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# 5G Services and Use Cases

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# Outline

- A comparison with other areas.
- New key performance parameters.
- New services and applications.
- Business impact.
- Conclusions.

# Learning from PCs (1)

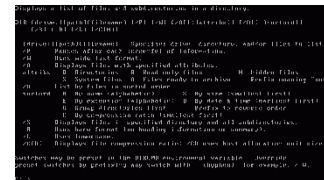
- Mainframes dominated, until PCs took over when computers were extended to the mass market.
- An operating system based on windows had a crucial importance in the spread of PCs.
- Easiness of use is essential for the mass market!



(IBM, 1972)



(Apple, 1986)



(Wikipedia, 1972)



(Microsoft, 2007)



(PhotosCom, 2008)



(Nokia, 2007)

# Learning from PCs (2)

- Initially, PCs had performance metrics that were orders of magnitude below the current ones (ZX Spectrum, 1982, 3.5 MHz, 16 kB, 0 GB).
- There's a race in wireless systems between services made available to users and data rates made available by terminals/networks!



*(Sinclair, 1982)*



*(Nadine Meade, 2000)*

# Learning from Cars

- In the beginning, the goal was for faster cars.
- Then, cars evolved for increased comfort and safety of passengers.
- Nowadays, cars are being sold for energy efficiency.
- Speed is no longer important!



*(T Ford, 1927)*



*(BMW, 1978)*



*(Lexus, 2008)*

# Terminals

- Terminals are varied, serving different usages and services:



(BigCircle, 2012)



(Apple, 2014)



(techclones, 2013)



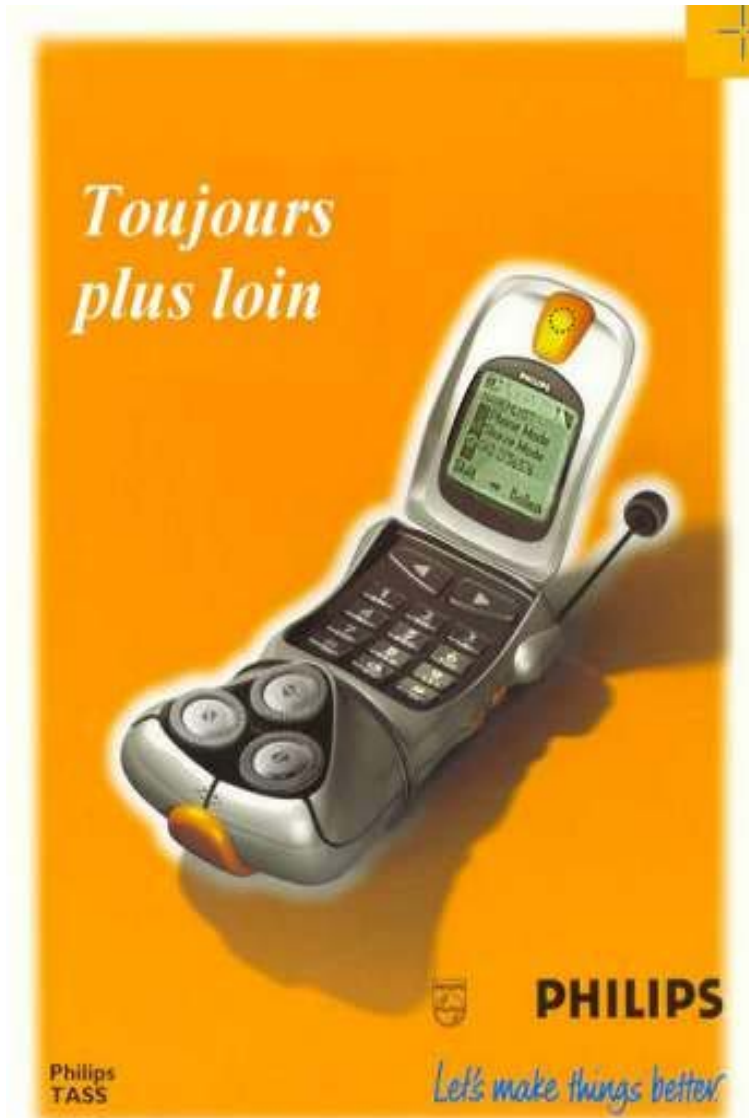
(tomsguide, 2013)



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# More Terminals



*Toujours plus loin*

**PHILIPS**

Philips TASS

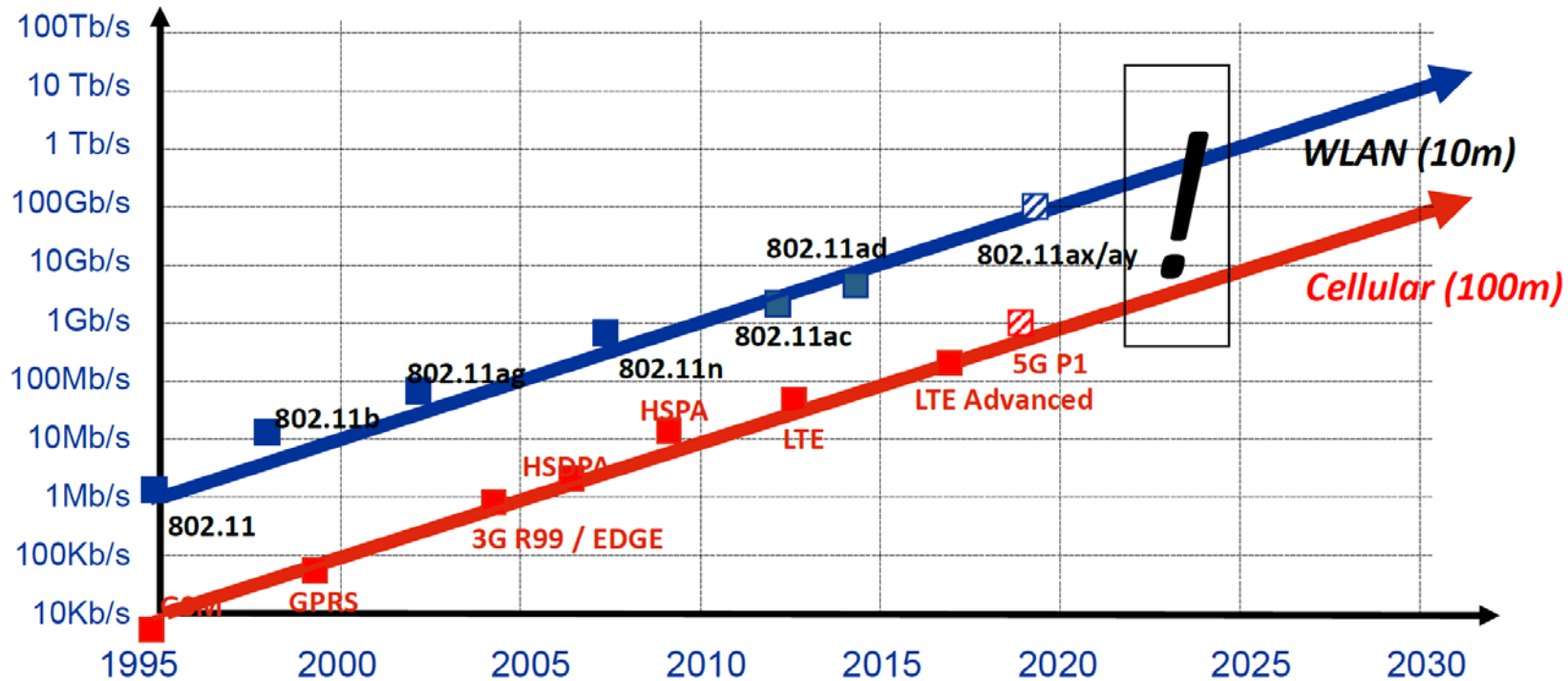
*Let's make things better.*

The advertisement features a silver Philips TASS mobile phone with a flip cover open, set against a vibrant orange background. The phone's screen displays a list of contacts or messages. The text 'Toujours plus loin' is written in a white, elegant script font in the upper left. The Philips shield logo and the brand name 'PHILIPS' are positioned in the lower right, with the slogan 'Let's make things better.' below it. In the bottom left corner, 'Philips TASS' is printed in a small, sans-serif font. A small yellow square with a white cross is located in the top right corner of the ad.



# Data Rate Evolution

- There's an exponential trend in data rates evolution:



(Fettweis, 2017)



# The Tactile Internet

- Order of magnitude of human reaction times:



1s



100ms



10ms



1ms

*(Fettweis, 2014)*

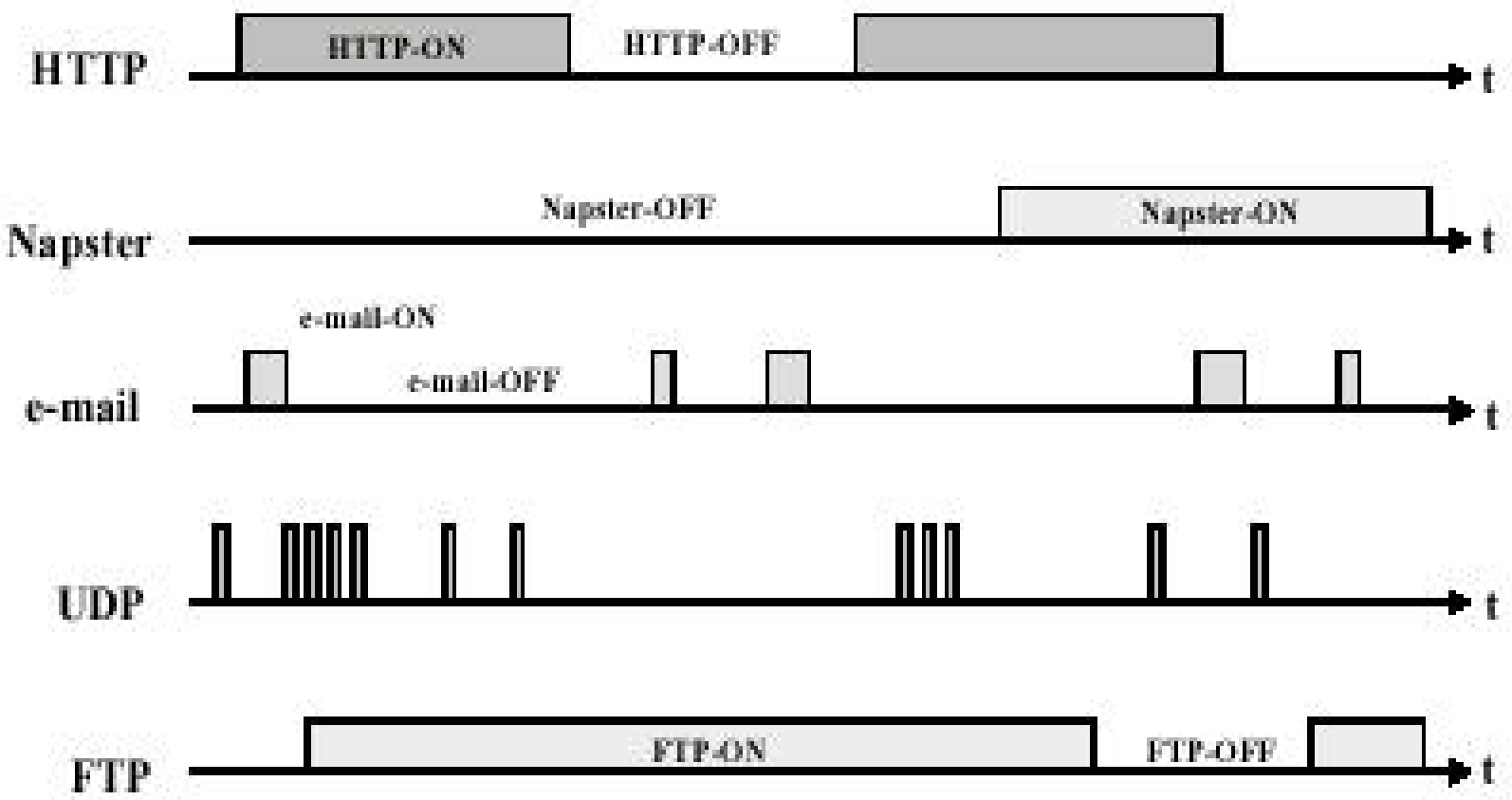
# Services' Classes

Service class	Conver- sational	Strea- ming	Inter- active	Back- ground
Real time	Yes	Yes	No	No
Symmetric	Yes	No	No	No
Switching	CS	CS	PS	PS
Guaranteed rate	Yes	Yes	No	No
Delay	Minimum Fixed	Minimum Variable	Moderate Variable	High Variable
Buffer	No	Yes	Yes	Yes
Bursty	No	No	Yes	Yes
Example	voice	video-clip	www	email

(3GPP, 2000)

# Data Traffic

- Examples of different types of traffic:

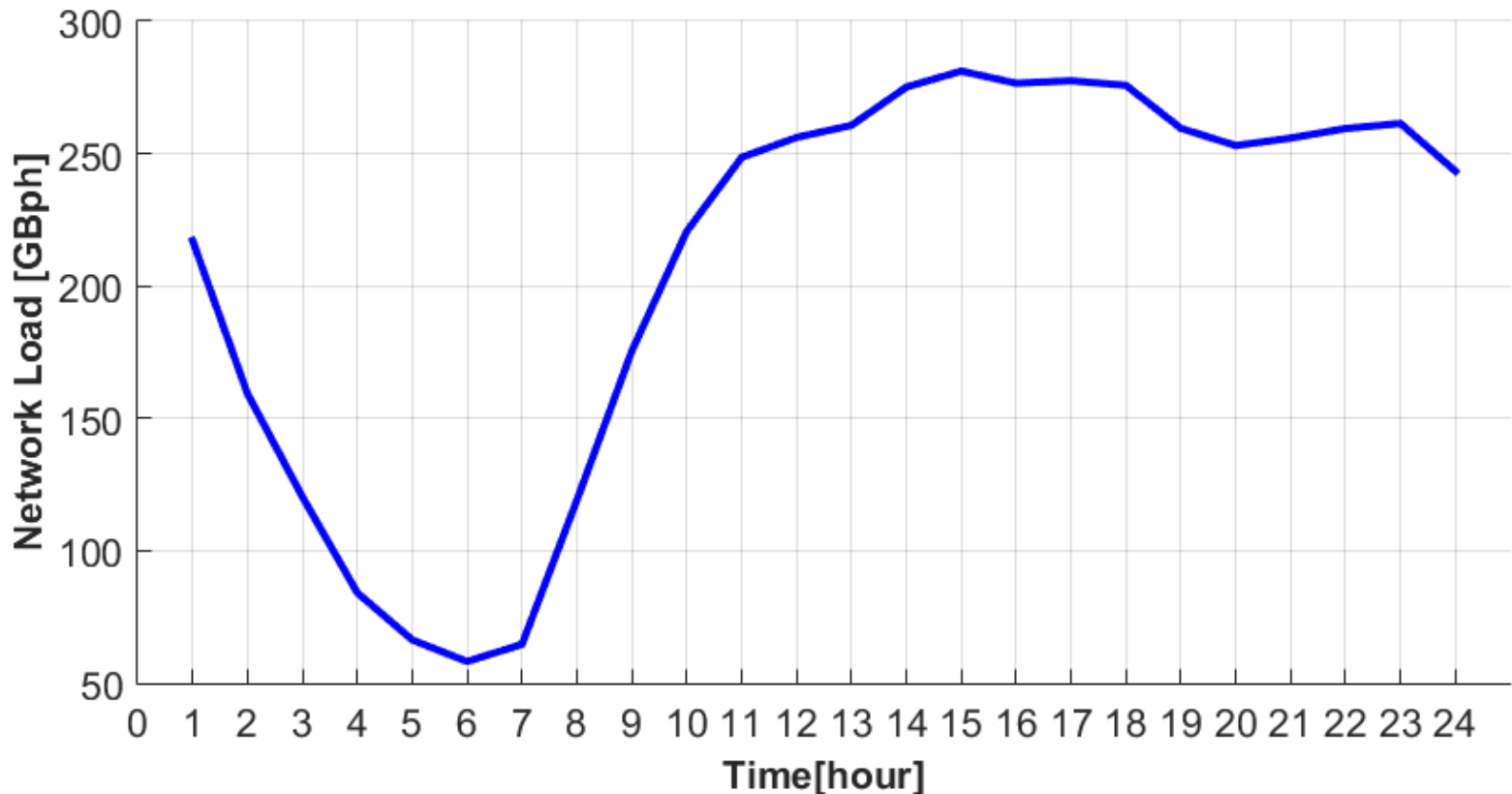


# Access Times

File	Size [B]	9.6 kb/s	384 kb/s	2 Mb/s	10 Mb/s	150 Mb/s	1 Gb/s
Email	10 k	8.3 s	0.2 s	0.0 s	0.0 s	0.0 s	0.0 s
Text	40 k	33.3 s	0.8 s	0.2 s	0.0 s	0.0 s	0.0 s
Photo	0.1 M	1.4 m	2.1 s	0.4 s	0.1 s	0.0 s	0.0 s
Doc.	2 M	27.8 m	41.7 s	8.0 s	1.6 s	0.1 s	0.0 s
Music	4 M	55.6 m	1.4 m	16.0 s	3.2 s	0.2 s	0.0 s
Video	10 M	2.3 h	3.5 m	40.0 s	8.0 s	0.5 s	0.1 s
HD film	5 G	48.2 d	1.2 d	5.6 h	1.1 h	4.4 m	40.0 s
4K film	100 G	2.6 y	24.1 d	4.6 d	22.2 h	1.5 h	13.3 m
8K film	300 G	7.9 y	72.3 d	13.9 d	2.8 d	4.4 h	40.0 m

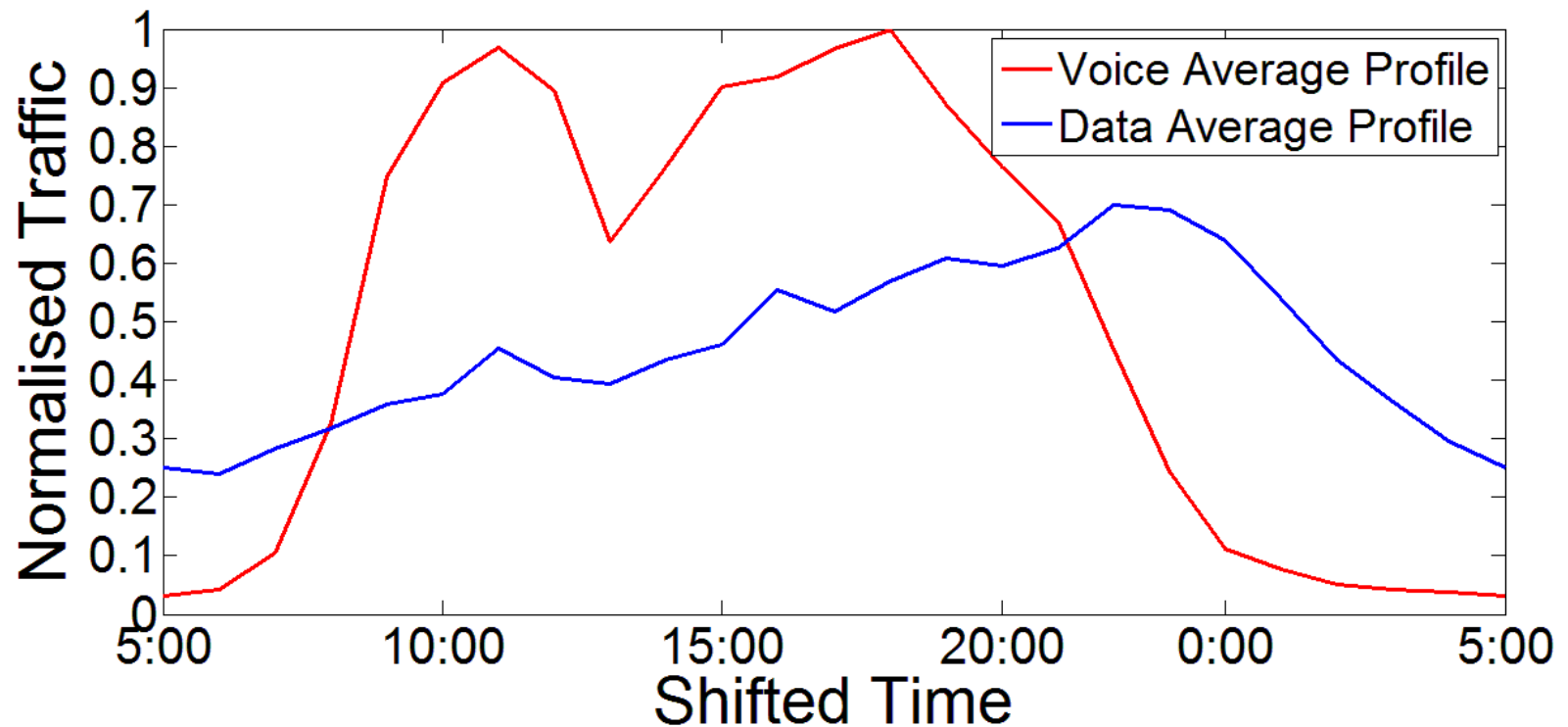
# Services Usage (1)

- Network deployment and management need to take advantage of human services usage, which is very much associated with daily activities.



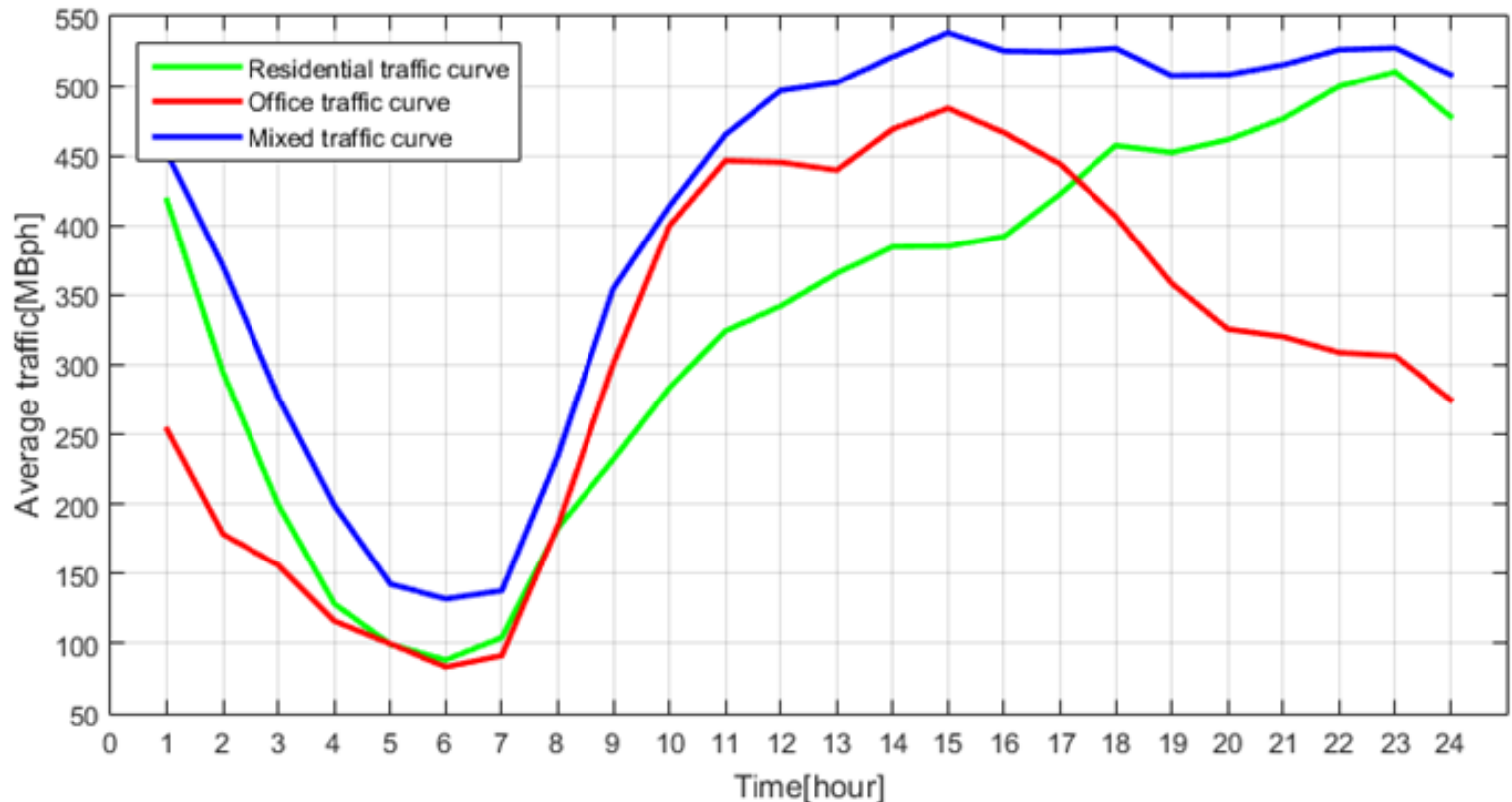
# Services Usage (2)

- Voice and data have a completely different behaviour.



# Services Usage (3)

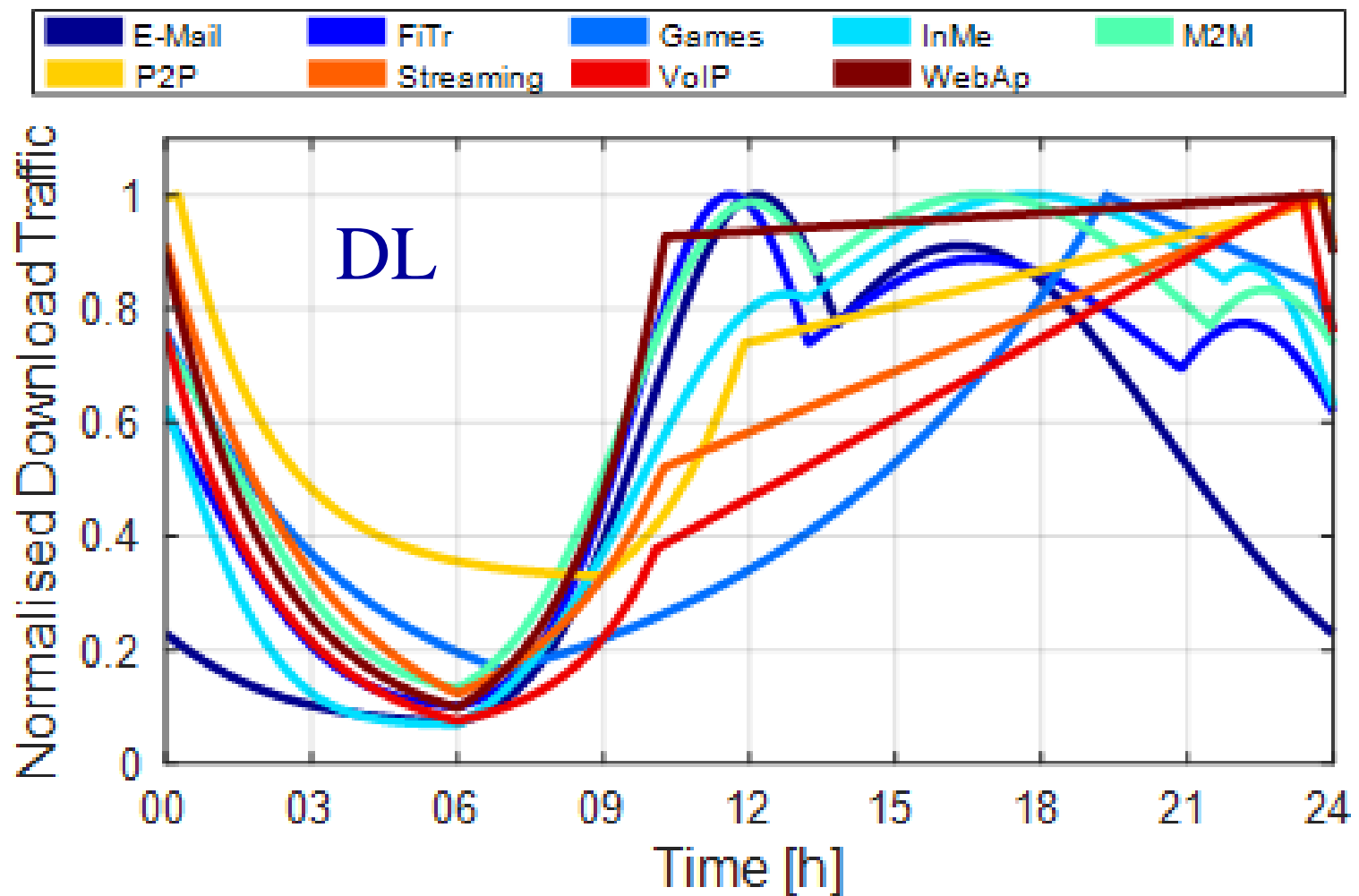
- The type of urban occupation has also influence on traffic behaviour.





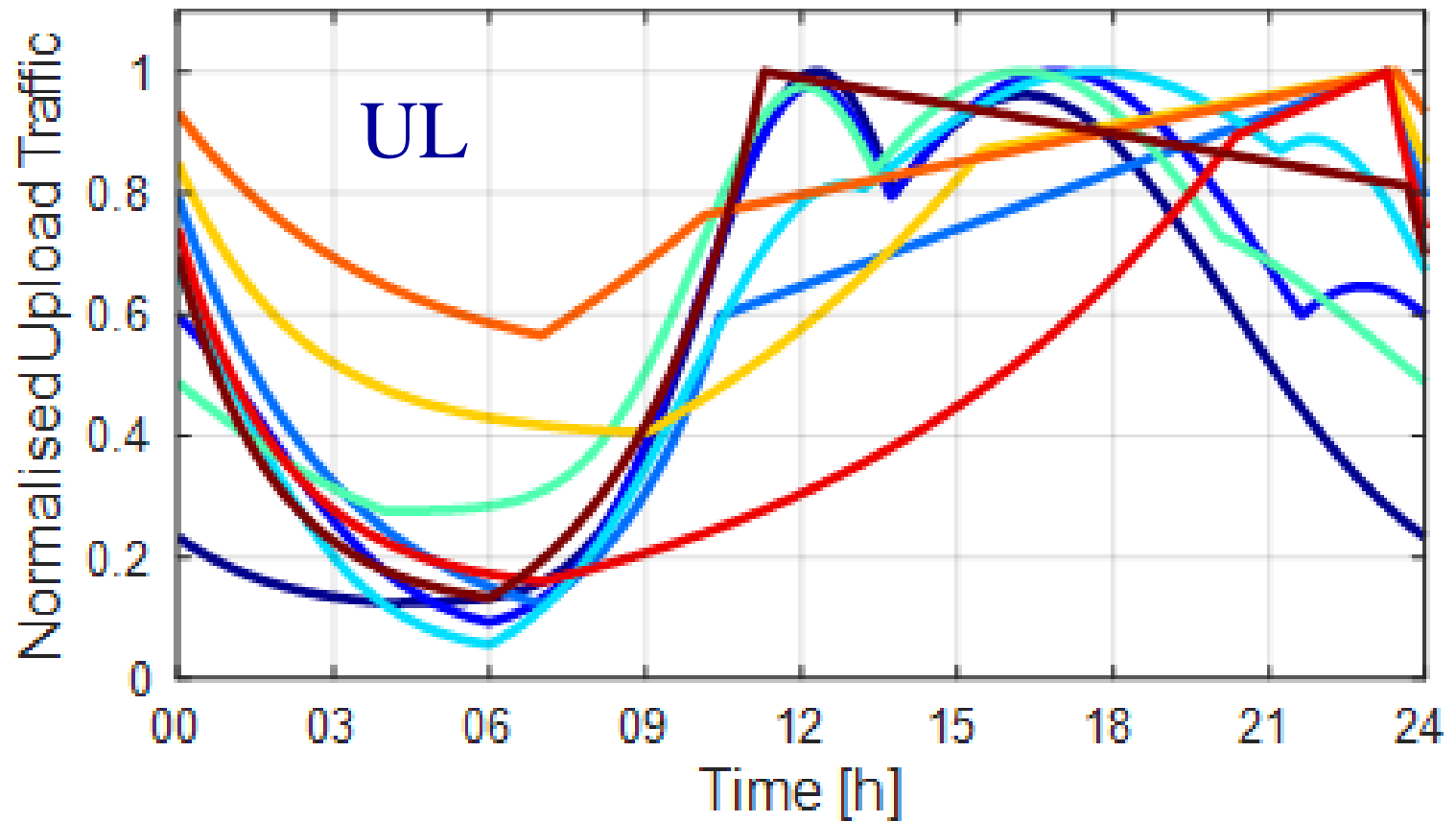
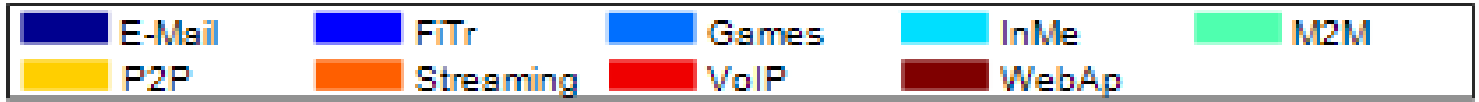
# Services Usage (4)

- The various data services have a different usage.



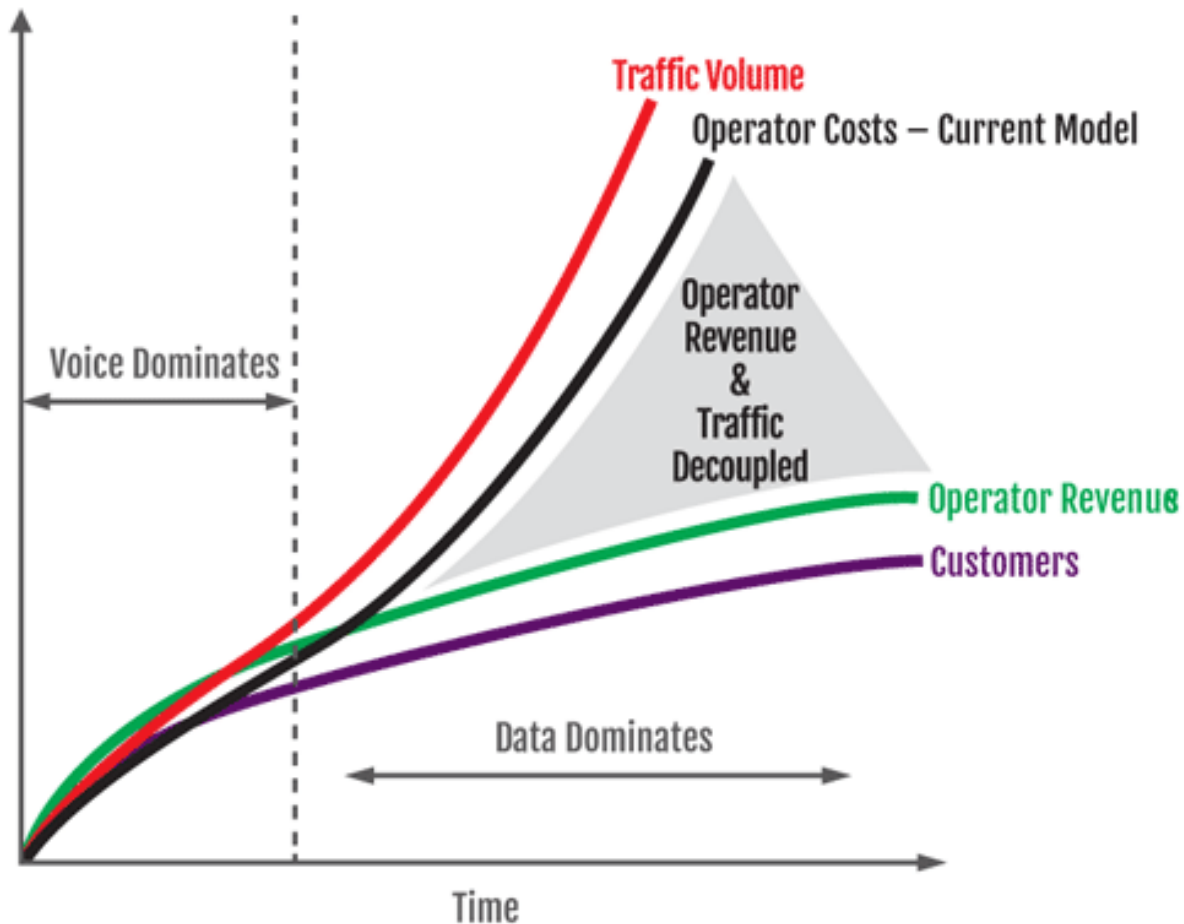
# Services Usage (5)

- DL and UL data services' behaviour is different.



# Operators' Key Problem

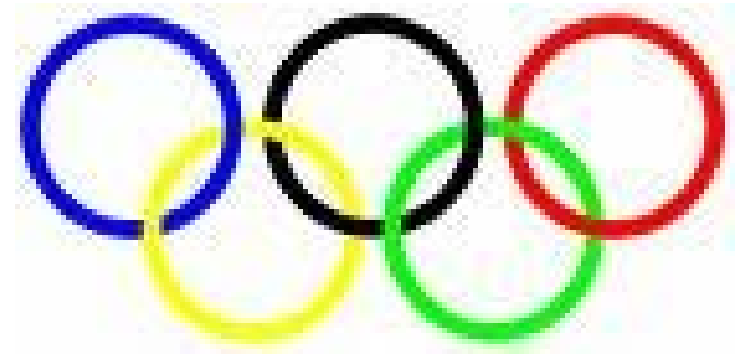
- How to “break the laws of physics”?



(Accenture, 2013)

# Which Perspective?

- The Olympic Games motto applied to current systems (i.e., more of the same, but just better), is a too shortfall goal.
- Now, more than ever, one should have a disruptive view of the future.



~~*Citius*  
*Altius*  
*Fortius*  
(Faster  
Higher  
Stronger)~~

# Current Perspective

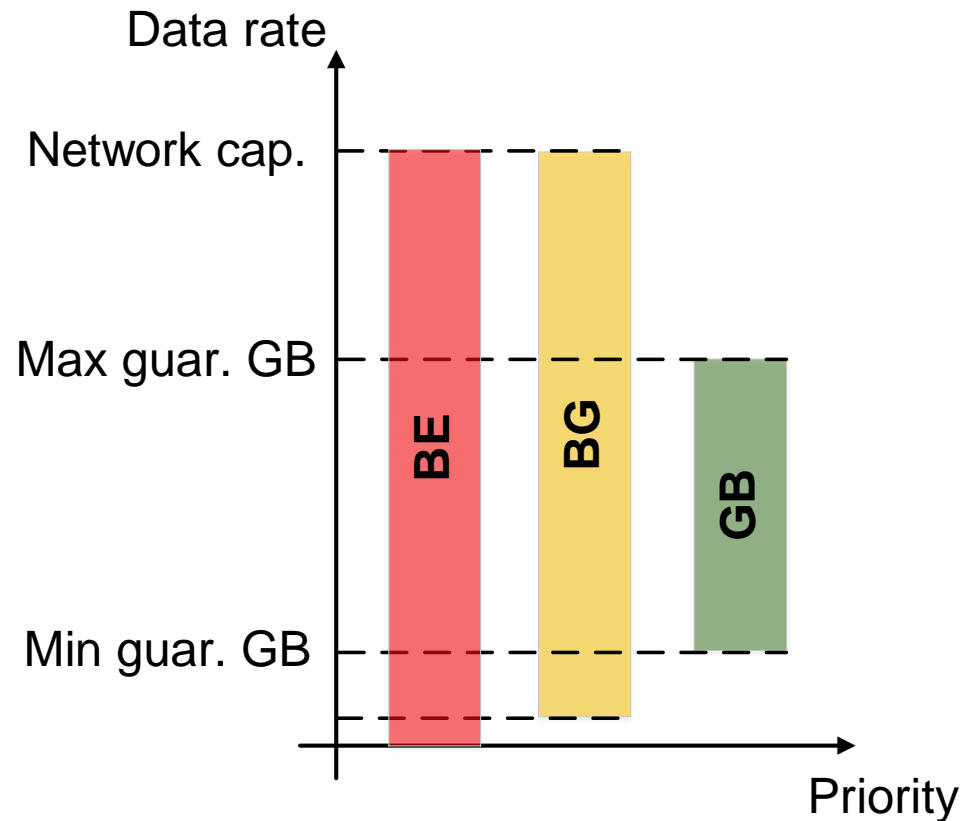
- Today's wireless systems are still very much used in the perspective of "one size fits all".
- We're no longer in the era of voice centric networks, hence, service differentiation must be used.



*(AutomationClerc, 2013)*

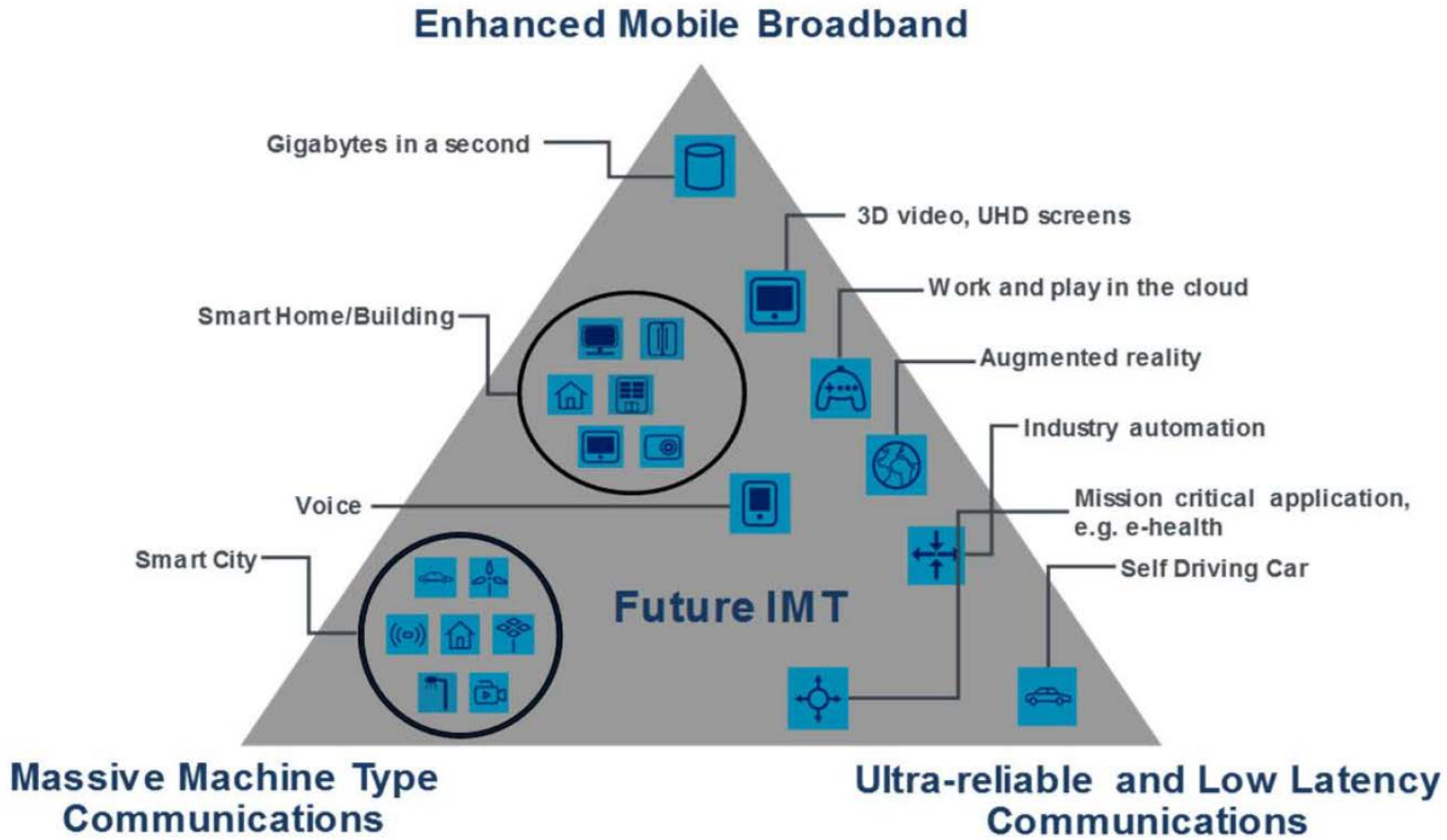
# VNOs' SLAs

- Three general Virtual Networks Operators' SLAs types can be considered:
  - GB - Guaranteed Bitrate
  - BG - Best effort with minimum Guaranteed;
  - BE - Best Effort.



# ITU's View on Services for 5G

- There are 3 key features:

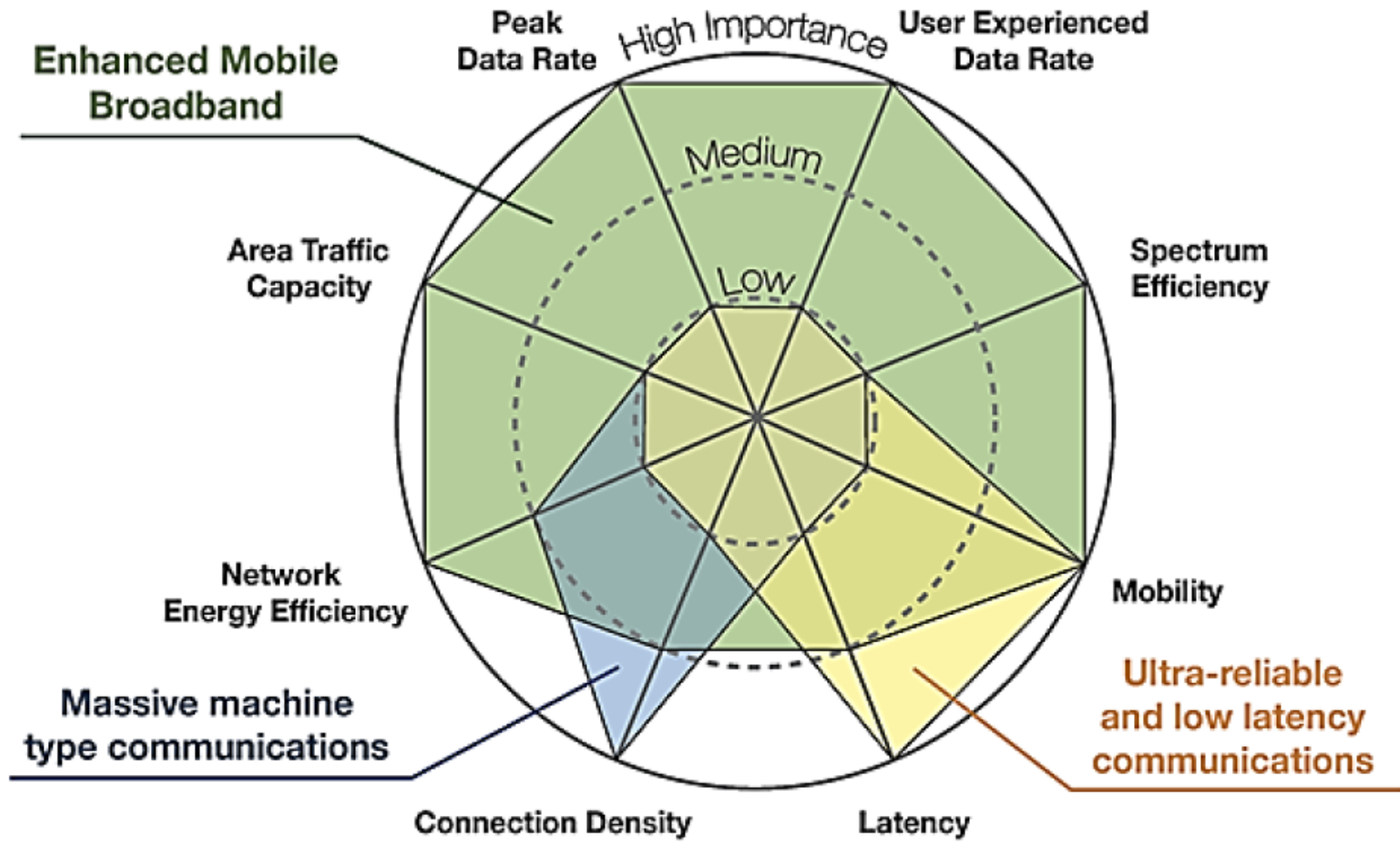


(ITU, 2015)



# Importance of Key Capabilities

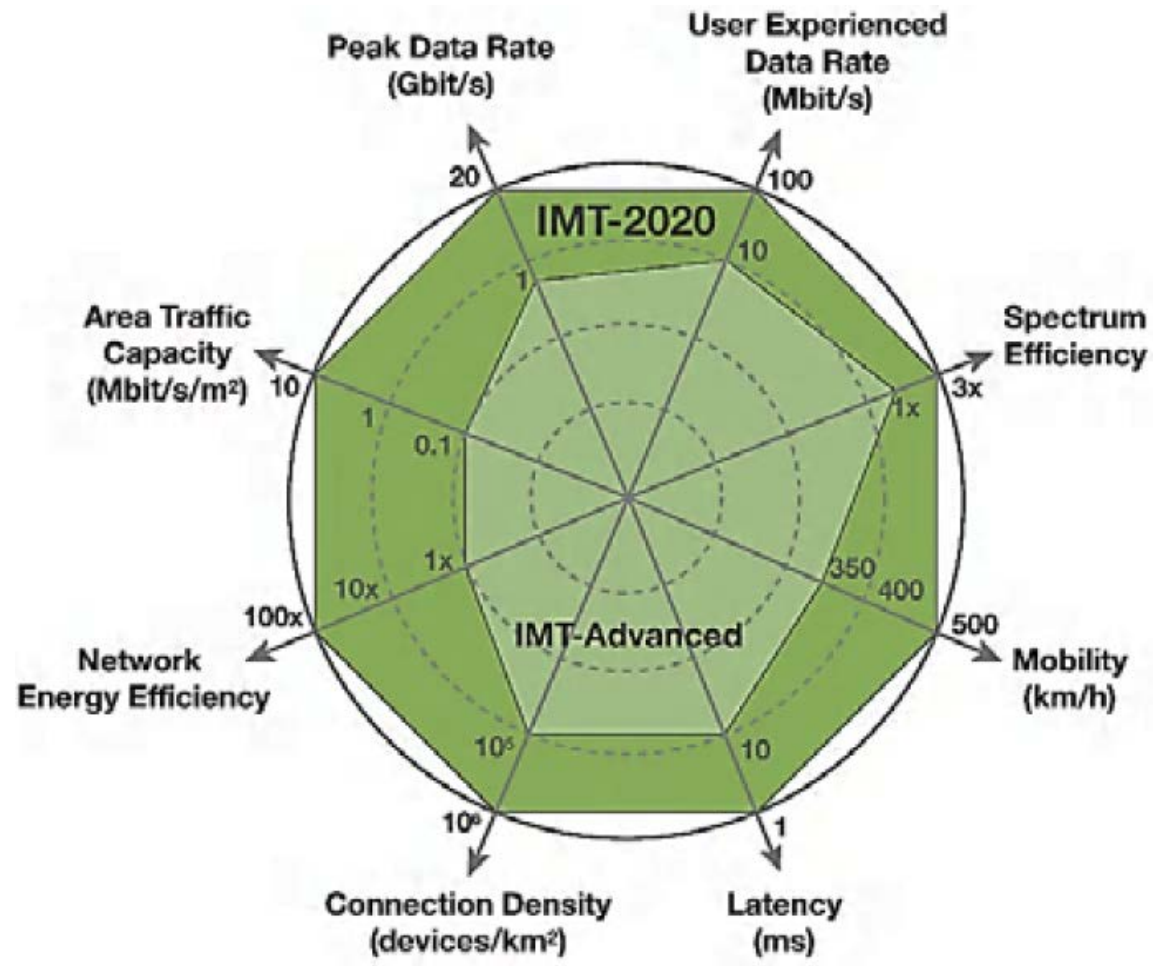
- The importance of features depends on services.



(ITU, 2015)

# Enhancement of Network Capabilities for 5G

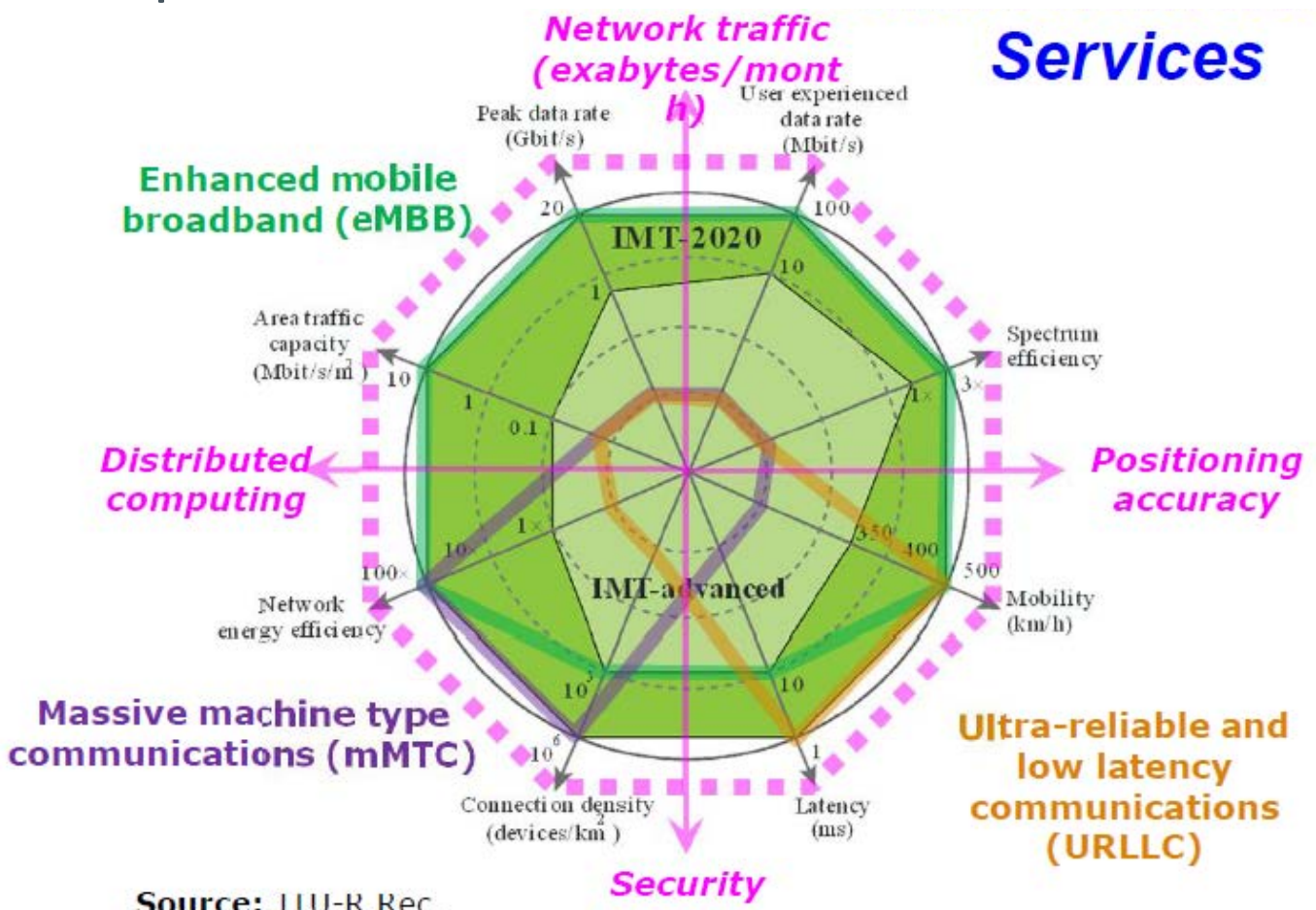
- There's a gap between 4G and 5G:



(ITU, 2015)

# New Service Dimensions

- New capabilities need to be ensured:

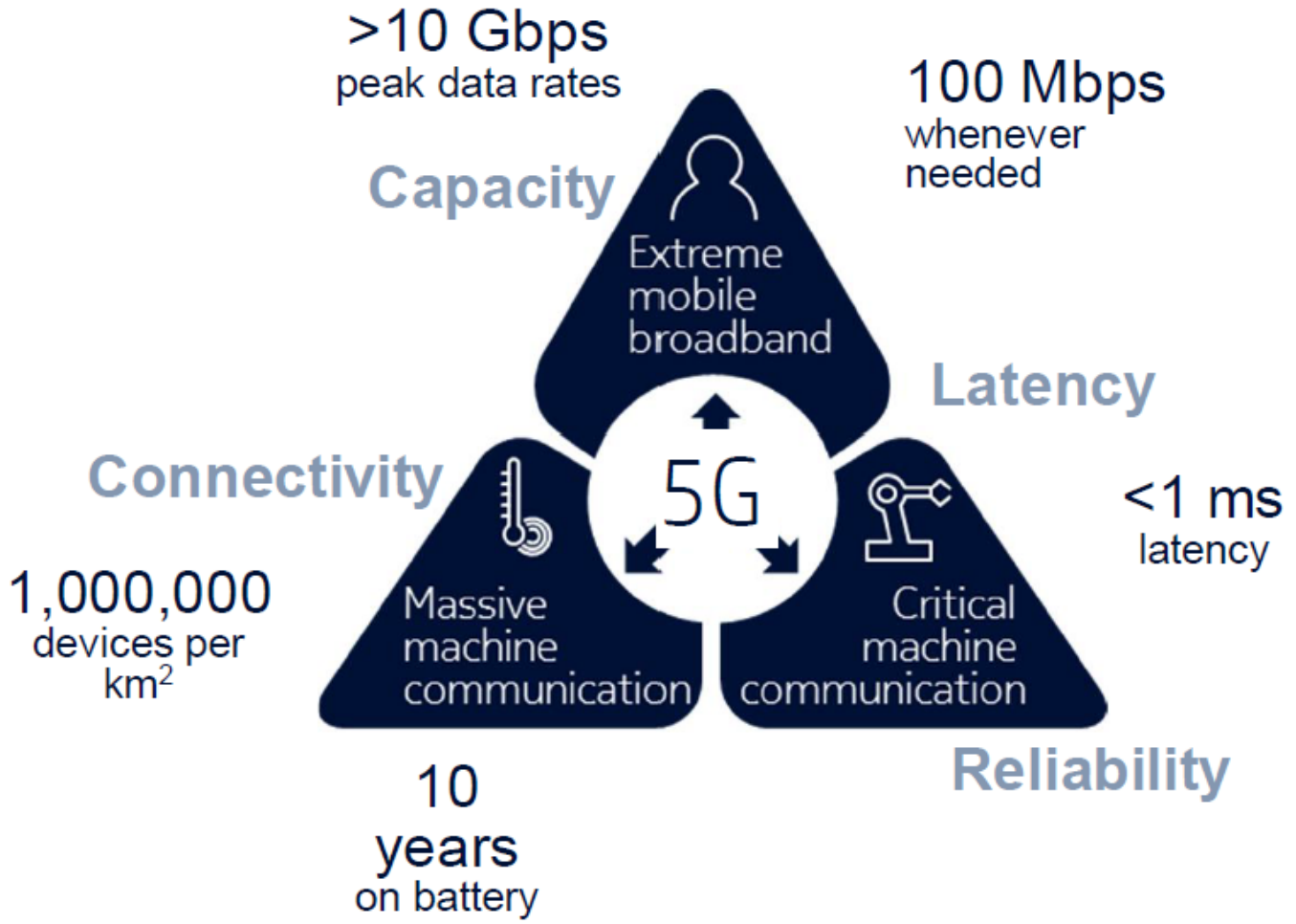


Source: ITU-R Rec. M.2083 (modified)

(EC, 2019)

# Current View on 5G Capabilities

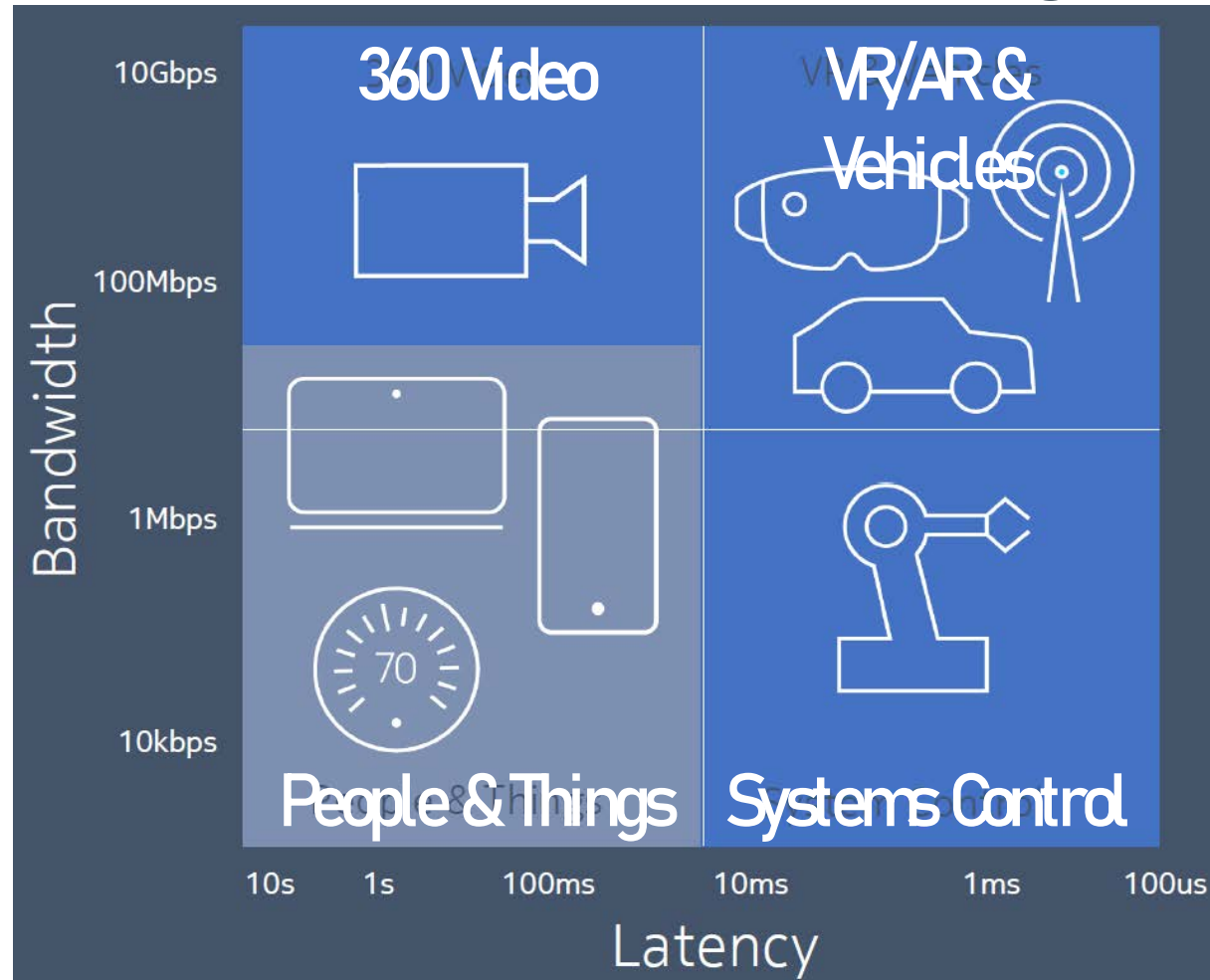
- Goals are very demanding:



(NOKIA, 2019)

# Service Requirements

- Machine-to-Machine will be dominating use cases:



(NOKIA, 2019)

# Evolutions of LTE-X

- LTE is evolving to accommodate several different versions, in order to accommodate the requirements from previous Private Mobile Radio communications systems, and 5G is expected to take this evolution further:
  - LTE-MCC (Mission Critical Communications)
  - LTE-R (Railways)
  - LTE-IoT (Internet of Things)
  - LTE-LAA (License Assisted Access)



# Information Access

- The paperless society will have a huge impact on networks:
- media is being consumed in portable devices;
- daily commuters will need a lot of information on an instantaneous basis.



*(Apple, 2010)*



*(musingsfrommedway, 2010)*



# Location Awareness

- Location based services are being introduced these days, upon user demand.
- The opposite is being introduced as well, i.e., the environment being aware that the user is present.



*(Unwired, 2007)*



*(Minority Report, 2002)*

# Internet of Things

- Today's systems are still based on a person being the end user.



*(Kenwood, 2007)*

- Future systems are considering machine-to-machine communications, i.e., IoT, as being potentially more important.



*(DHD, 1998)*

- Sensor networks are emerging as one of the “killer” network structures of the future.



*(SensorProd, 2007)*

# What services? (1)

- Mobile 3D Internet:  
visualisation of 3D images from a terminal.
- Real-time ad hoc communities:  
extending social networks into happenings on the spot.
- Prosumers:  
users playing a decisive role as producers and consumers of contents.



*(Builder AU, 2008)*



*(FutureLab, 2008)*



*(enriquedans, 2006)*

# What services? (2)

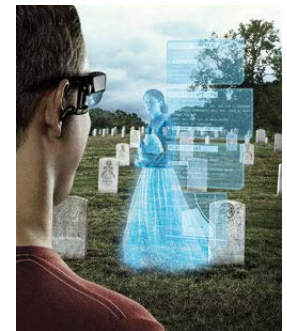
- Context aware mobile web:  
physical and social awareness of users' experience.
- Interactive context aware games:  
games adapted to the user's physical environment.
- Augmented and virtual realities:  
addition of real and combination of virtual information to real life objects.



*(DanceInternational, 2005)*



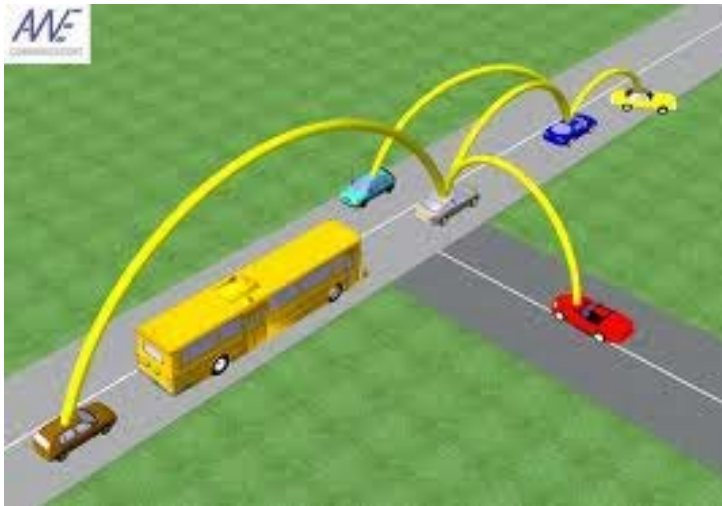
*(UniversalStudios, 2007)*



*(Spectrum, 2008)*

# Vehicular Communications

- Vehicular communications are a major area under development:
  - vehicle-to-vehicle;
  - vehicle-to-infrastructure.



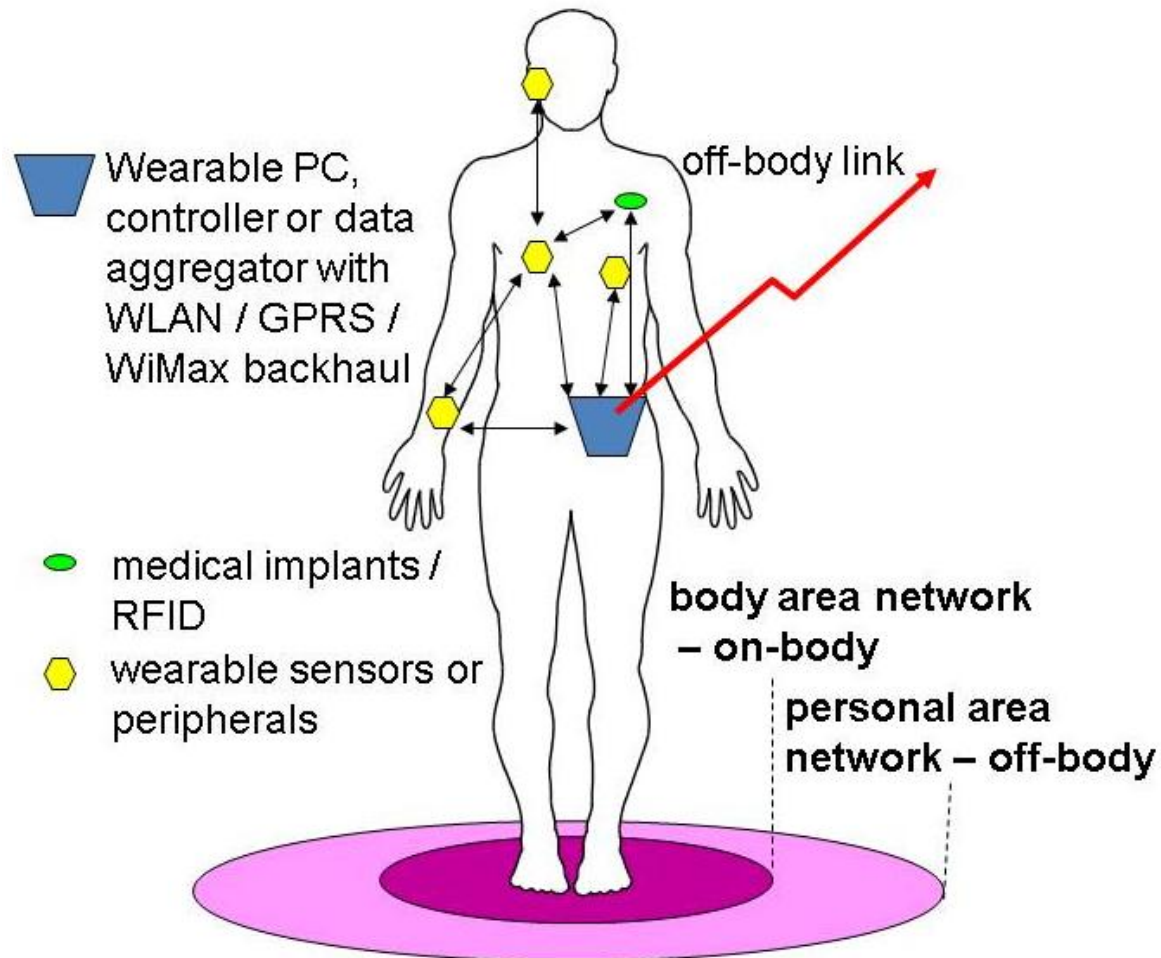
*(awe, 2011)*



*(car2car, 2008)*

# Body Area Networks

- Several BAN application scenarios are envisaged.





# Industrial Evolution

- The extension to industrial applications is going to be unlimited:
  - utilities
  - factories
  - infrastructure
  - transportation
  - ...



(ABB, 2019)



(ABB, 2019)



(ABB, 2019)



# Critical Communications

- Critical communications services will evolve from current 4G views:
  - command and control
  - public safety
  - secure information



*(Thales, 2019)*

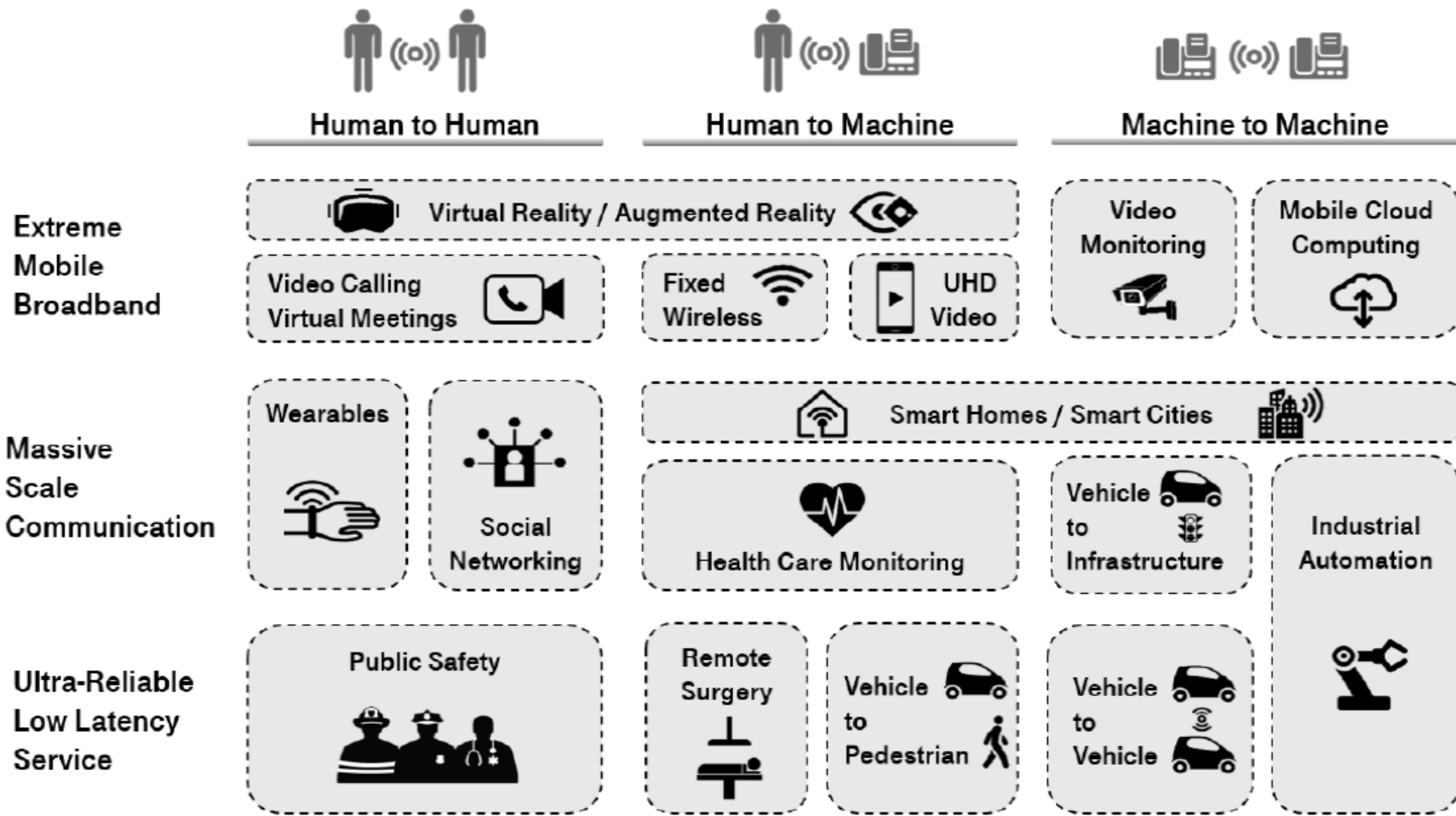


*(Capcom, 2019)*



*(Motorola, 2019)*

# The Human to Machine Transition



(5G Americas, 2017)

# Smart Cities

- Smart Cities are getting a lot of attention lately, encompassing:
  - Public information and training
  - Emergency warnings
  - Health, inclusion and assisted living
  - Intelligent Transportation Systems
  - Environment, Energy Efficiency, and Smart Grids.



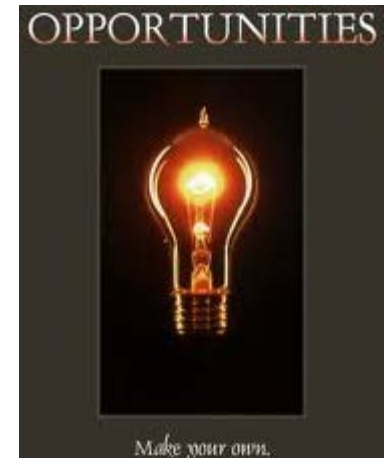
*(colourdesign, 2010)*



*(photoaki, 2010)*

# Too Many Players

- Many opportunities can be identified, as well as challenges and barriers.
- It extends beyond ICT, needing to incorporate other dimensions.
- It is a very fragmented market, dealing with a high number of stakeholders and a huge variety of systems (interoperability!?).



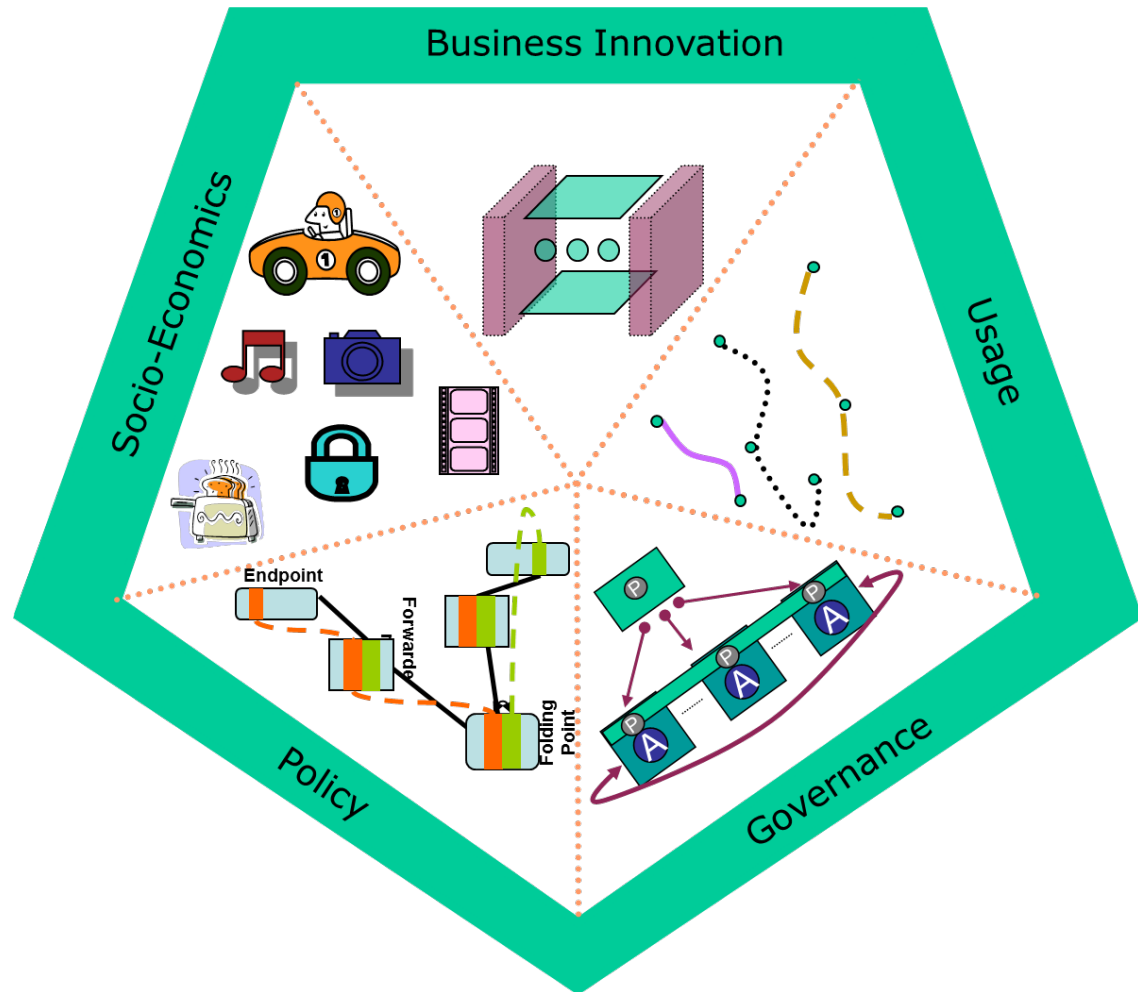
*(inetgiant, 2010)*



*(LynTopinka, 2006)*

# A Broader View

- When dealing with the application of technology, one needs to have a broader view, beyond the technical aspects.



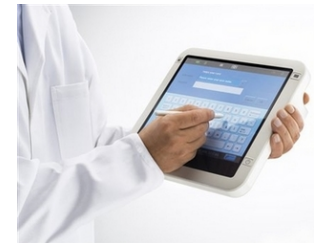
(4WARD, 2010)

# Health, Inclusion and Assisted Living (1)

- The following key areas were identified:
  - wireless diagnostic and disease management,
  - hospital consultation and emergency scenarios,
  - assistive technologies,
  - well being and personalisation.



(T 2010)  
echnology



(M 2010)  
edical



(P 2010)  
recision

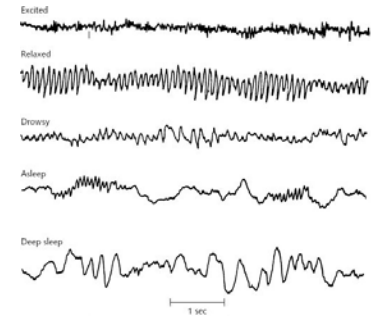


(E 2010)  
nvironment



# Health, Inclusion and Assisted Living (2)

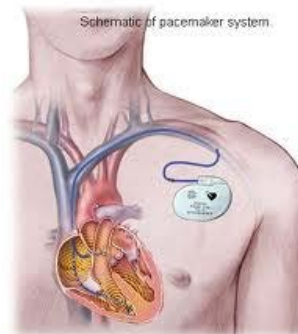
- Application requirements can vary a lot:
  - wide range in the volume of data,
  - continuous measurement,
  - “error free” data,
  - delivery of alarms,
  - personalised devices,
  - ...



(answers, 2010)



(hermes, 2009)



(biojoblg, 2008)

# Intelligent Transportation Systems

## (1)

- These key areas were identified:
  - urban and road traffic management,
  - efficient trip management,
  - communication services (V2V and V2I),
  - mobile prosumer.



( I D R C )  
2 0 1 0



( v e h i c l e t r a c k )  
2 0 1 0



( a u t o m o )  
2 0 1 0  
k

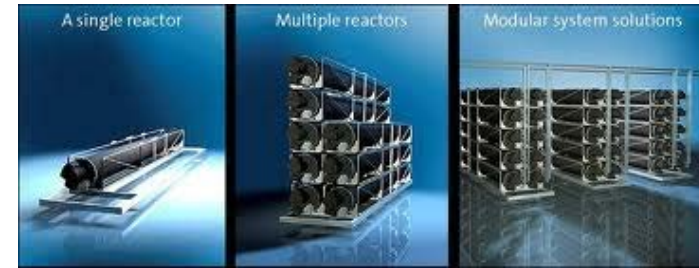


(webcredible, 2010)



# Intelligent Transportation Systems (2)

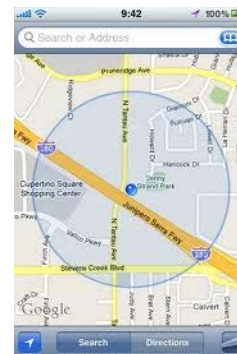
- Requirements include:
  - scalability of solutions,
  - heterogeneity of devices,
  - availability of accurate location information,
  - real-time exchange of data,
  - ...



(grundfos, 2009)



(USurrey, 2008)



(Apple, 2010)

# Environment, Agriculture and Energy Efficiency (1)

- Several key areas were identified:
  - integration into infrastructures,
  - sensor and actuators systems,
  - smart devices,
  - smart grids.



(best buildings 2010)



(senseye, 2015)



(solarstreet, 2010)



(allthingsgreen, 2010)

# Environment, Agriculture and Energy Efficiency (2)

- Requirements encompass:
  - reliable real-time communications,
  - battery long life,
  - specific sensor and actuator networks,
  - redundant communication channels,
  - ...



(masternewmedia, 2009)



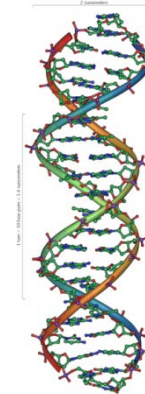
(digikey, 2009)



(headway, 2010)

# Policy (1)

- Research on the Future Internet needs to interact with other areas (biology, sociology, psychology, construction, cars, ...).
- This interaction will increase the complexity concerning regulation and policy.
- Will there be ethical barriers, like those existing today in biology/medicine?



(Wikipedia, 2008)



(RICS, 2008)



(PBASE, 2008)



(Amazon, 2008)



# Policy (2)

- Whether we like it, or not, some policy aspects do need to be taken into consideration, e.g., the possibility of Governments having access to data.
- How to comply with the interests of so many players (telecom operators and vendors, service and content providers, banks, goods distribution, ...), with different development cycles?



(Tecnotrekos, 2008)



(Swissbank, 2008)



(GeeAyBee, 2007)



# Conclusions

- The evolution from 4G to 5G is based on a new set of performance parameters, beyond data rate.
- Communication latency and connectivity capacity play an important role in 5G, yielding non-direct human services and business ones, i.e., no longer focused on the consumer market.
- The variety of services and applications is going to increase beyond imagination.
- Many challenges are still open, namely the deployment of services by companies with very different development cycles.



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# The End

- “I think there is a world market for maybe 5 computers”, Thomas Watson (IBM), 1943.
- “There is no reason anyone would want a computer in their home”, Keneth Olsen (DEC), 1977.
- “The best way to predict the future is to invent it”, Alan Kay (UCLA), 1971.





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# Thank you!

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URL: <http://grow.tecnico.ulisboa.pt>

