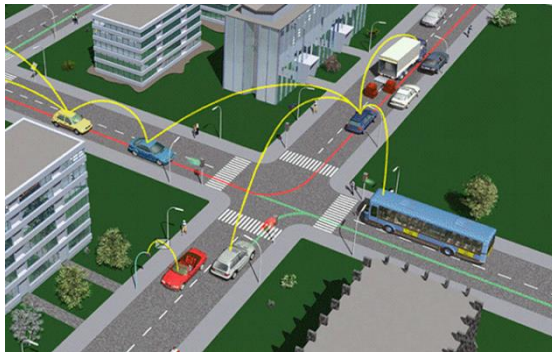
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A specific example – power meters

- Powermeter for automated reading of use and enabling differentiated pricing
    - 3.3 Million meters in Denmark – 42 billion readings per year (when fully implemented)
    - To compare
        - 8 billion SMS per year
        - 1.1 billion Dankort transactions per year

The CERN experiment – a classic example of a Time Sensitive Network (TSN) based on "classical" technology (Ethernet)

Muon Detectors · Electromagnetic Calorimeters · Solenoid · Forward Calorimeters · End Cap Toroid · Barrel Toroid · Inner Detector · Hadronic Calorimeters · Shielding

Detector characteristics
Width: 44m
Diameter: 22m
Weight: 7000t
CERN AC - ATLAS V1997
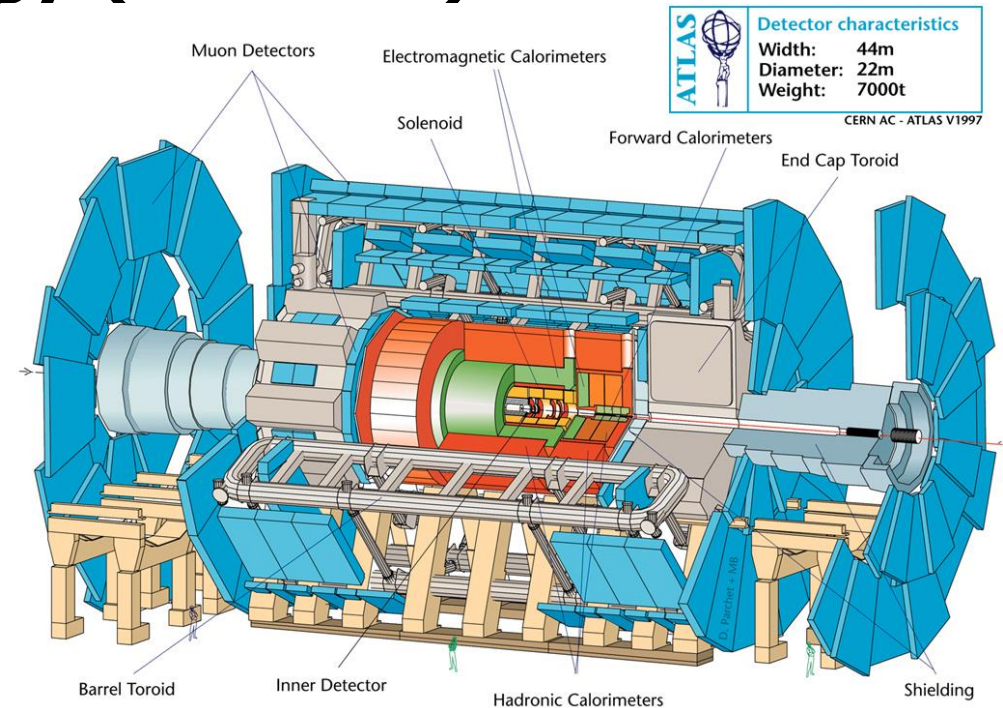
Massive amount of data from many sensors that needs be time correlated

IoT is often more about latency and jitter than capacity

The conneted car (and other transport tools)

Several Tbyte data per trip generated from sensors and engine control

In 2017 more SIM-cards were installed in cars than in smartphones

60-80 GBytes data per race – send in realtime to team researchers (in this case Williams in Oxford)

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Network architecture evolution

DTU Fotonik, Technical University of Denmark

Summer University 2009

The Internet
"from the outside"

The INTERNET

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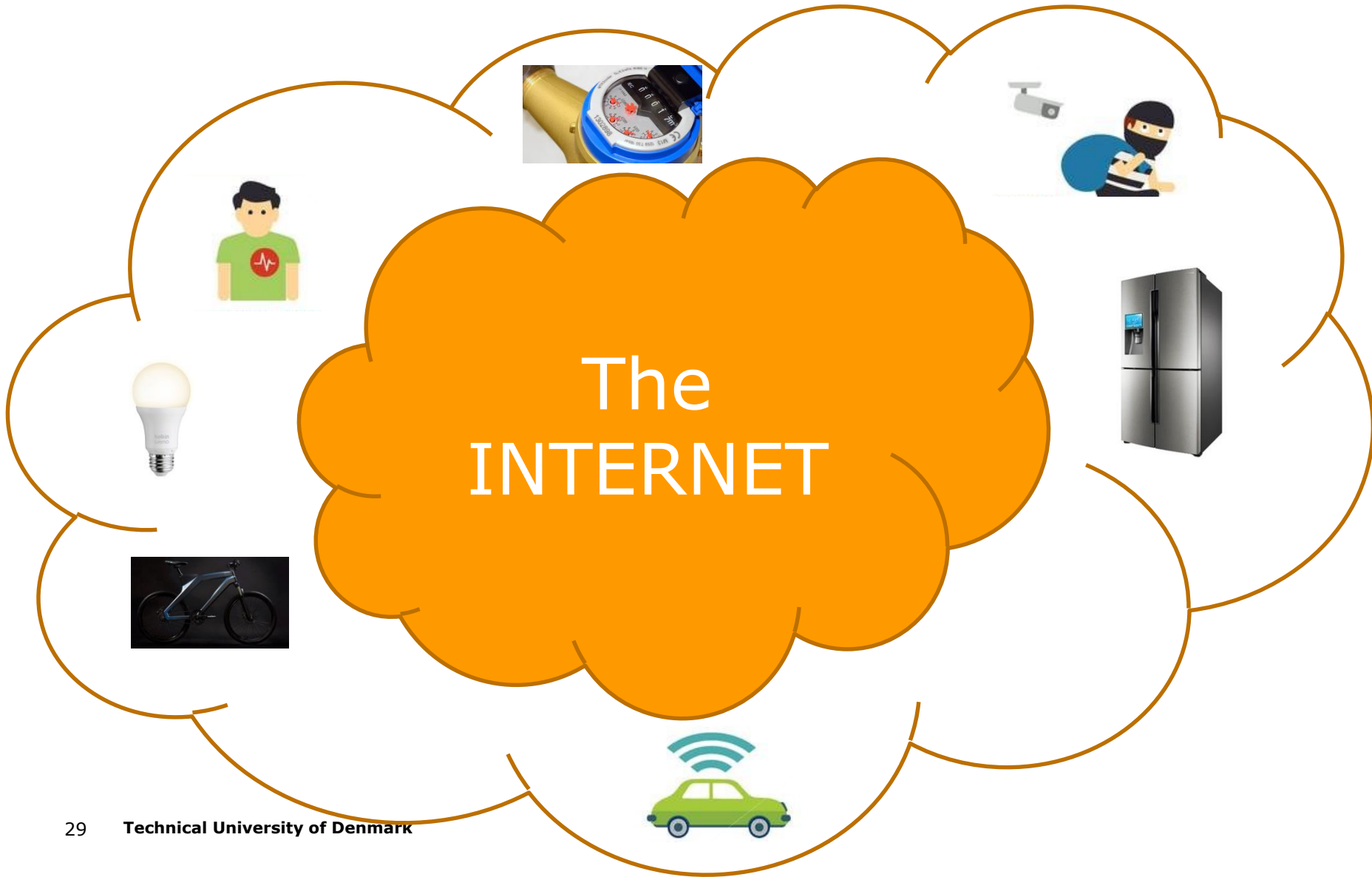
The Internet
"from the inside"

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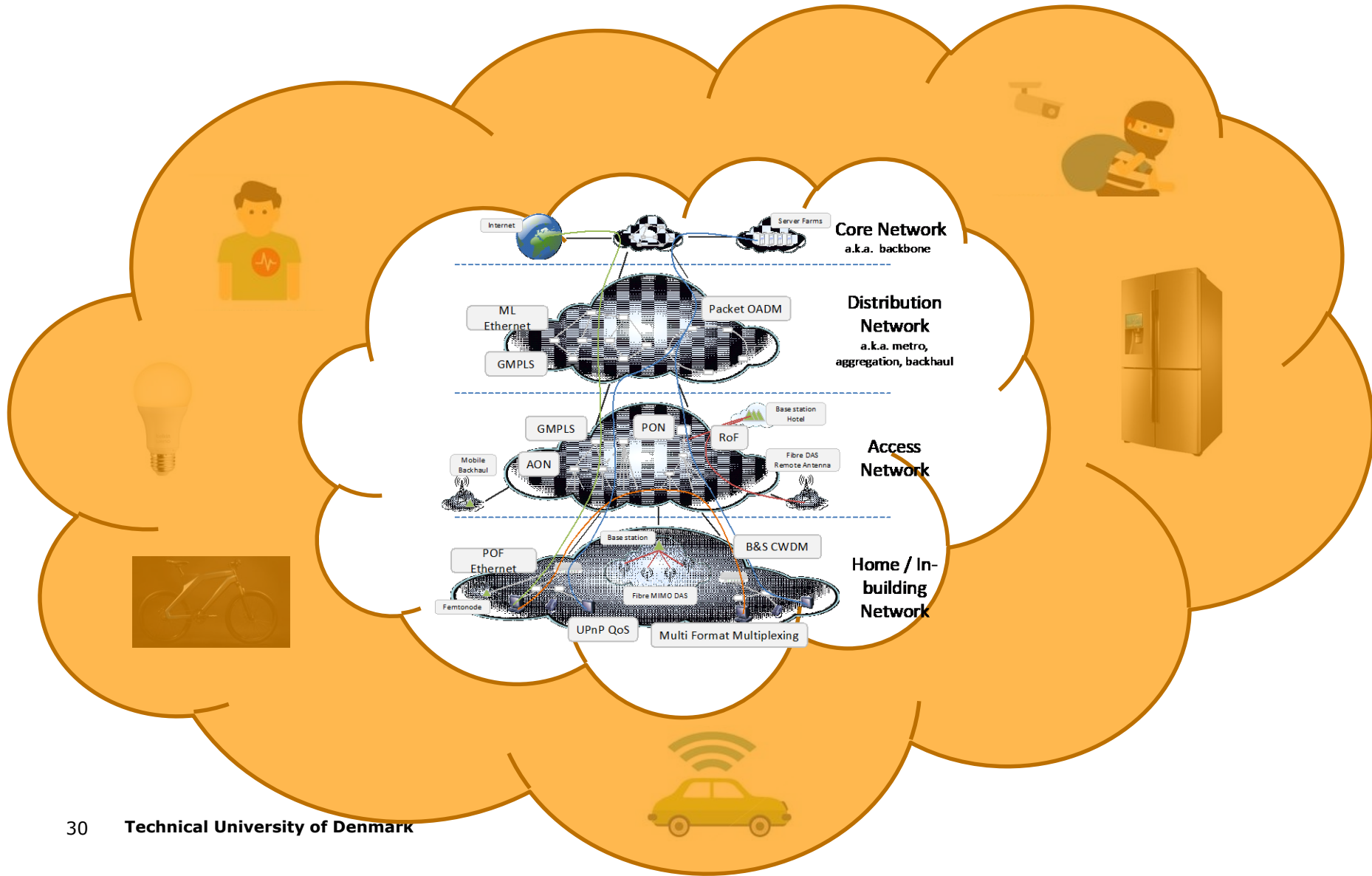
Network and services becoming more integrated

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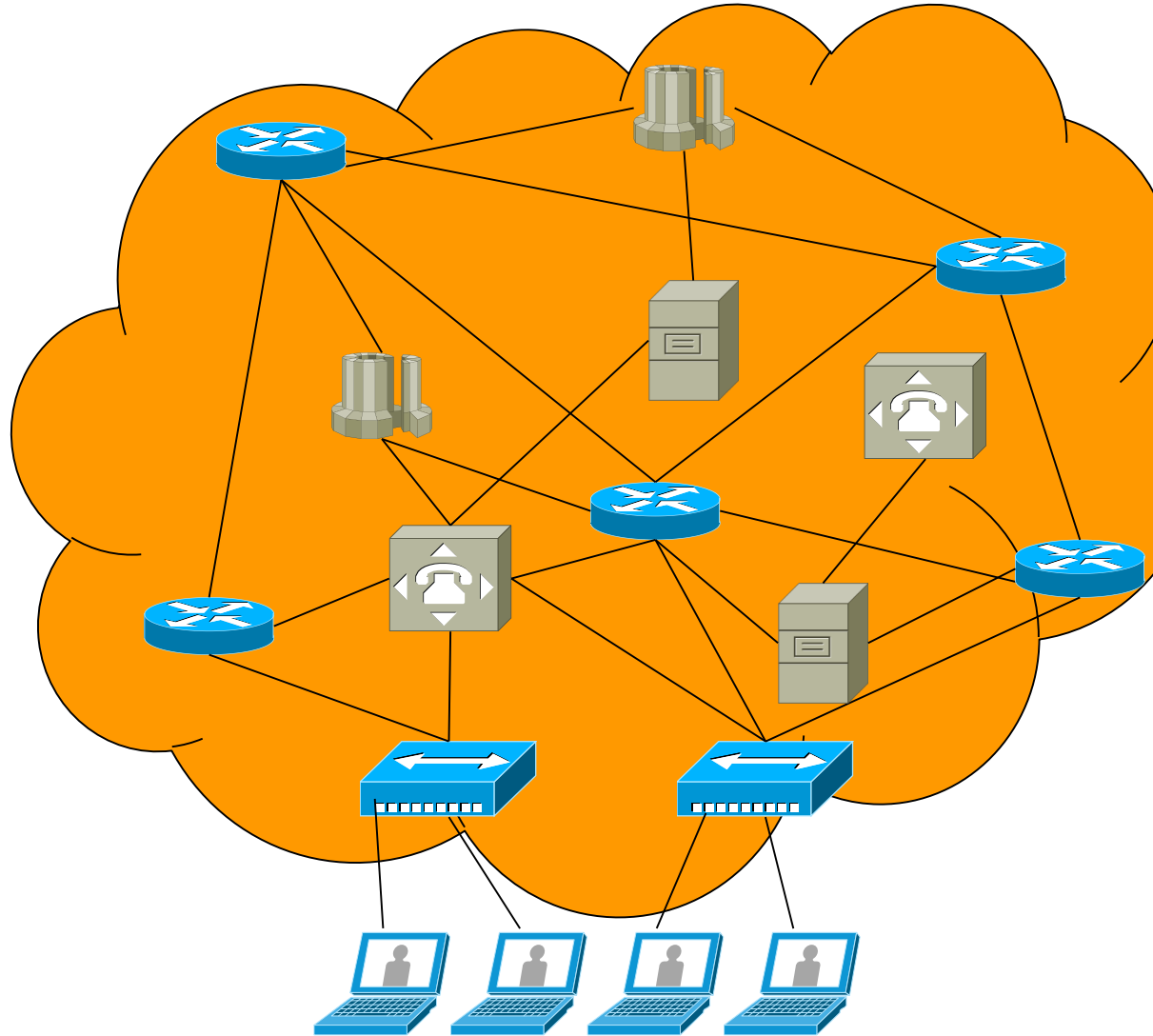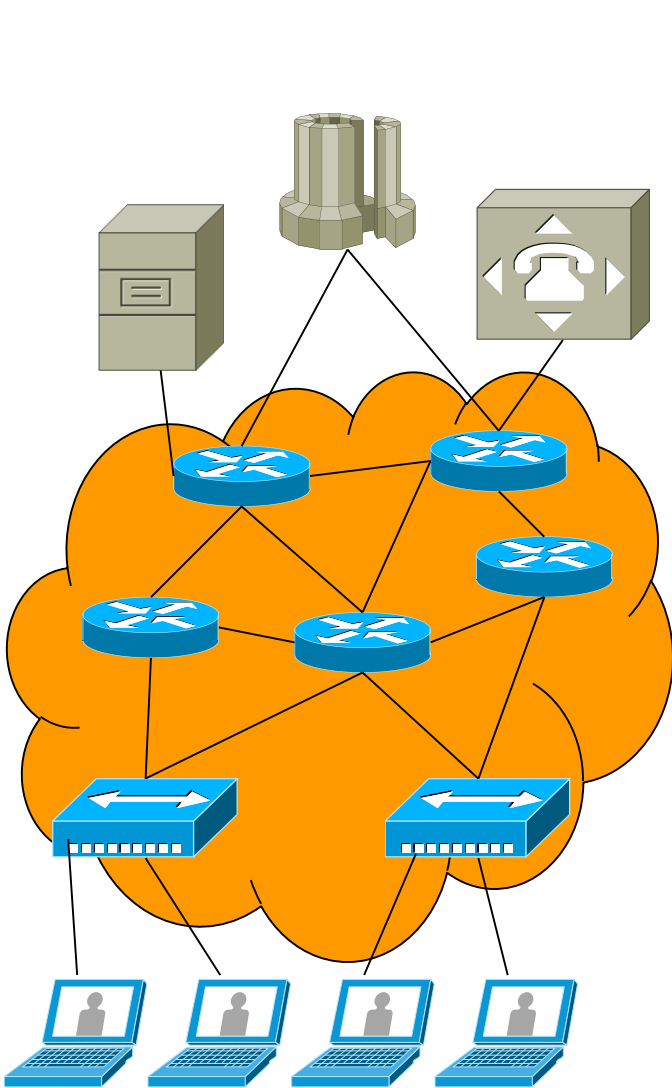
Future Internet
- "new applications and easier use"

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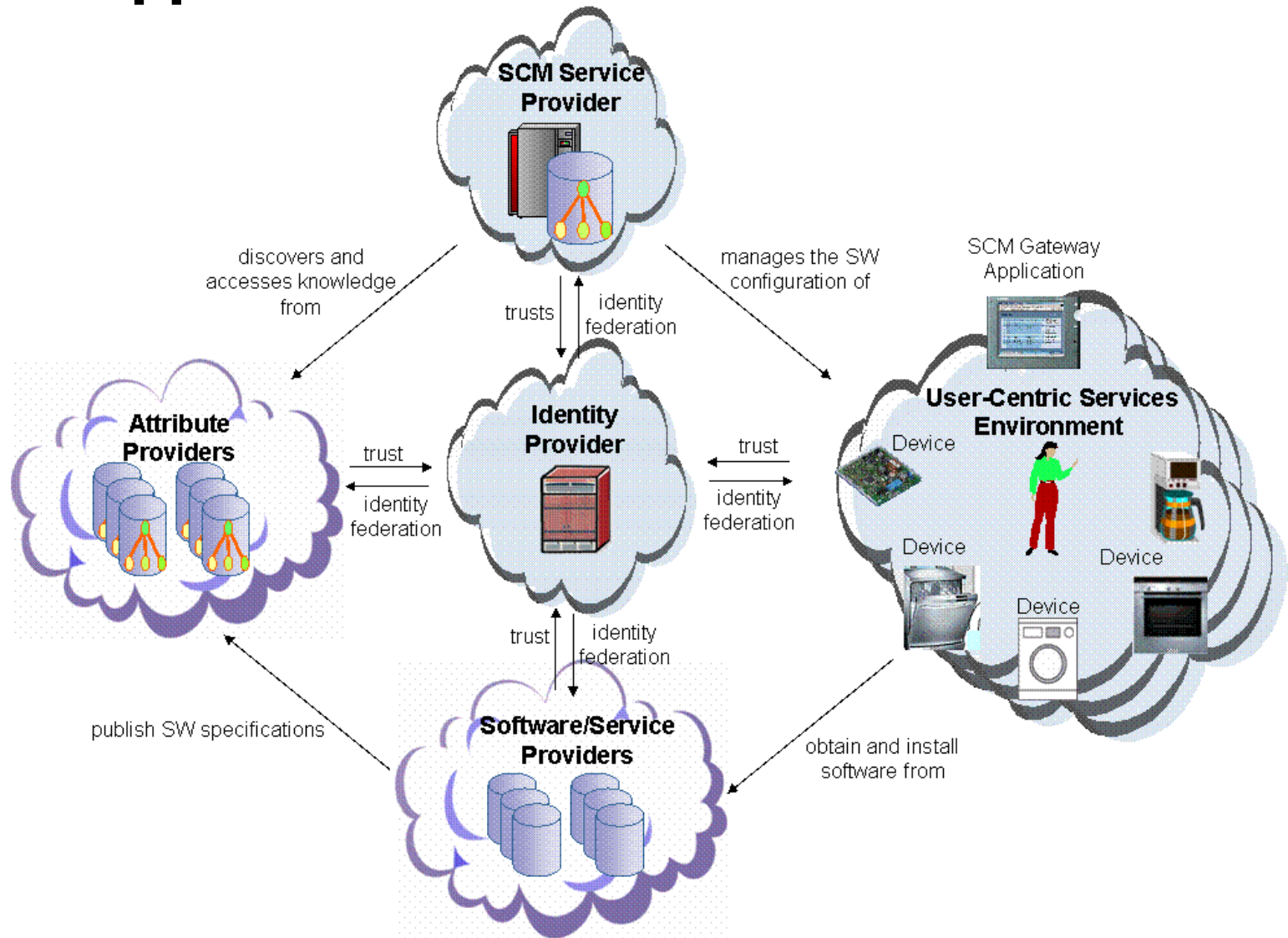
Data flow and service structure

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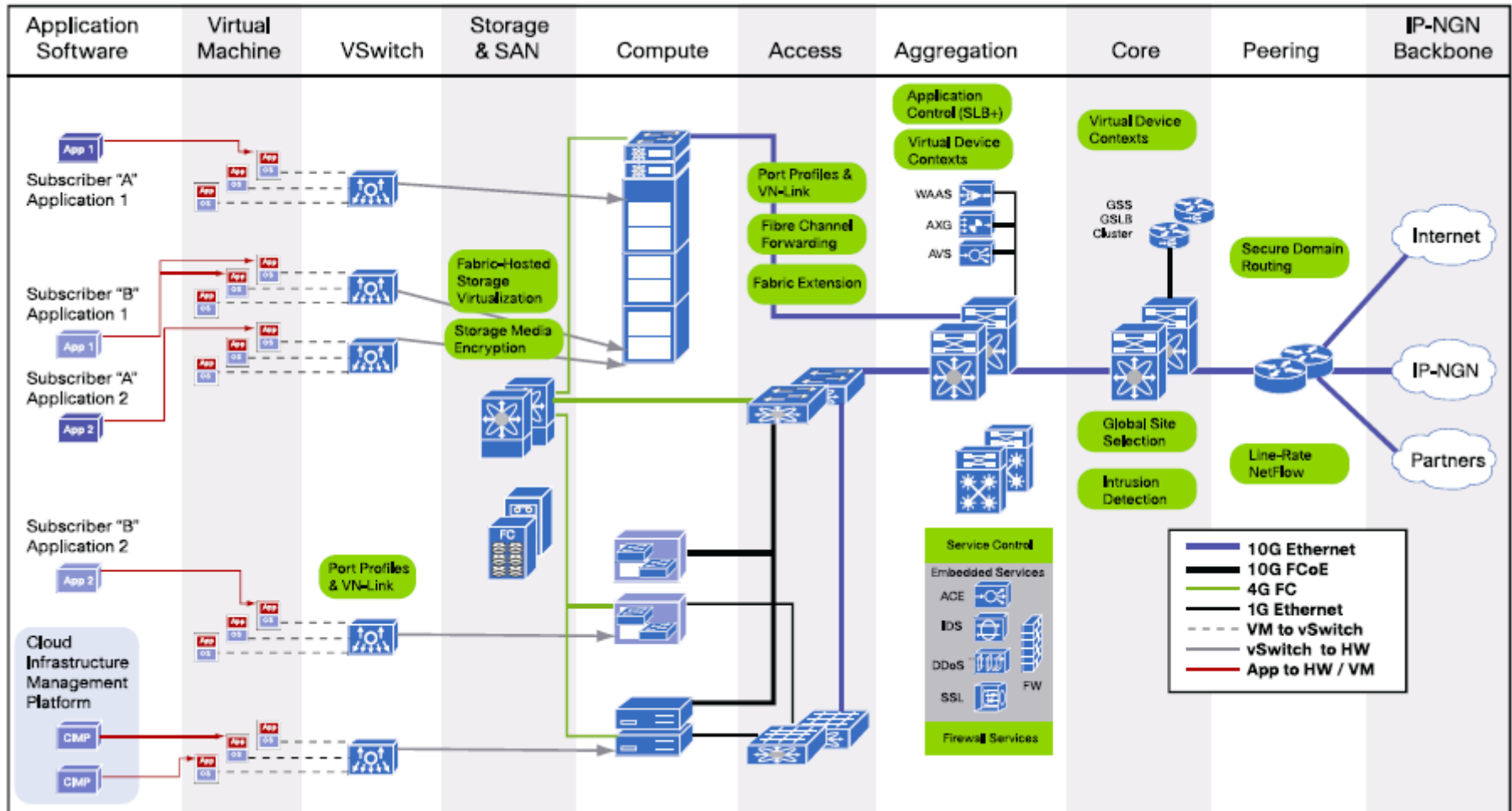
Where do we move the data – the "Cloud"

Controled application infrastructure (Network, computing, storage)

Global public Internet (Network, computing, storage)

Private home ICT infrastructure (Network, computing, storage)

Controled application infrastructure (Network, computing, storage)

Global public Internet
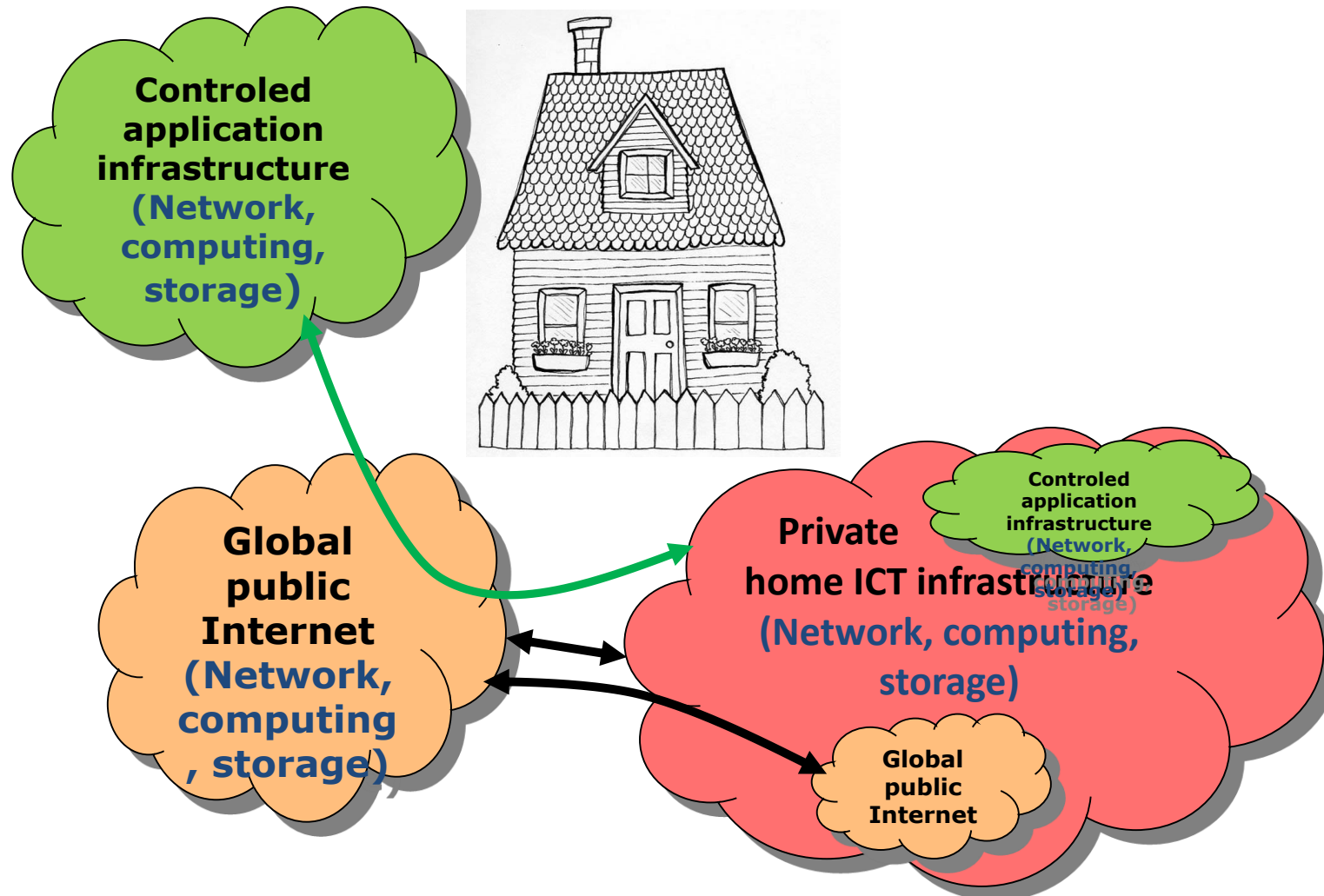
Secure and reliable use of data in realtime applications

- Data plays an important role in many new applications – intelligent support in transport system (cars, trains, aircrafts)
- Data security is strongly linked to data availability – unavilability of data is often bigger risk than data leaks in for example healthcare.
- Latency is becomming a bigger and bigger problem for ICT applications – location and mirroring of data is essention in realtime use.
- IoT driven ICT systems

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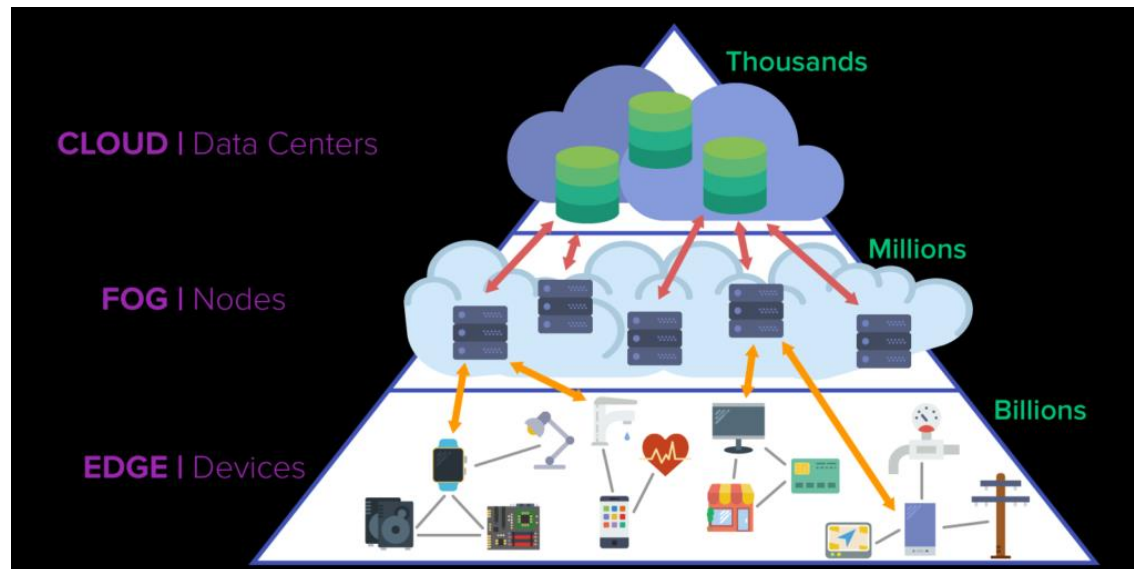
Cloud – a technology not a "place"

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Stratified future internet

Source : FMIA-TT_Reference Model_Ver1 0 _20110301
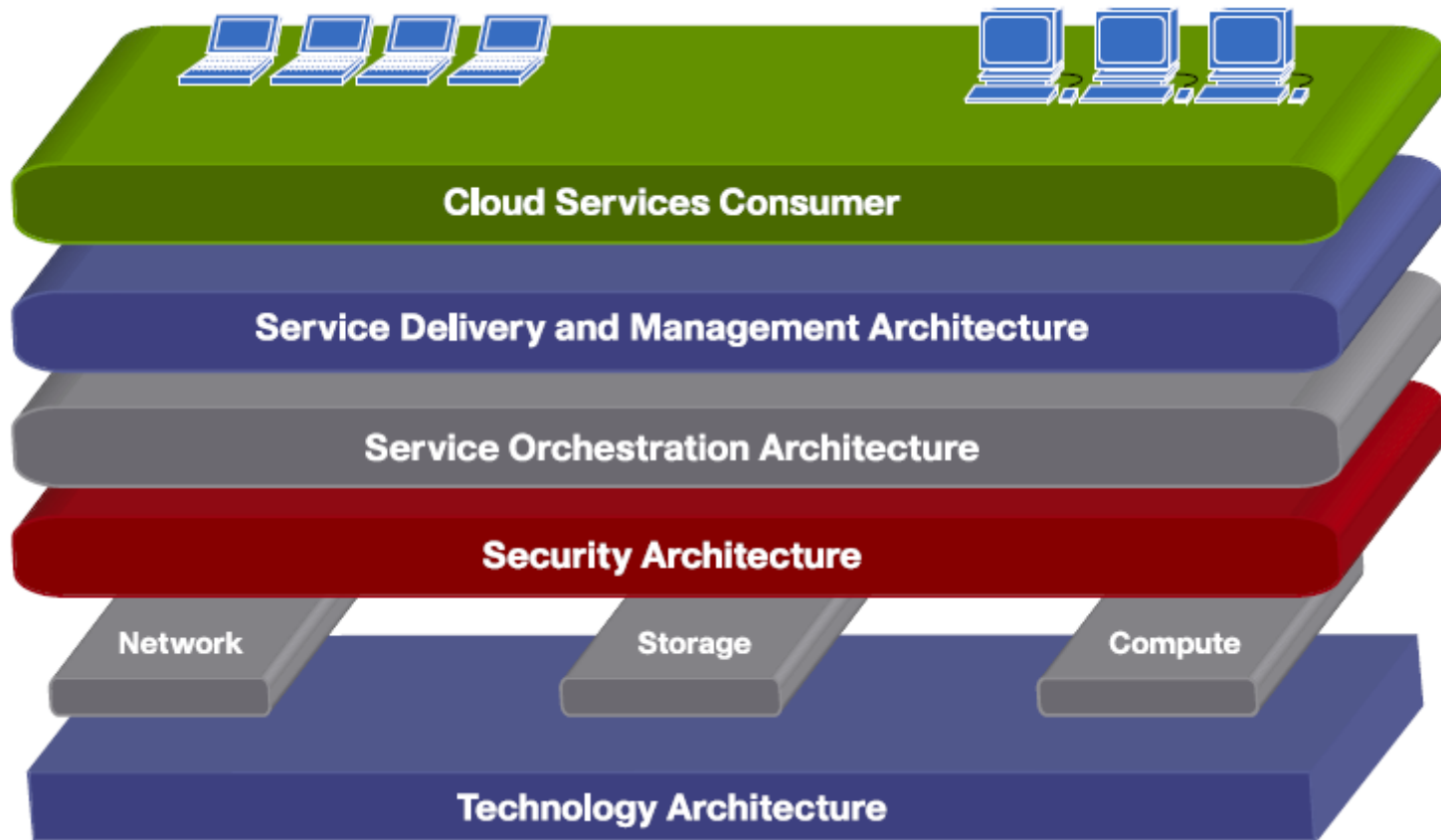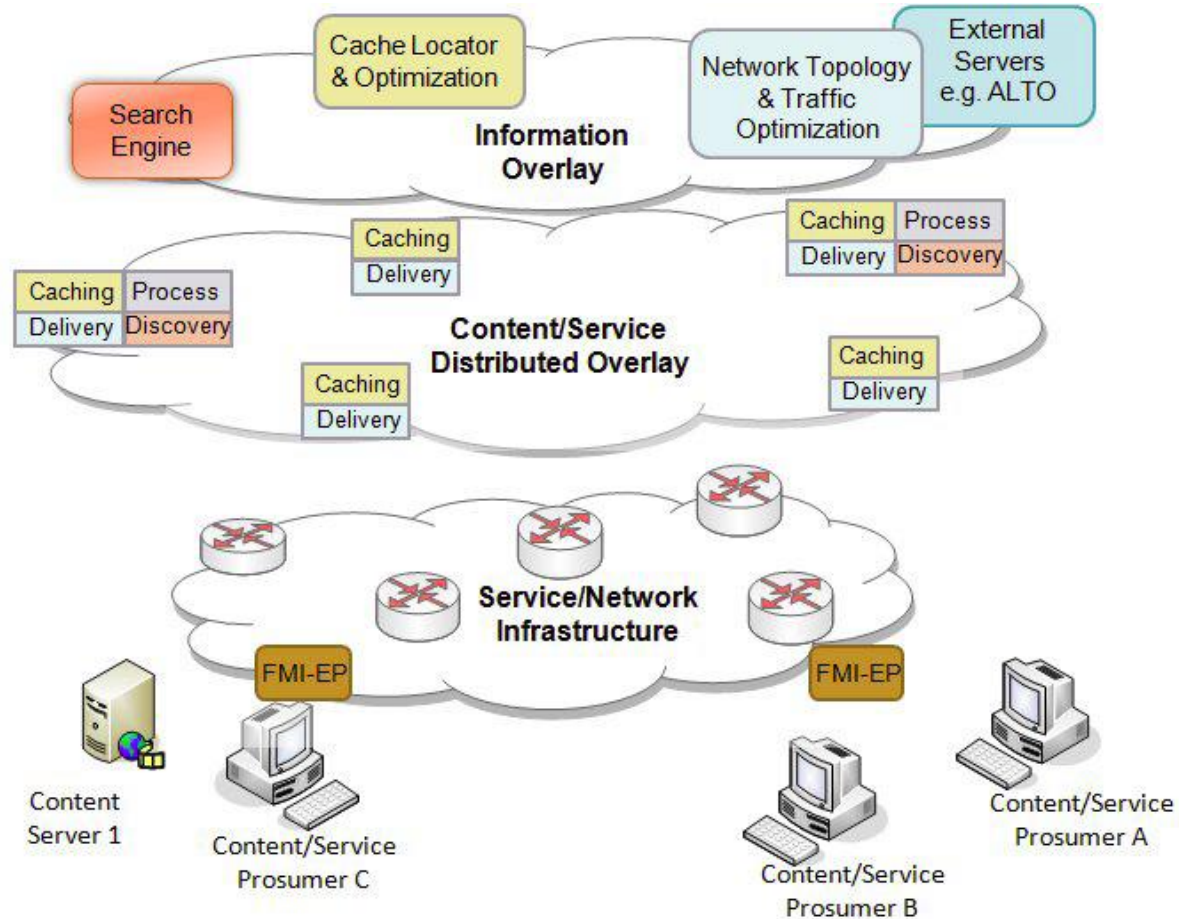
Startified Future Internet architecture

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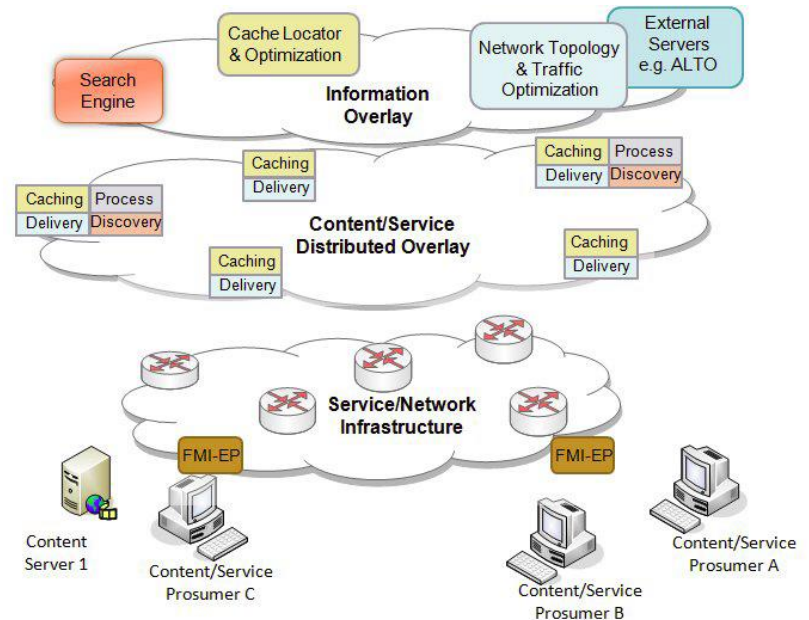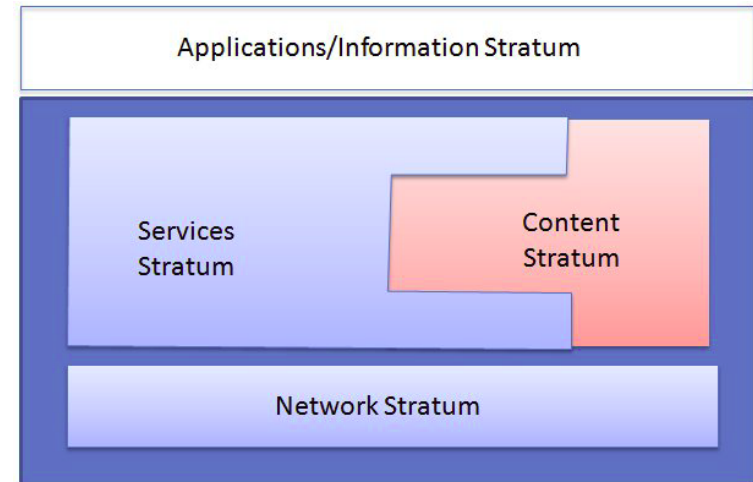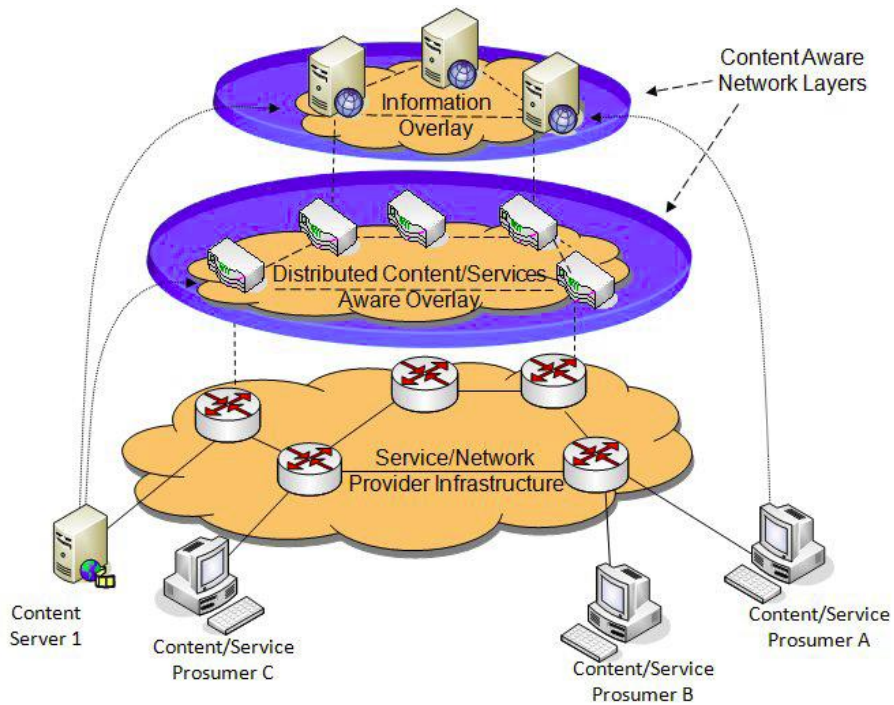
5G slicing – stratification in the next generation access network (breaking net neutrality?)
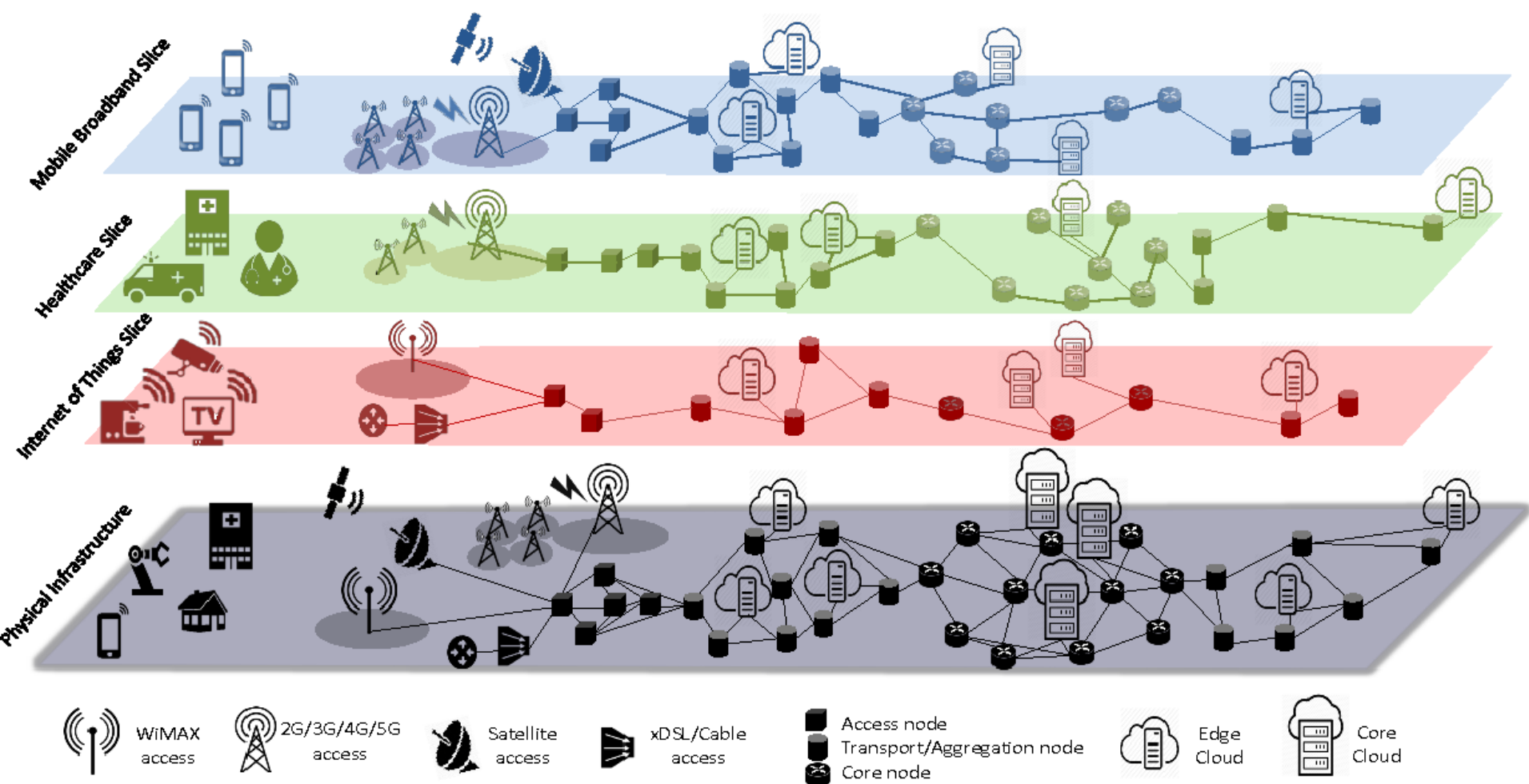
Conclusion

- Current internet is primarily an entertainment platform – suited for some gadgets, but not critical IoT applications.

- IoT and eHealth will require much higher availability and security to become useful for critical applications in e.g. healthcare and other similar areas.

- IoT and eHealth is not so much about high bandwidth/capacity as now – the quality of the Internet of Things will have to be measured differently than today.

- Services and infrastructure needs to more tightly integrated.

- Network elements will become service elements (e.g. basestations and accesspoint will also become a part of data and processing services)

- Trusted service management a must!!

- Generic platforms (open?) are essential – possible?
5G slicing approach promise solution, but needs validation. Significant investment needed!! (estimated 1200 Billion DKr/year investment in R&D worldwide for the coming years to reach goal)

Questions

$$f(x+\Delta x) = \sum_{i=0}^{\infty} \frac{(\Delta x)^i}{i!} f^{(i)}(x)$$

Δ $\int_a^b$ ε Θ $\sqrt{17}$ ∞ $+$ Ω $\int$ $\delta e^{i\pi} =$

{2.71828182845

χ^2 $\sum$!
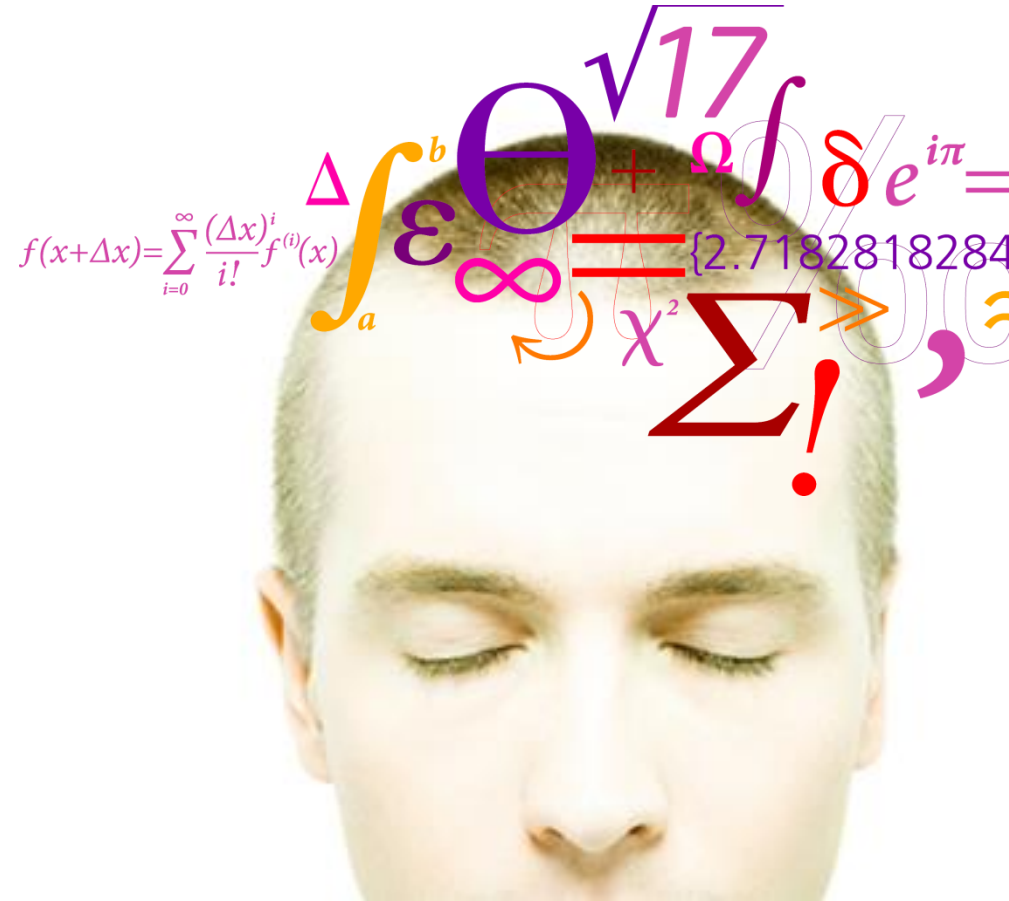
Datahijacking in the core of the internet

- Rules and regulations are different from country to country
- Currently strong focus on location of stored data (e.g. GDPR regulation in EU)
- However, very little focus (or knowledge) on how data is reaching the datacenter/storage location.
- Source and destination might be in same country or regulated region, but the data path might go through other parts of the world.
- The Internet was based on trust – and has basically not really been upgraded since.
- Let's have a look at the routing procedures of the internet – the BGP protocol.

"5G mobile network evolution"
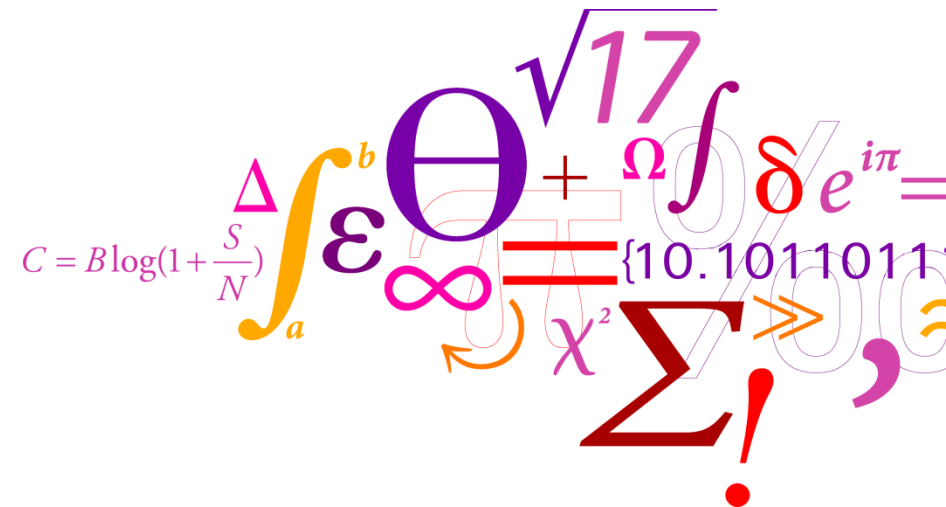
5G as a solution for next generation telecom

- 1st phase telecom: We connect buildings

- 2nd phase telecom: We connect people

- 3rd phase telecom: We connect things

Telemedicin is a key driver for 5G

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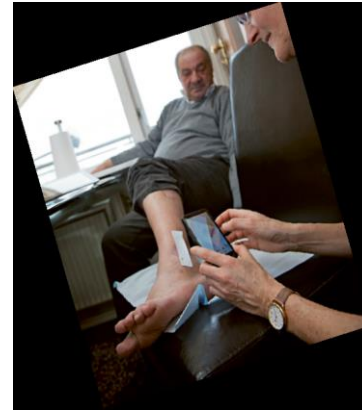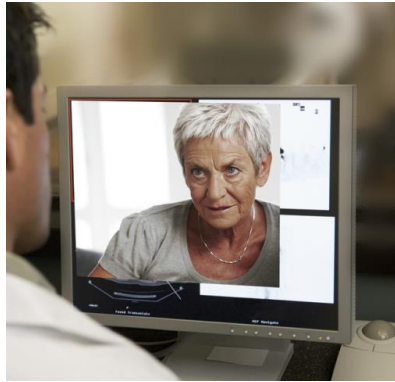
5G slicing

- Traditional network design mode cannot meet the requirements of diverse and isolated 5G scenarios
- 5G network slicing technology is an innovative technology in the 5G era. Based on a common infrastructure, it flexibly provides low-cost, differentiated, customized, and isolated end-to-end networking capabilities to meet the vertical industry's differentiation and customization requirements.

mMTC

No mobility, small data : 100kbps
Low throughput, terminal life:10years
High density:
100 million connections/km2

eMBB

High throughput : 100Mbps~1Gbps
Supporting high mobility

uRLLC

Latency : 5ms~20ms
High reliability
Supporting Edge computing

- Diverse requirements
- Differentiated performance and functional requirements

Evolution from traditional one-fit-all to customized and on-demand networking

4G : One network carrying multiple services (Mobile broadband, IoT)

PCRF

UE — eNB — SGW — PGW — Traffic Flow1 / Traffic Flow2

4G one-fit-all :
- Using APN/QoS parameters for different traffic flows, and the weak isolation between traffic flows
- One-fit-all network, Complex functional design
- Inflexible feature extensions

5G Network Slicing : Logical isolation/dedicated (diverse, differentiated scenarios)

UE1 / UE2 / UE3

Slice1 — eMBB AR/VR
Slice2 — mMTC IoT
Slice3 — uRLLC Automatic Driving

1956 2016
CCITT / ITU-T

中国移动 China Mobile

ITU

Standardisation is not that simple.

Relationship between 3GPP and other SDOs
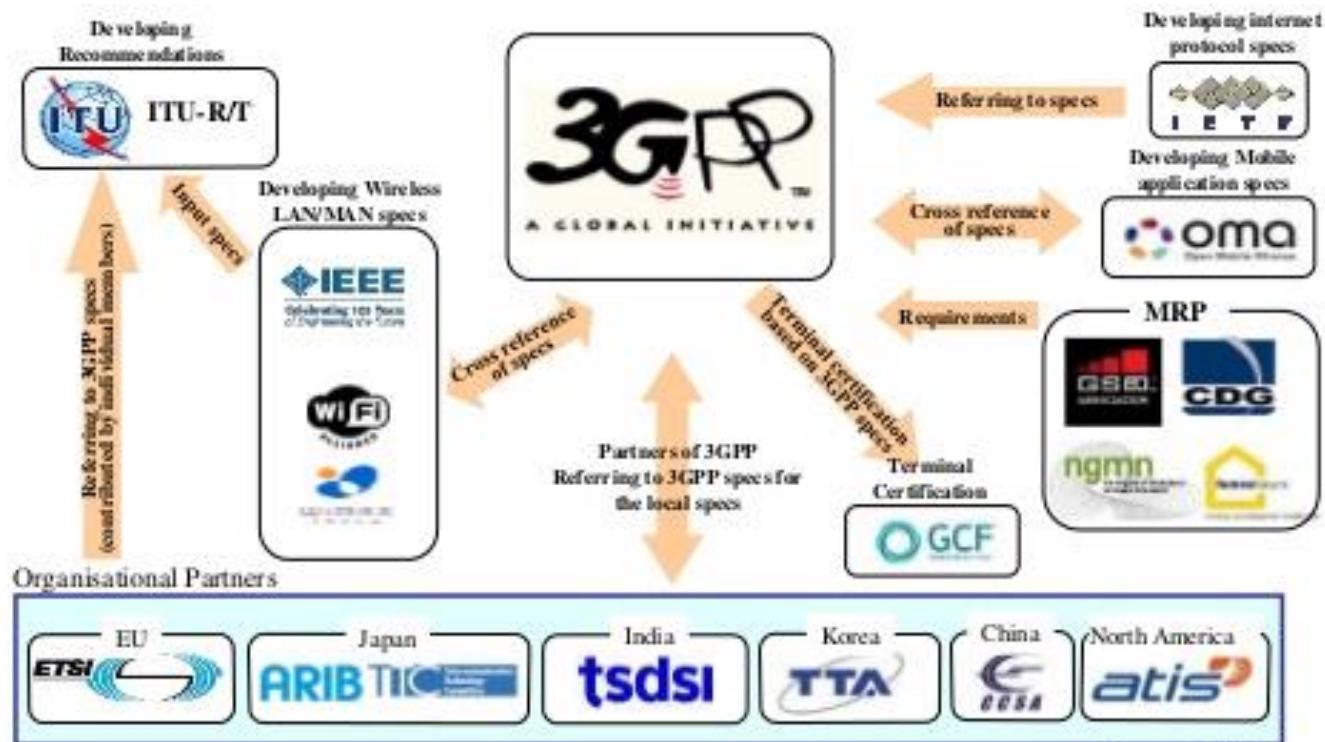
Source: 3GPP

Standardisation is not that simple.

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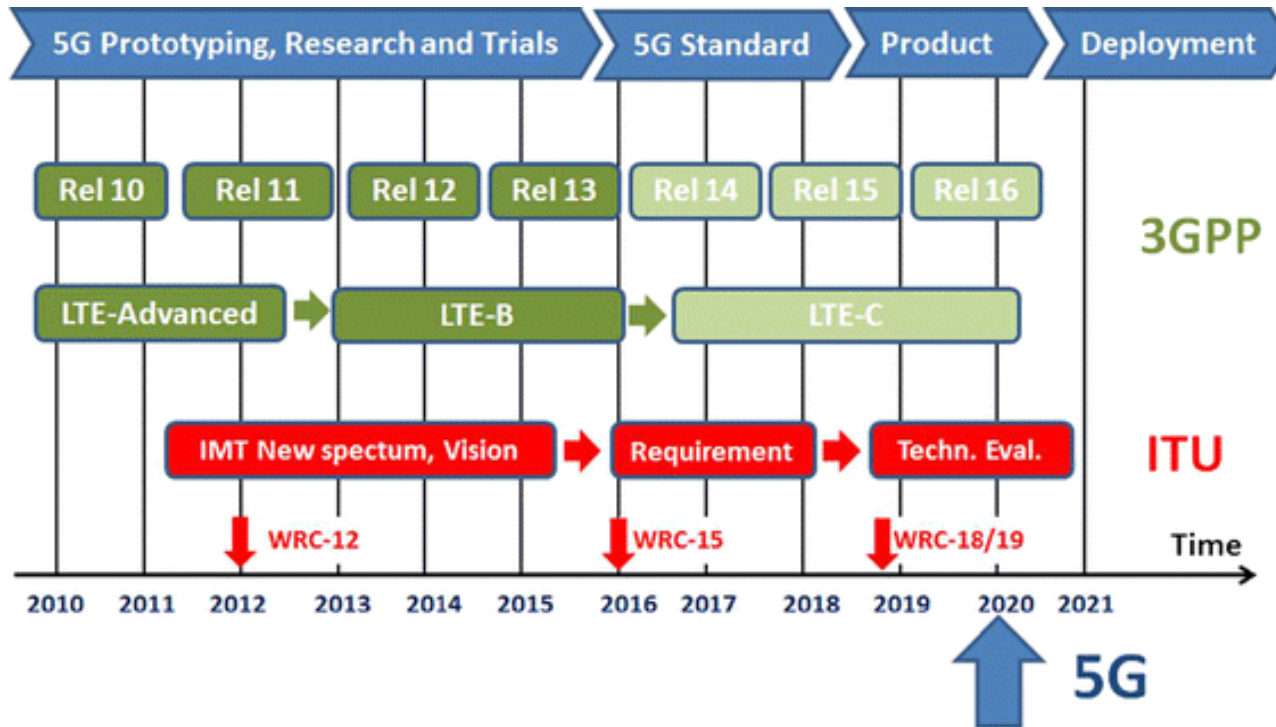
Radio Frequence allocation

Detailed Timeline & Process For IMT-2020 in ITU-R
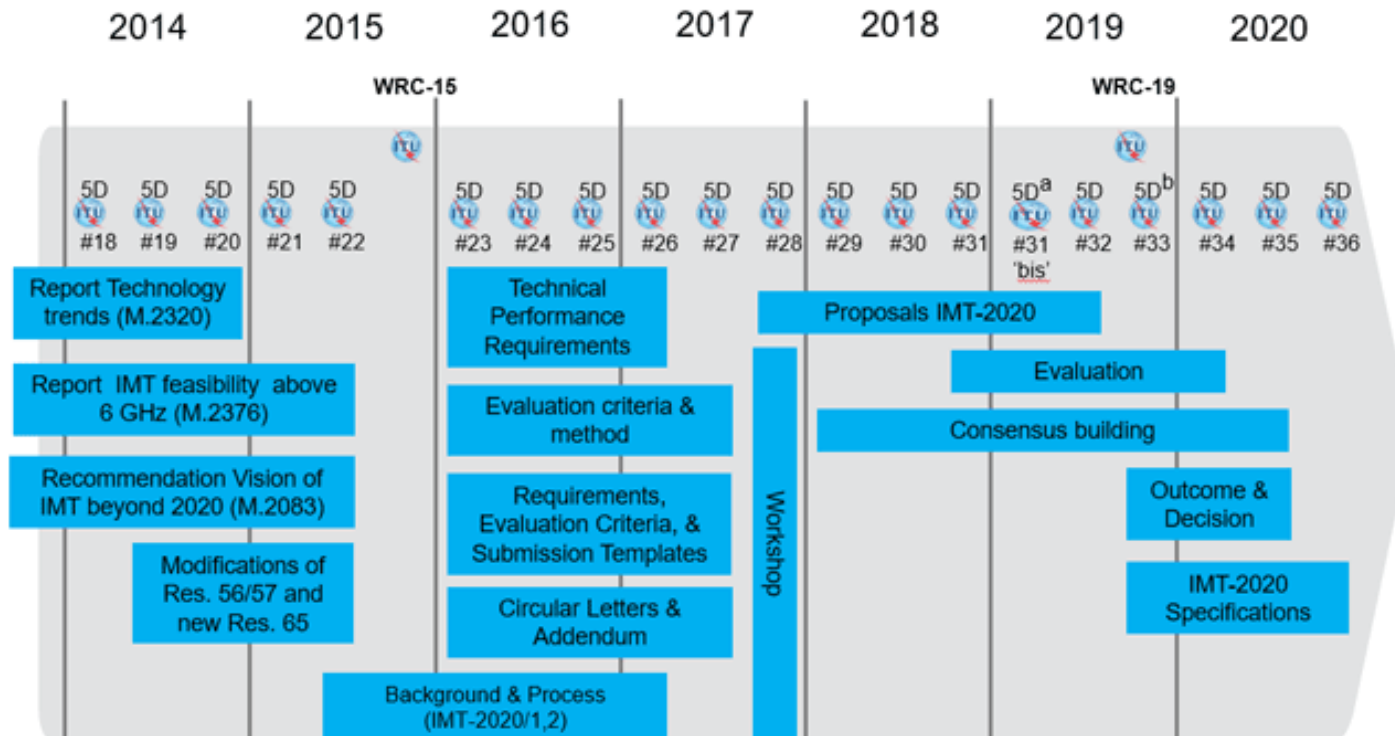
Additional details associated with Figure 1 above including a table of the anticipated IMT-2020 related deliverables.

ITU-R Working Party 5D Planned Meeting Schedule for Years 2016-2020

Getting more capacity in the mobile network
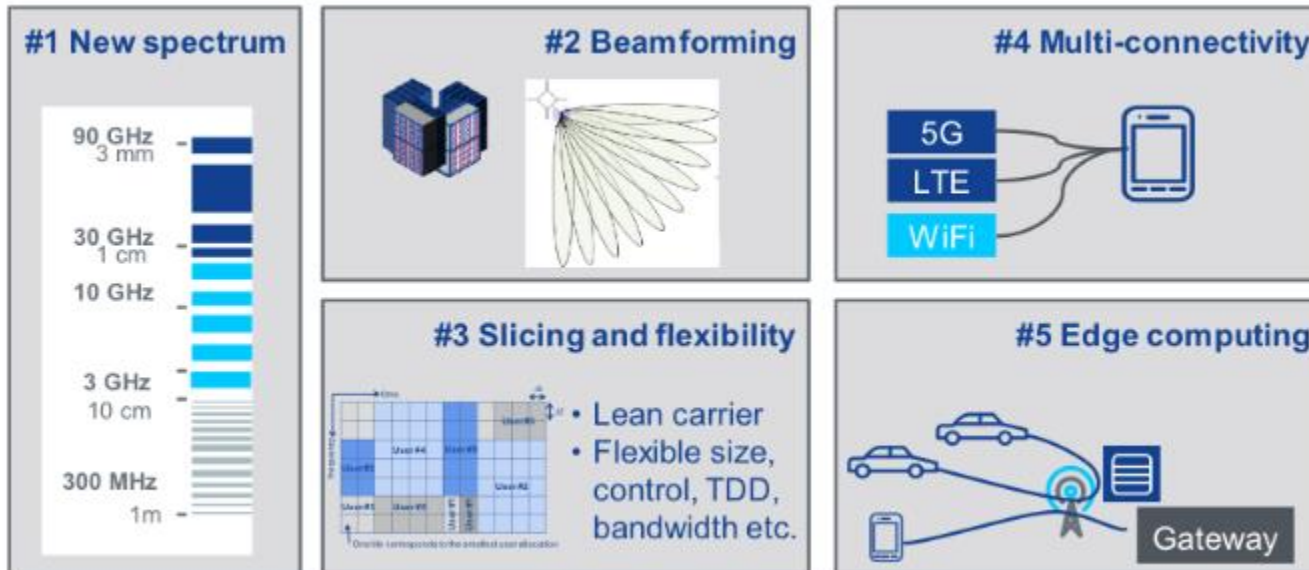
Beamforming – only send signal where needed.
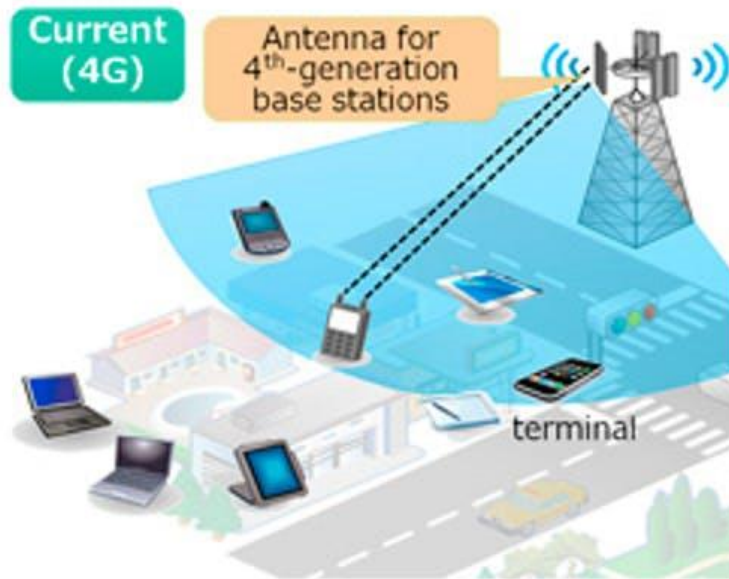
Ultra-Reliable Low-Latency Communication (URLLC)
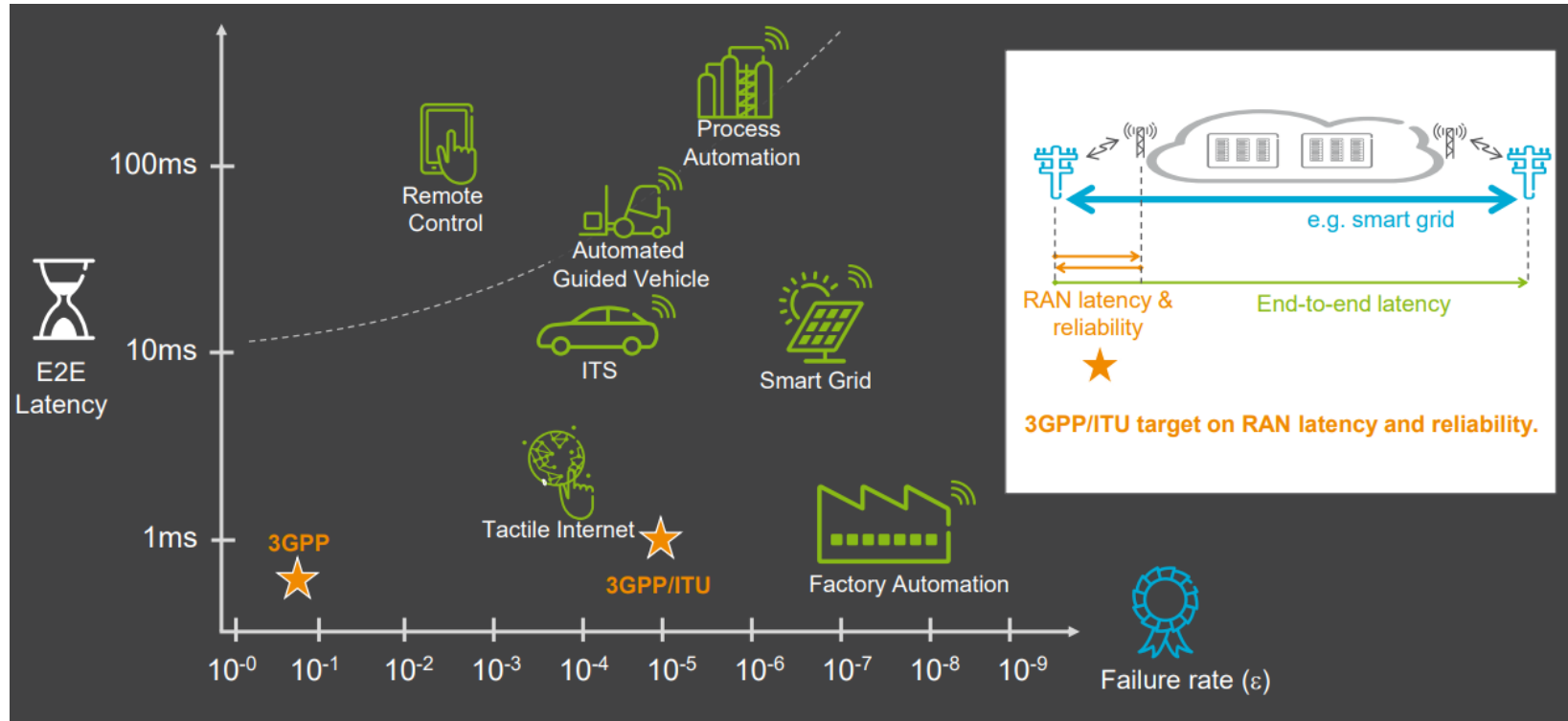
URLLC (Ultra-reliable low latency communication): Services for latency sensitive devices for applications like factory automation, autonomous driving, and remote surgery. These applications require sub-millisecond latency with error rates that are lower than 1 packet loss in 10^5 packets [ITU-R M.2410.0].

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The 5G URLLC
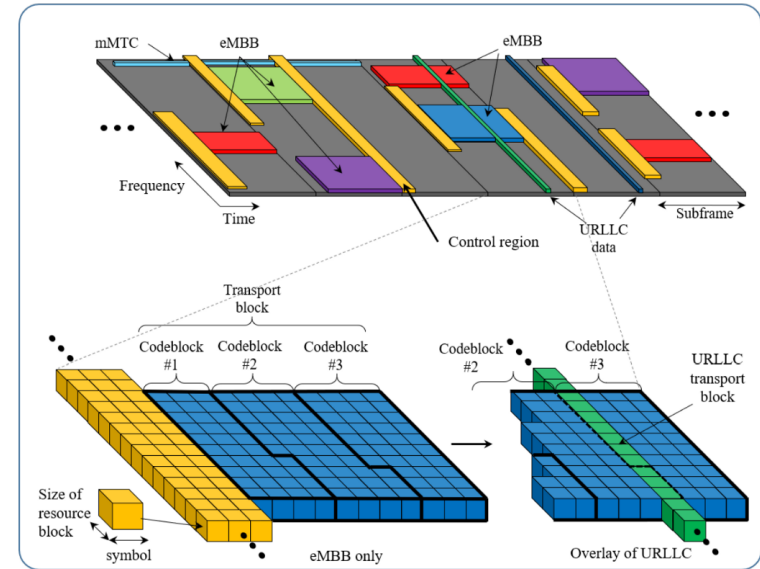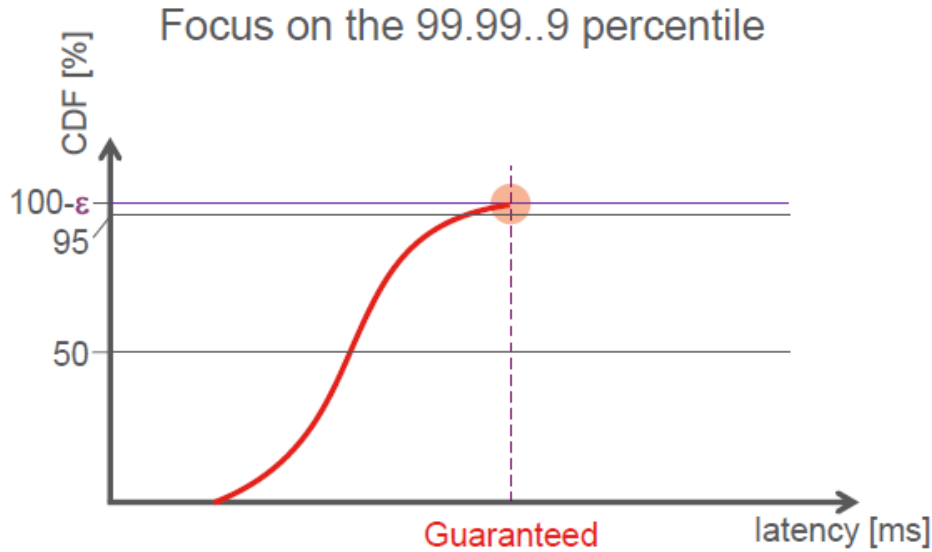
Low latency achieved by sending only 10-100 at a time.
Reliability achieved no-grant communication and diversity
Combining Ultra reliability and low latency ?

Heathcare need to be ultra reliable

Robot:
System immanent latency currently 180 ms
Human:
Maximum latency tolerance 250 ms

Up to 10 Mbps, 5-10 msec E2E

Negotiation and exchange of information with team members / objects

Surgeon

Information basis
- Team members
- EHR (incl. video and Images)
- Supply Chain Management
- Patient flow management
- Billing

Team-members
- Remote surgeons
- Remote Anesthetist
- On-site surgeons
- On-site Nurses
- Radiologist (Digital Images)
- Pathologist (Biopsies)
- Blood-bank
- Pharmacy
- Intensive Care Unit
- Objects, sensors, CPS

Interpretation and Plausibility Check

Robot Internal

Network

Cooperative maneuver and trajectory planning

100 Mbps, 10 msec E2E

Prediction of situation and of intention

Exchange with other Team members / objects

Up to 50 Mbps, 10 msec E2E

Cooperative recognition

Sensor input from different locations and other team members

Up to 10 Mbps, 10-20 msec E2E

Information to other team members

Up to 100 Mbps, 10 -50 msec E2E

Network Specifications:
- Reliability: 99.99x %
- Availability: 99.99x %
- Interference 0
- Indoor penetration 20 – 100 meters
- Outdoor range 1000 meters

Own sensors

e.g. Longitudinal & Lateral tool Accelerations (minimum 5 degrees of freedom), in situ navigation, pressure, temperature, object tracking, etc., video (HD or pre-processed), Sensors for proximity measurements (device-to-device), vital parameters (heart rate, blood pressure, SPO2, CO_2, etc.)

Reliable high capacity and high performance networks

- Maintaining growing capacity in segments (at stable cost).

- Enabling cross layer and cross domain administration.

- Improving resilience (end-to-end).

- Defining new network architectures and new node designs.

- Integrating new areas into common infrastructure.
  – rather than making new
    dedicated solutions.

- Ensure high flexibility e.g. based on virtualization.

- Maintain holistic view.
  (combining generic theory and principles for communication networks.
  – and apply these to many different (all?)
  kinds of existing and future networks).

Source: EU FP7 GEYSERS project
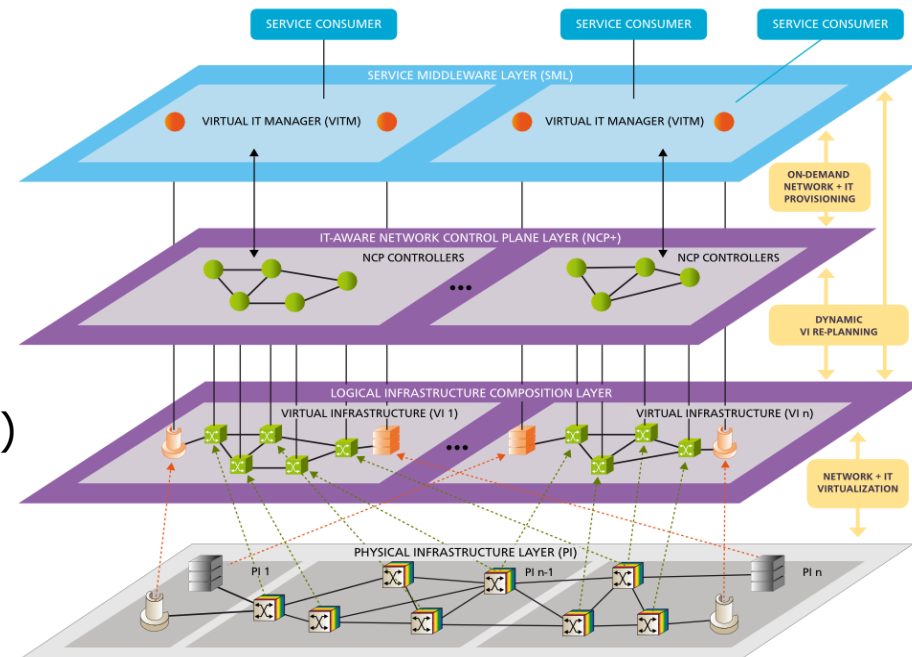
5G slicing – a possible approach for a generic solution (cost efficient ??)

WiMAX access

2G/3G/4G/5G access

Satellite access

xDSL/Cable access

Access node
Transport/Aggregation node
Core node

Edge Cloud

Core Cloud
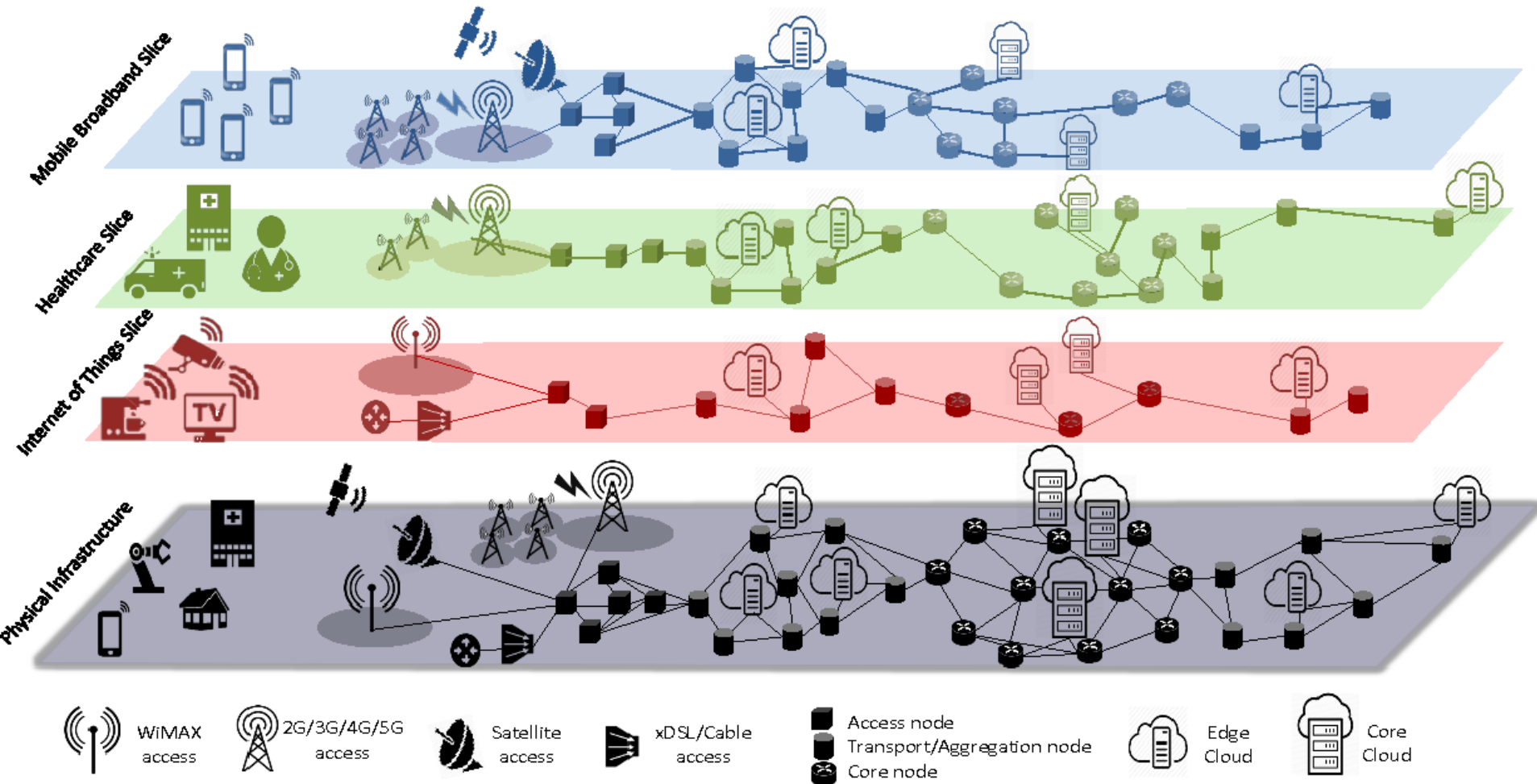
Software Defined Networks (SDN) and Network Function Virtualization (NFV) introduces massive processing and storage functions inside the future ICT infrastructure
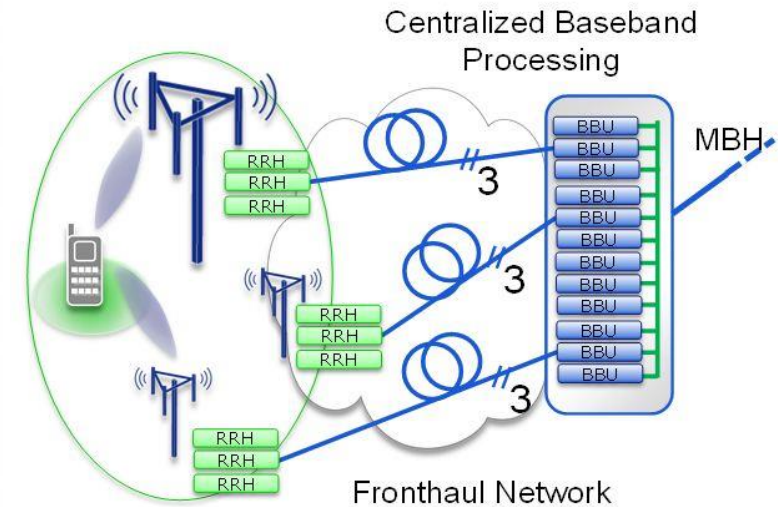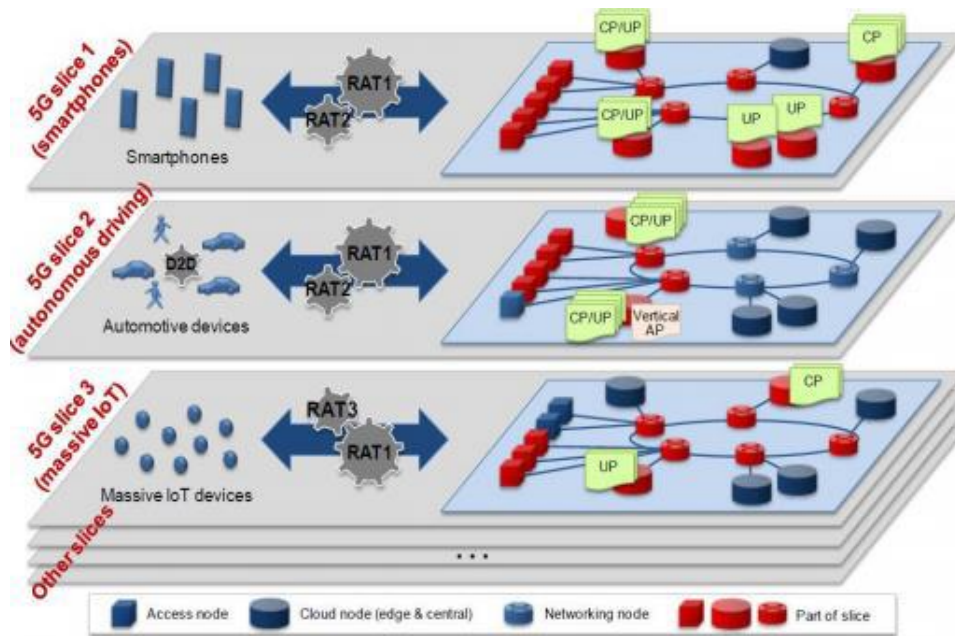
Networks and IT systems gets more and more integrated !!

SDN – Software Defined Networks

- Not a standard – but a concept (creates many interpertations including this ☺)
- "Defined" indicates flexibilitet and dynamisk optimizationering – but the concept is equally about functional distribution and supplier independance).
- Possibilities for fast deployment of services – but also delayed deployent in case of lack of costumers
- Use of resources as a cloud - NFV
- Based on a very centralised control structure – at least logically

Proven concept from e.g. TMN,
ITU M.3000 with Q3 og X interface
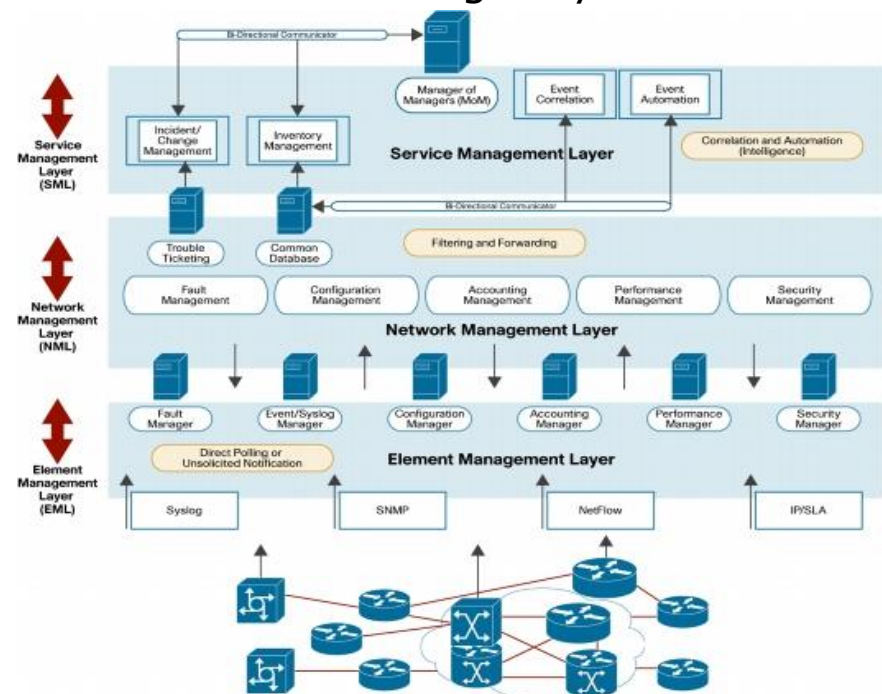
Fundamental demand
– separation of HW og SW

- HW and (primary) SW must communicate via a "standardised" interface – for exampel OpenFlow or NetConf (a.k.a. separation of control plane and dataplane)

- The SW component must be able to work on a separate (general purpose) platform and will be able to control more HW components at the same time – basic NFV.
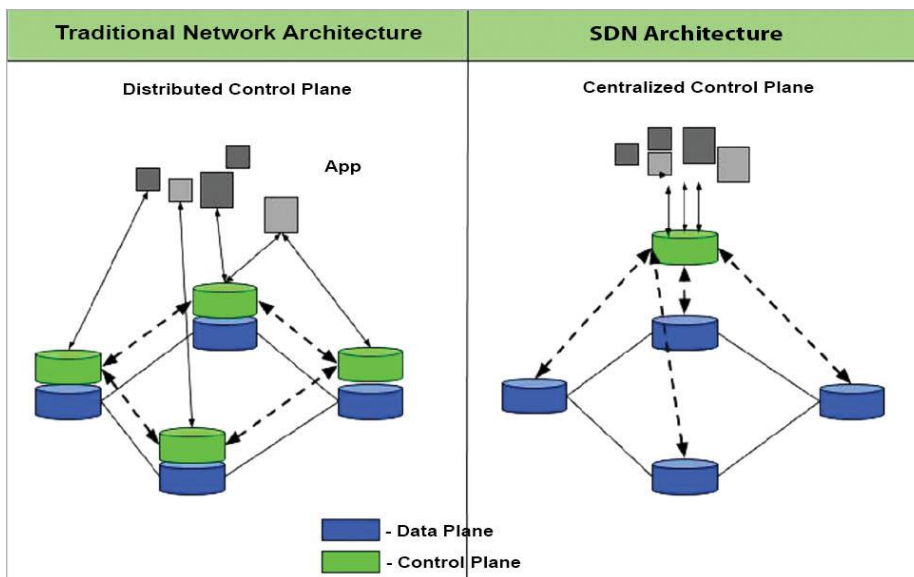
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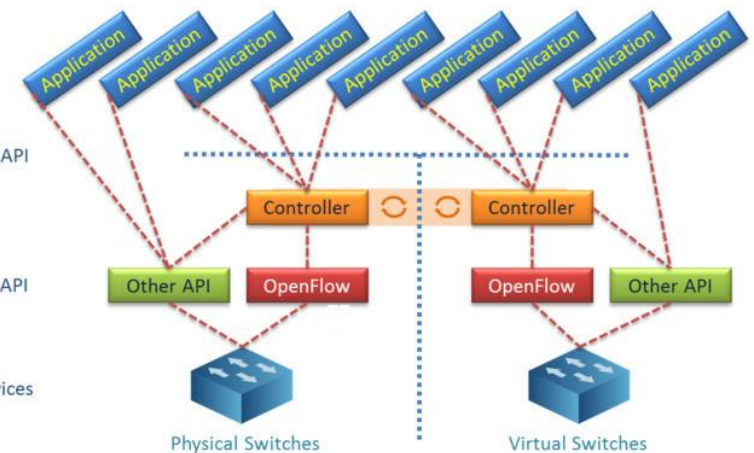
Flow based forwarding
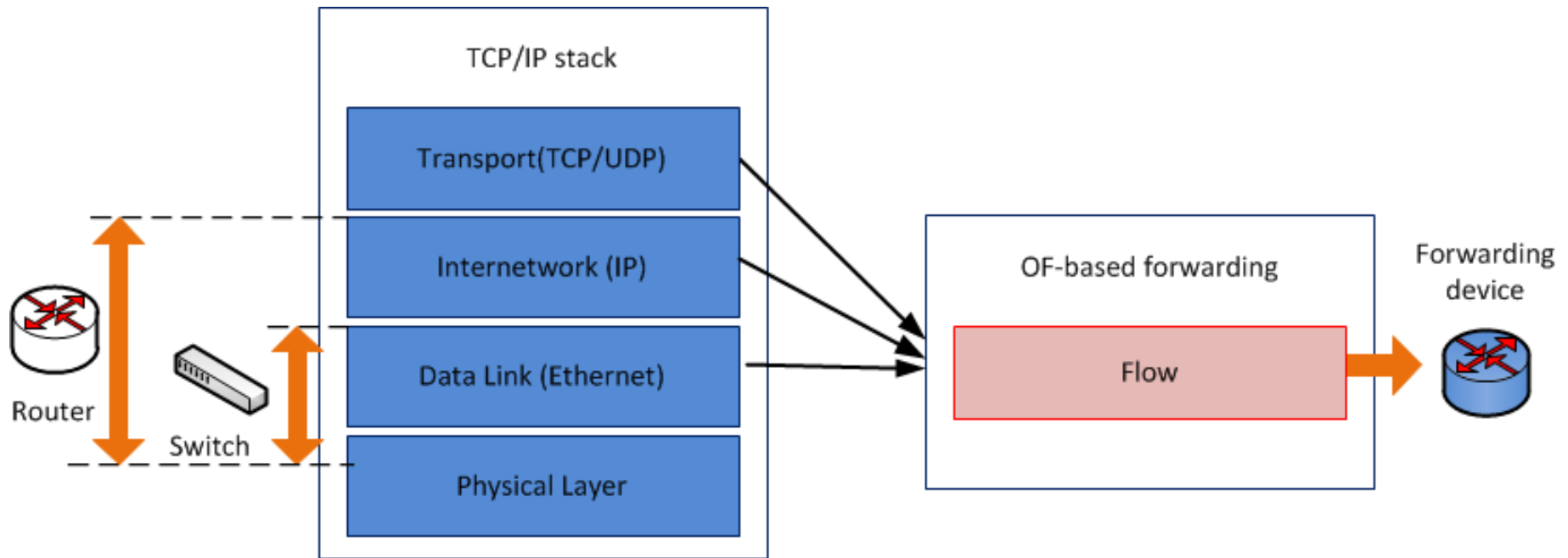
Traditional Forwarding Device: hubs, switches, routers, …

SDN-based Forwarding Device

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One concept – many solutions
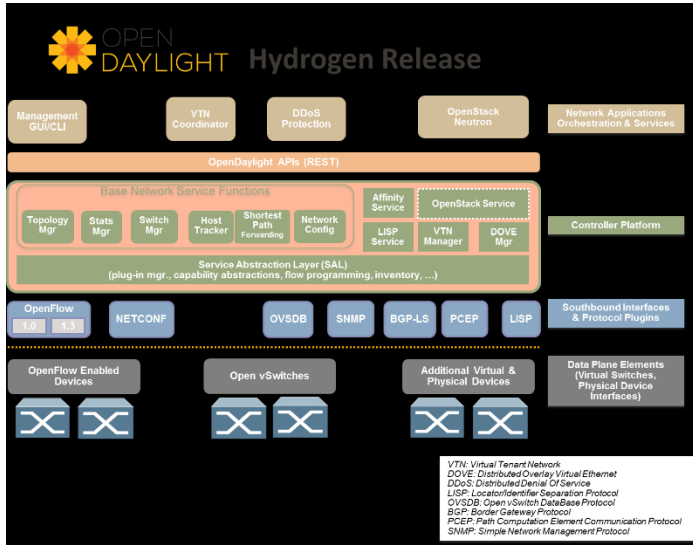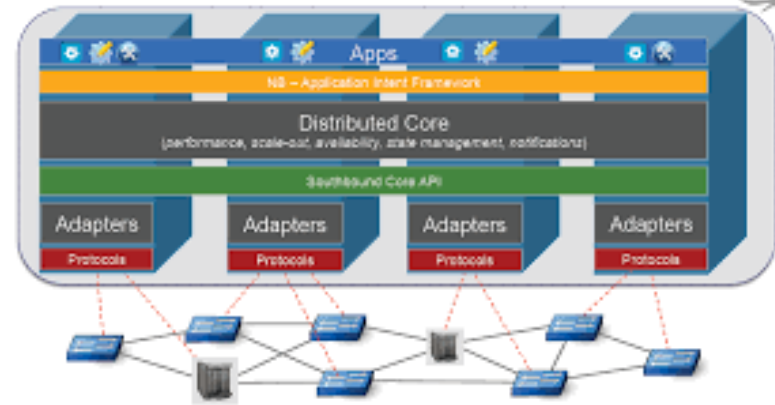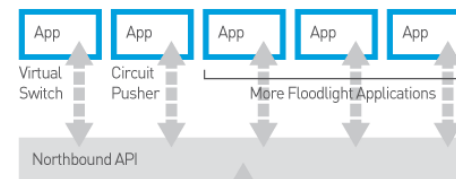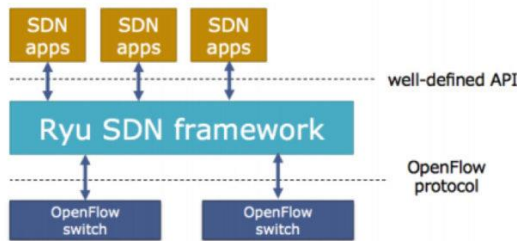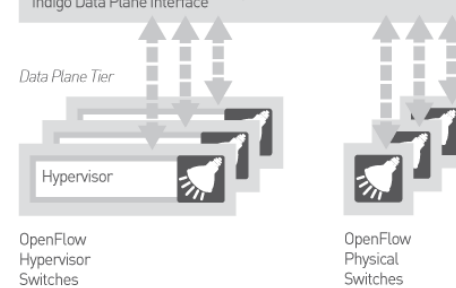
SDN-based net. virtualization: One big sw.

✓ A service provider offers infrastructure to multiple customers/tenants

✓ Ideally, each tenant sees one big virtual switch connecting his devices
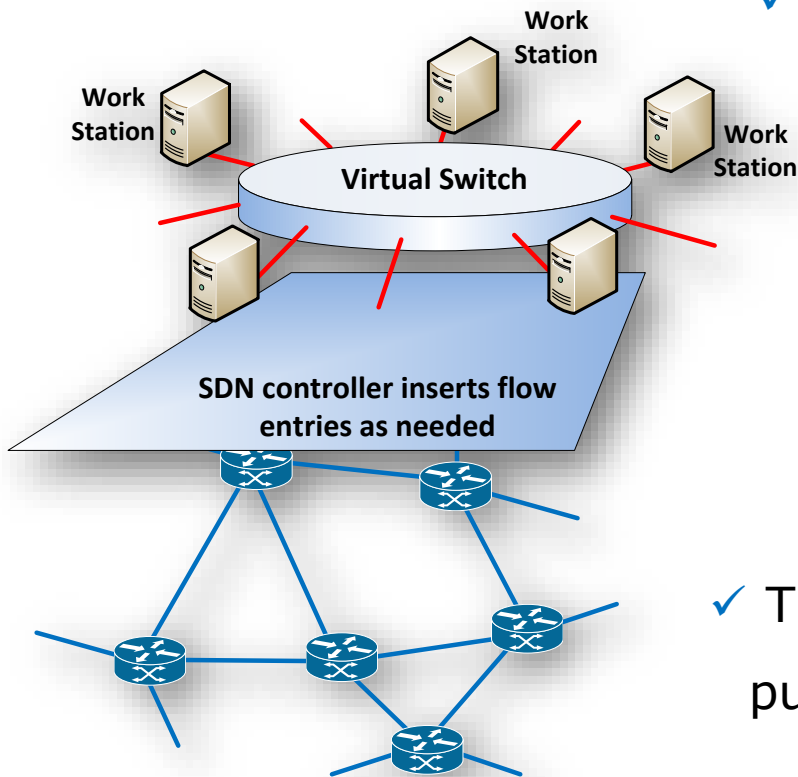
✓ Express network services as policies in the SDN app:

➢ Host A not allowed to reach Host B

➢ Ex: 100 Mbps for Web traffic to/from Server X

Work Station

Work Station

Work Station

Virtual Switch

SDN controller inserts flow entries as needed

✓ The SDN controller enforces the policies by pushing flow entries in the switches

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Many possible applications
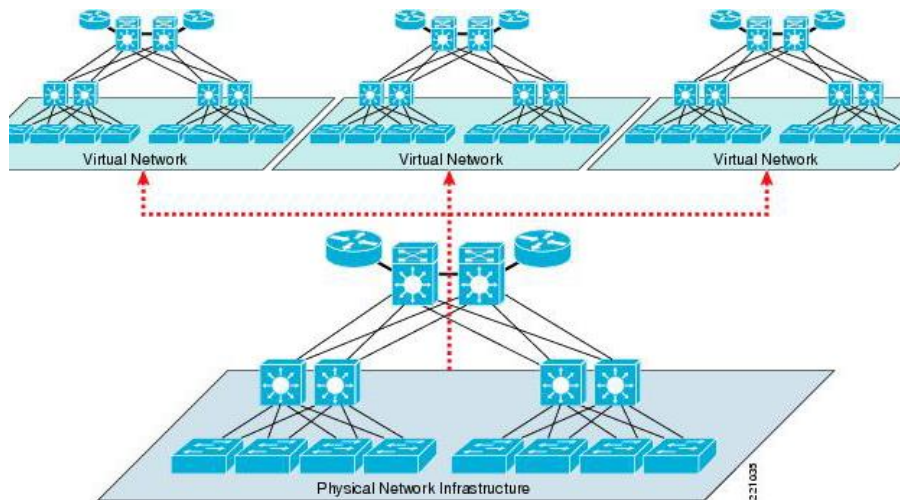
Network slicing
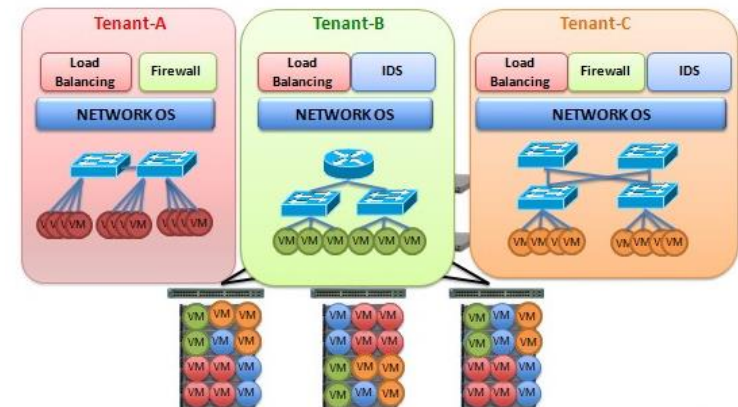
Virtuelle operatører

Network Functions Virtualization (NFV)

✓ Solution: execute all functions/servises ("network functions") on "general pupose" hardware, in a virtual architecture (virtual machines, data center)
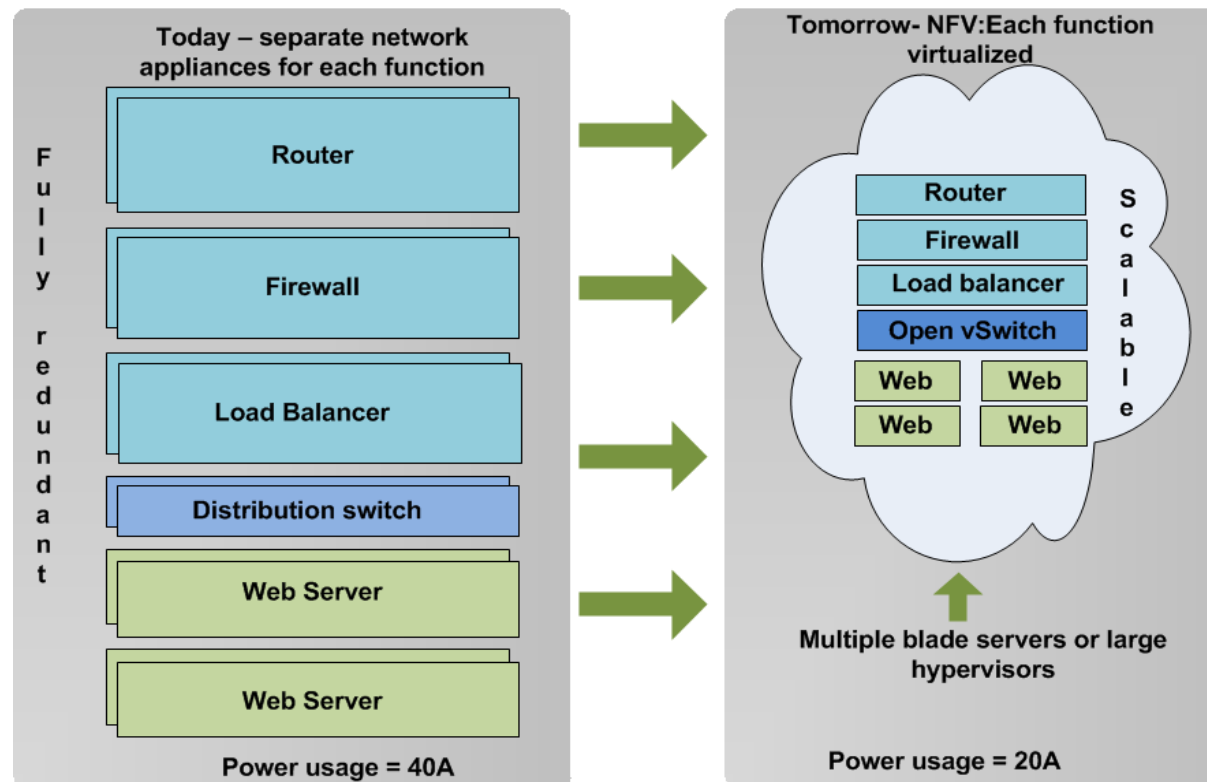
Source: http://wikibon.org/wiki/v/Network_Function_Virtualization_or_NFV_Explained

NFV – i 3G og LTE mobil Radio Access: CloudRAN
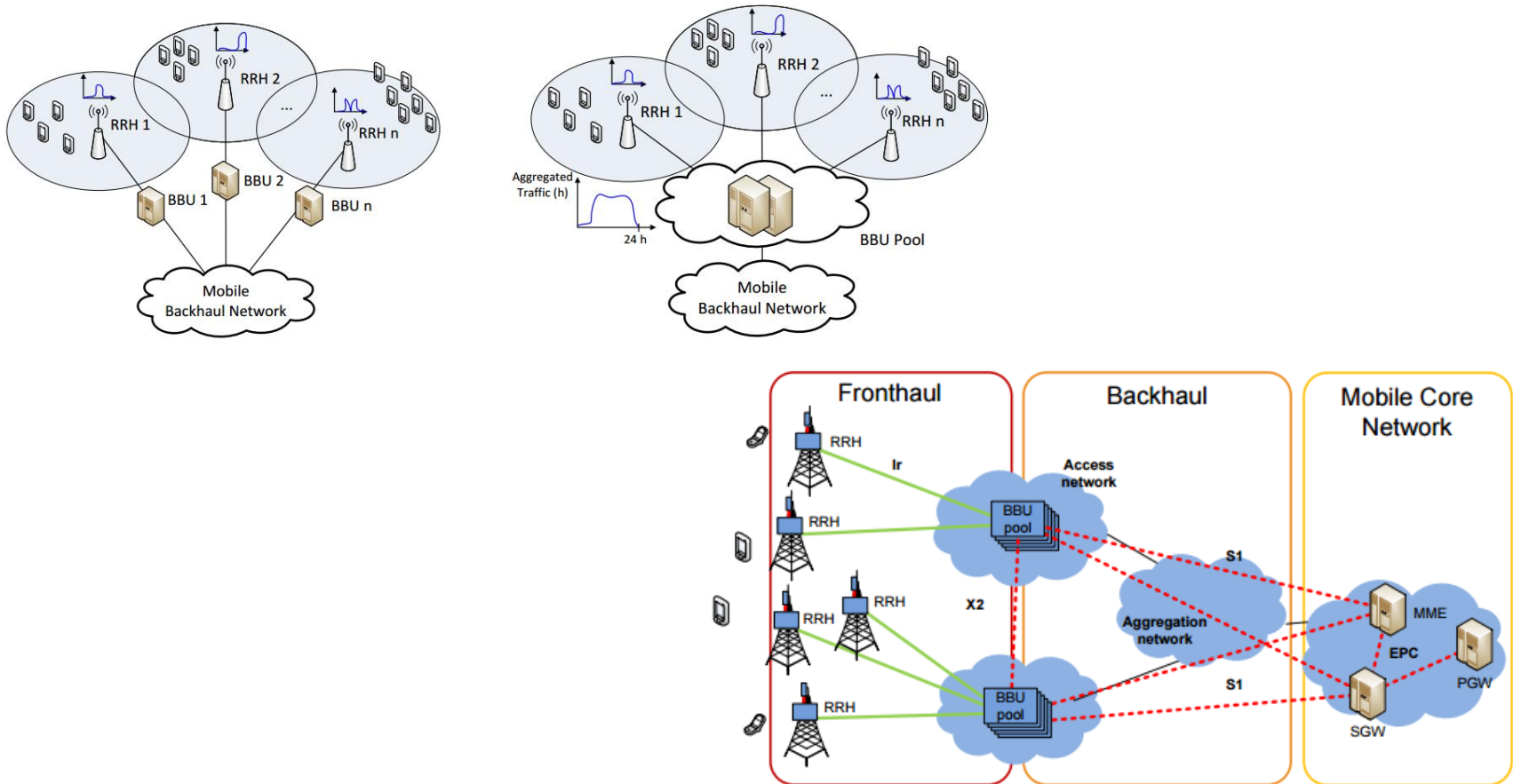
Images Source: A. Checko et alt.: *Cloud RAN for Mobile Networks, a technology overview. IEEE Communications, surveys and tutorials. DOI:* 10.1109/COMST.2014.2355255

5G is very political
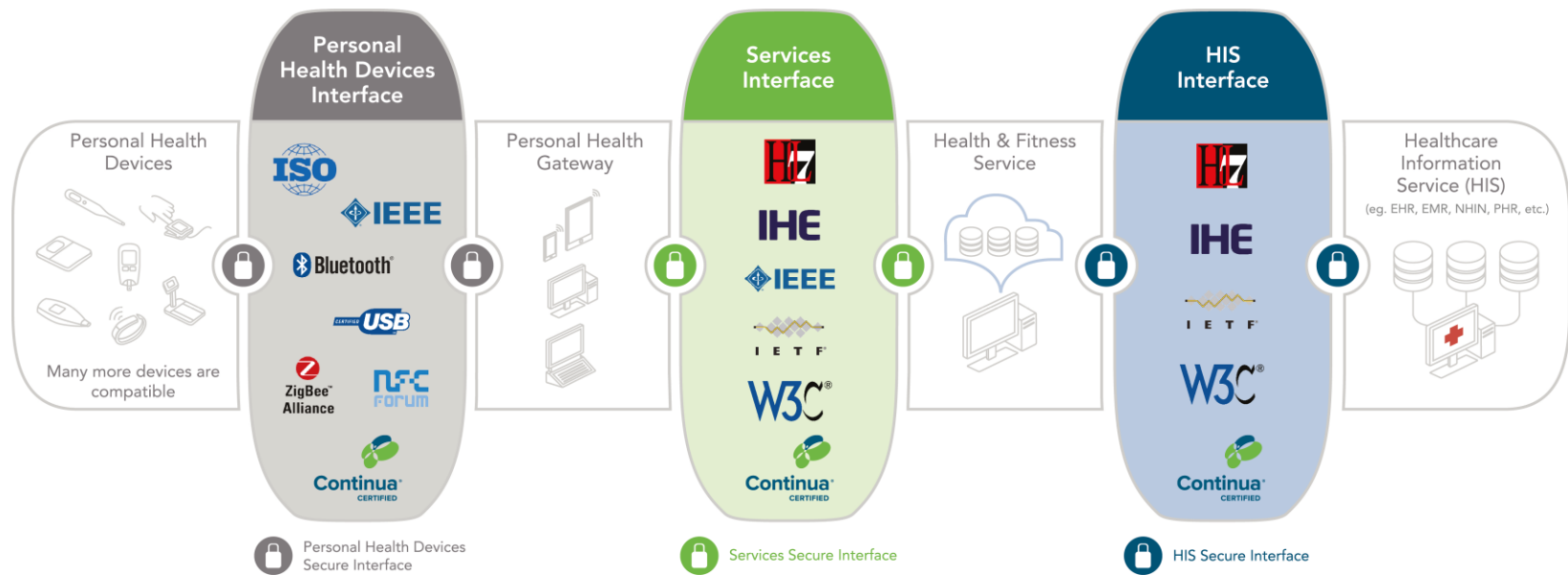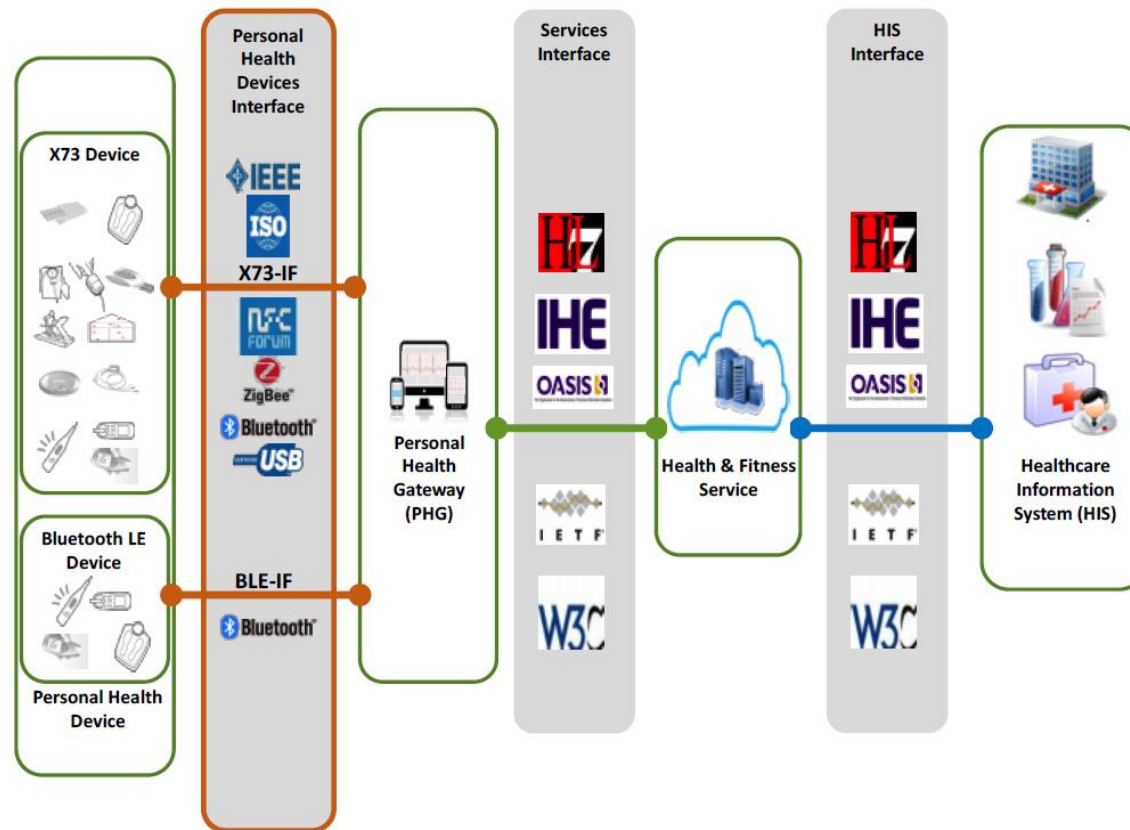
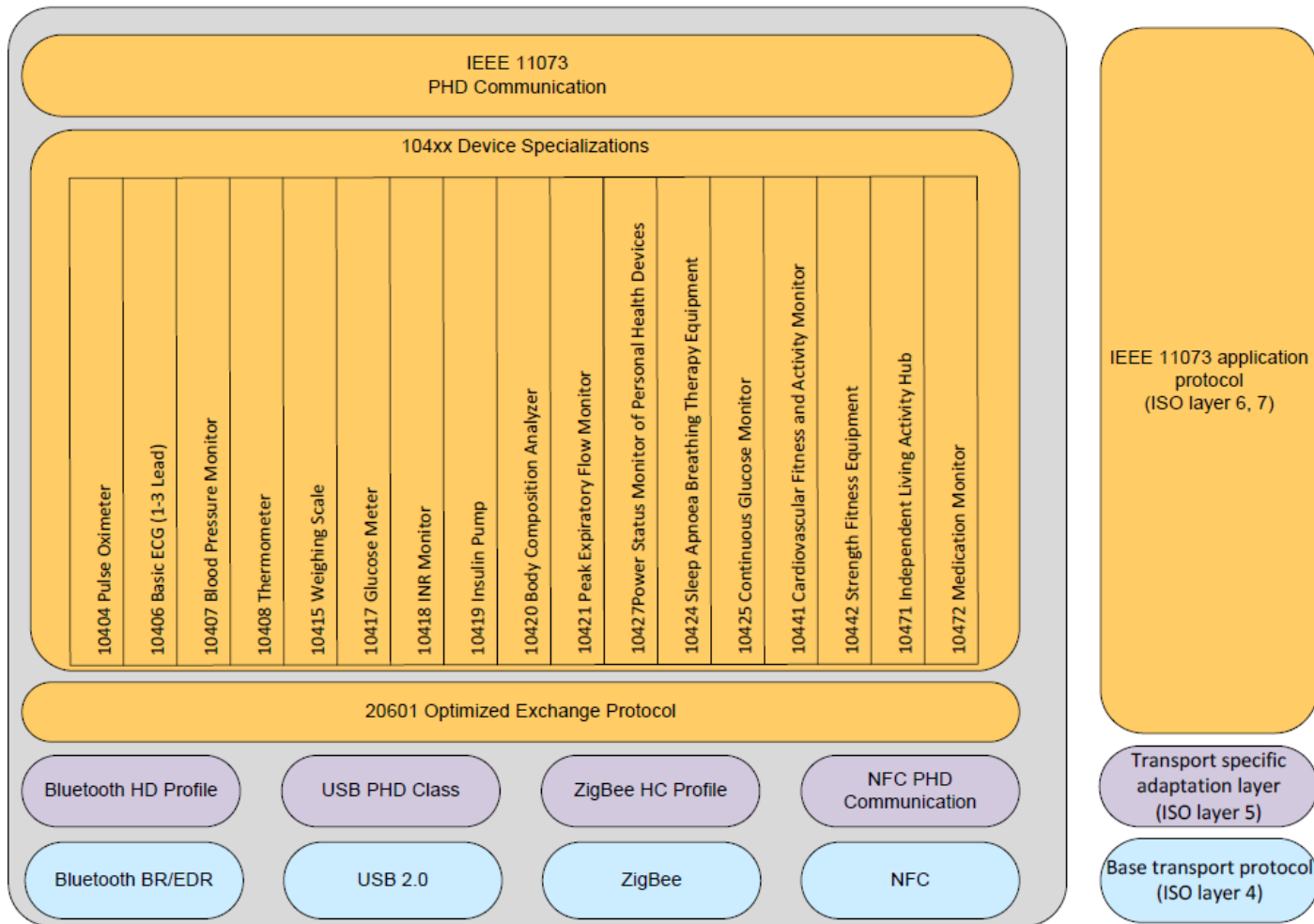# "CONTINUA a framework personal connected health"
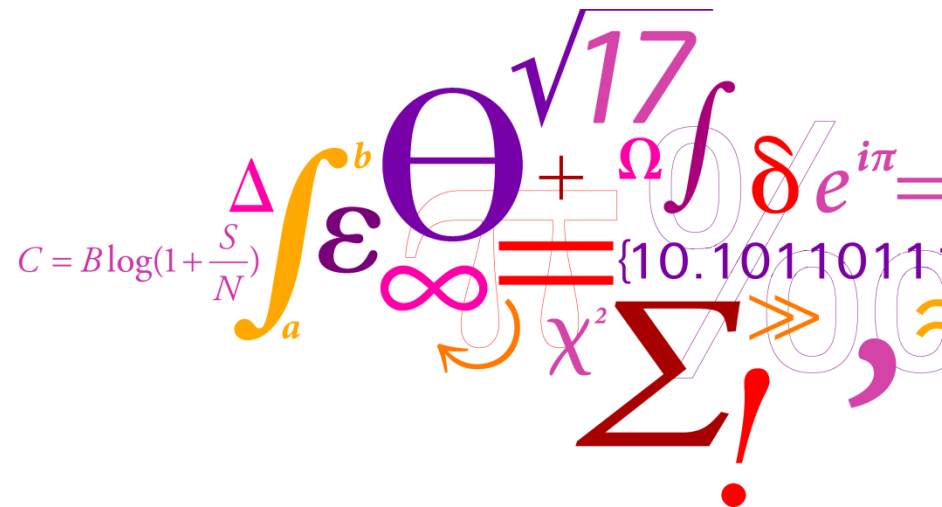
Continua E2E Reference Architecture

Personal Health Devices Interface

X73 IF protocol stack

To organize its work, Continua segmented the market in three large Domains style
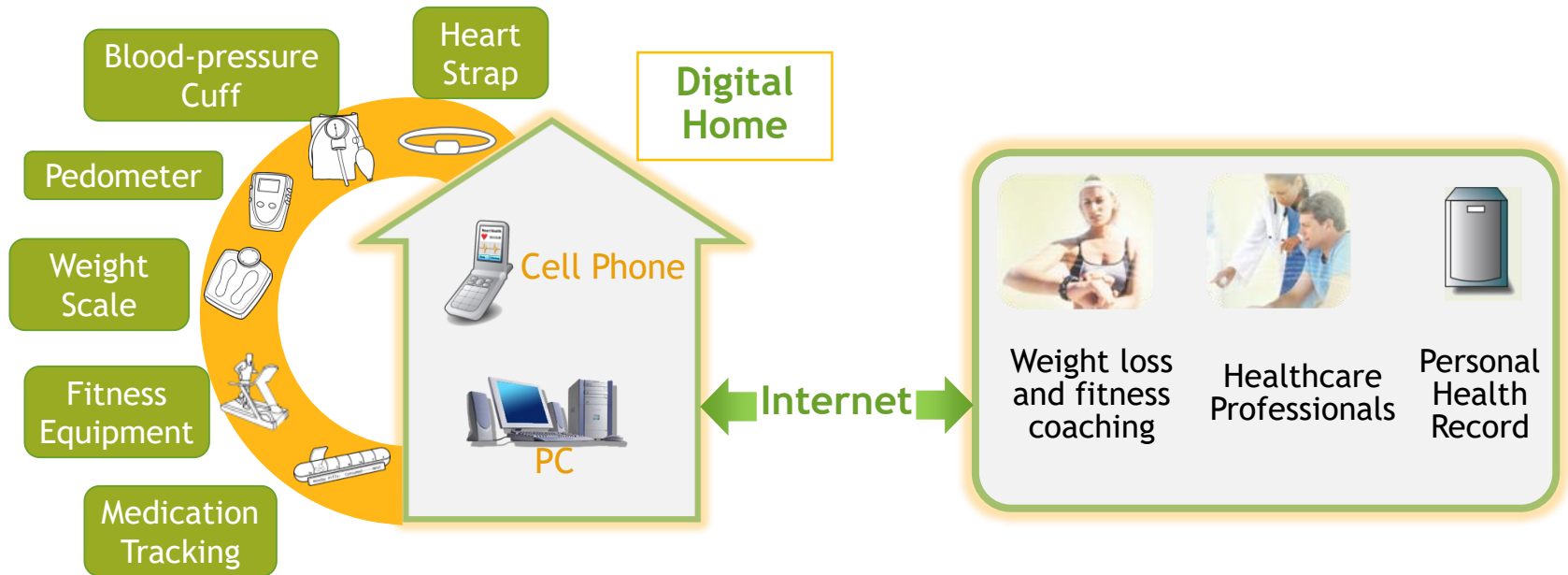
Living Independently Longer

Wellness

Fitness

Manage Chronic Conditions

People are at the center of everything we do

Wellness
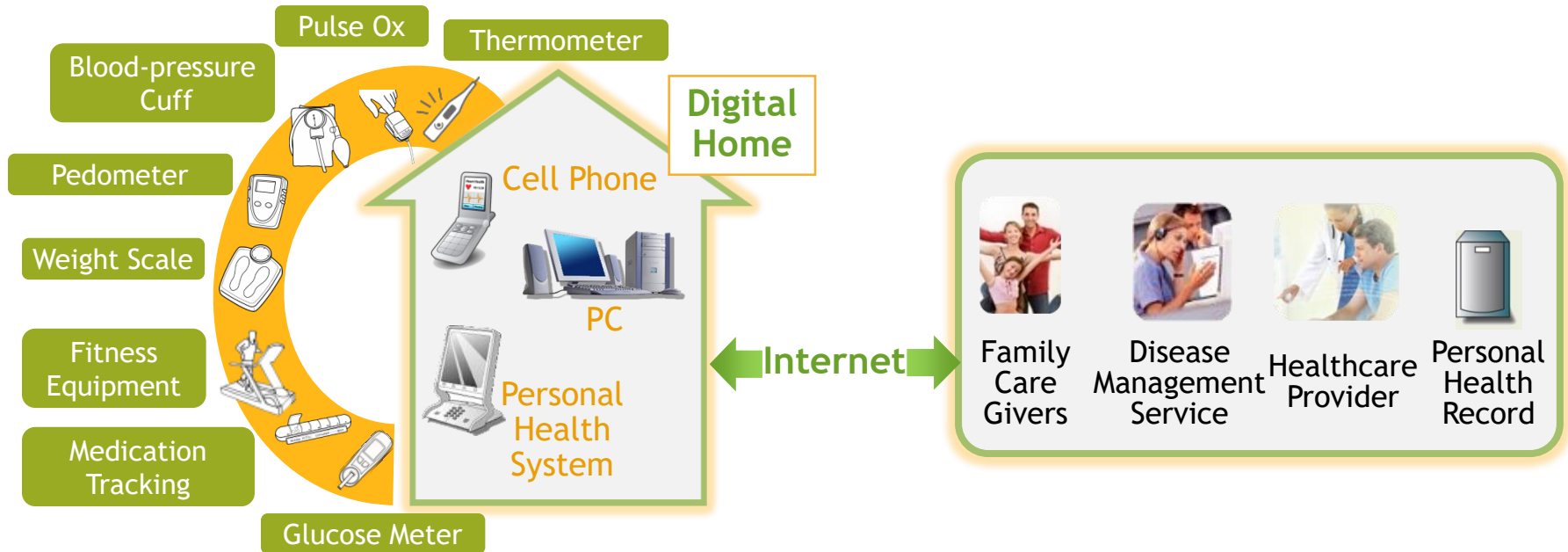## One billion adults overweight worldwide

Continua member companies help individuals live healthier, more active lives by connecting them to their wellness team through a more efficient exchange of personal fitness information.

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Manage Chronic Conditions
860 million individuals with chronic conditions world wide

Blood-pressure Cuff
Pulse Ox
Thermometer
Pedometer
Weight Scale
Fitness Equipment
Medication Tracking
Glucose Meter

Digital Home

Cell Phone
PC
Personal Health System

Internet

Family Care Givers
Disease Management Service
Healthcare Provider
Personal Health Record

Continua member companies help individuals with chronic conditions live healthier lives by connecting them to their care team through a more efficient exchange of personal health information.

Living Independently Longer
600 million elderly individuals world wide
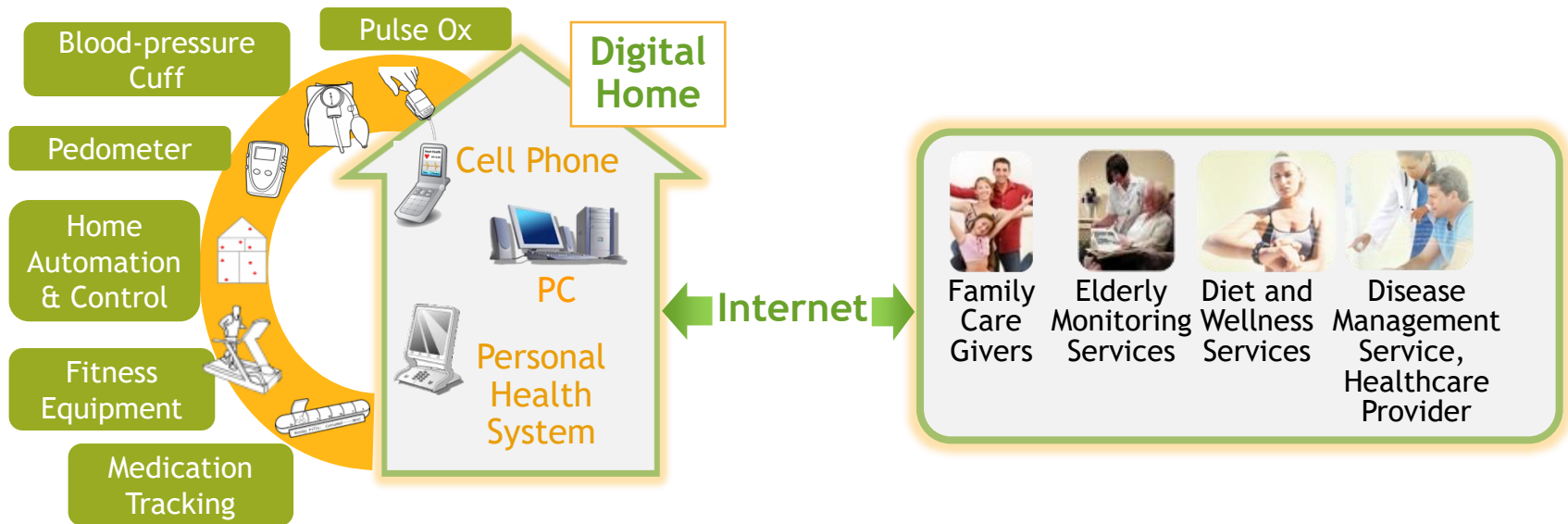
Continua member companies help the elderly live independently longer, with dignity and security, through the efficient exchange of personal health and safety information that connects them to their family and care team.

Already Complete: Interfaces & Standards

Personal Device

Aggregation Manager

Telehealth Service Center

Health Records

Personal Device items:
- Thermometer
- Pulse Oximeter
- Pulse / Blood Pressure
- Weight Scale
- Glucose Meter
- Cardio / Strength
- Independent Living Activity
- Peak Flow
- Medication Adherence
- Physical Activity

ISO
IEEE

Continua BT Profiles

Bluetooth

CERTIFIED USB

ZigBee

Device Connectivity

Continua HEALTH ALLIANCE — IHE

W3C HL7 GSMA WiFi ALLIANCE

Wide Area Network (WAN) Interface

Health Record Network Interface
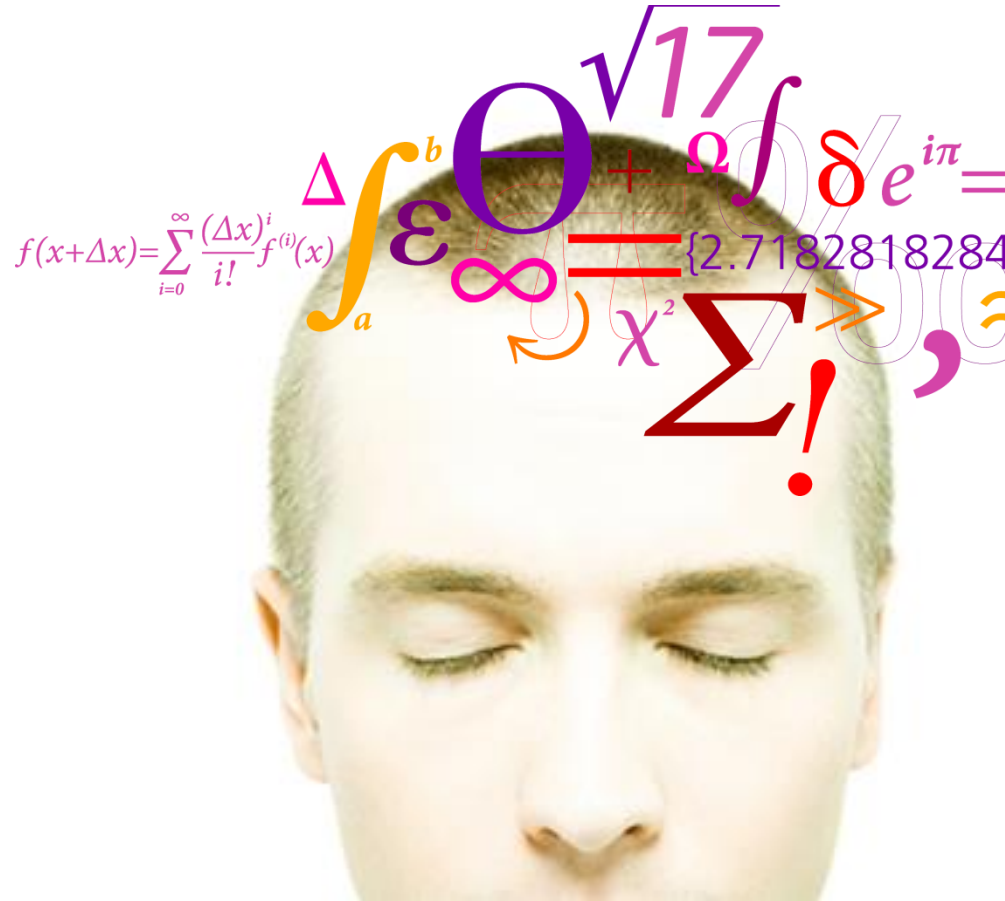
CCD

PCD 01

EHR

HIE

PHR

NHIN

Thank you for attending
Questions ☺

TTRN summerschools

- TTRN - Transatlantic Telemedicin Research Network
  - Started by Ålborg University and UC Berkeley – now expanded with more partners
- This year in Odense (hosted by the university hospital) 12-16/8
- Next year in Boston
- In 2021 at DTU – Copenhagen (Lyngby)