



# 5G AND MOBILE CLOUD

ITG Fachtagung Mobilkommunikation

Hans J. Einsiedler



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# AGENDA

- Challenges of mobile communication and the next generation of communication – 5G
- Seamless mobility starts now
- Infrastructure challenges
- New communication model – evolution or revolution?
- The future of the devices
- R&D&I Activities in the EU for future Internet services and test facilities

# **CHALLENGES OF MOBILE COMMUNICATION AND THE NEXT GENERATION OF COMMUNICATION - 5G**



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# CHALLENGES FOR MOBILE COMMUNICATION

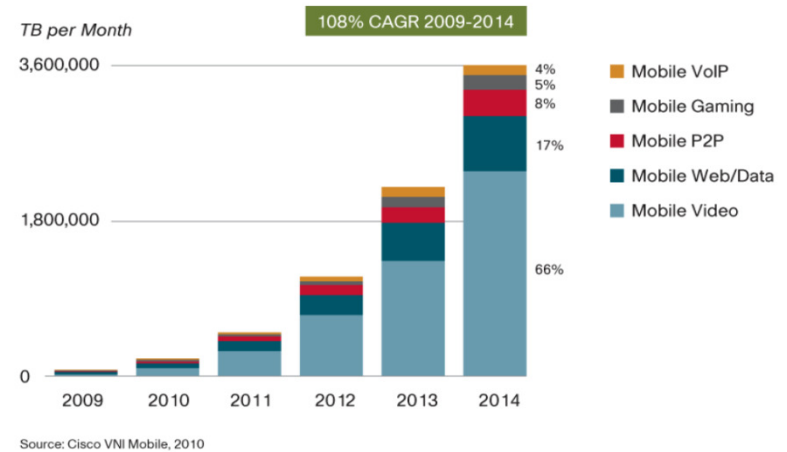
## Key facts

Fast growing mobile data volume and number of subscribers.

## Impact

Gap between mobile data volume and revenues is growing.

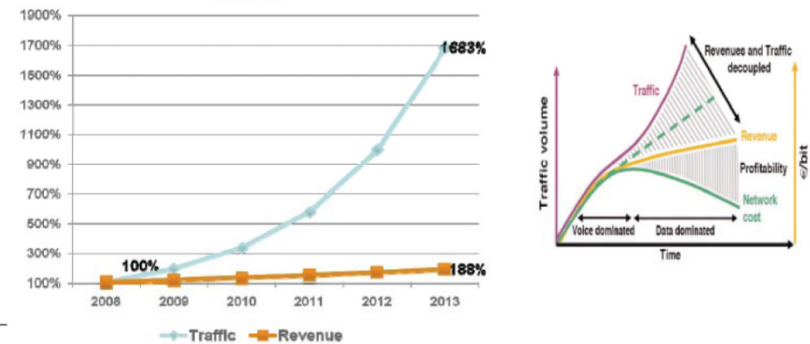
### Mobile Traffic Classes Forecast



### Traffic vs. Revenues Forecast

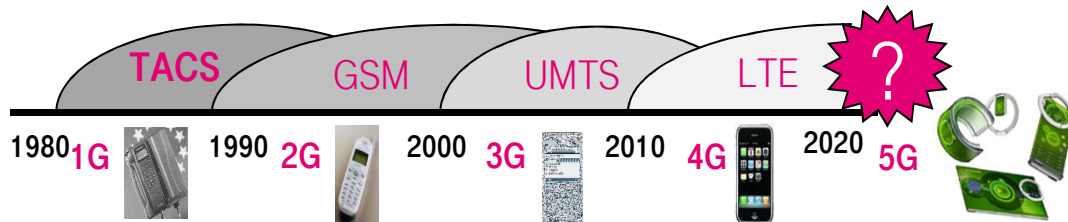
**Global mobile data traffic volumes to grow to 17x 2008 levels by 2013, whilst revenues grow by factor of 1.8x**

Global mobile data traffic and revenue growth, 2008-2013



# WHY IS THERE A NEED FOR 5G?

- Innovation cycles for new mobile radio network generation approximately every 10 years
- ITU-R WP 5D initiated a study on “IMT vision for 2020 and beyond”



## Data traffic avalanche

- More mobile users
- Increase of (HD-) video-based service usage
- Higher usage of cloud-based applications

## Massive growth of connected devices

- Expected increase of number of devices from 5 bio. in 2010 to 50 bio. in 2020 mainly by introduction of massive machine-type communication
- Paradigm shift from human-centric to human & machine-centric systems

## Diversification of services and equipment

- Novel services (e.g. augmented reality, M2M, public safety) with varying QoS requirements
- Diverse radio node and user device capabilities (single/multi-antenna/-RAT\*, low-high power,...)
- Additional nomadic/mobile network nodes (relaying/multi-hop) and device-to-device (D2D) communications

\* Radio Access Technology

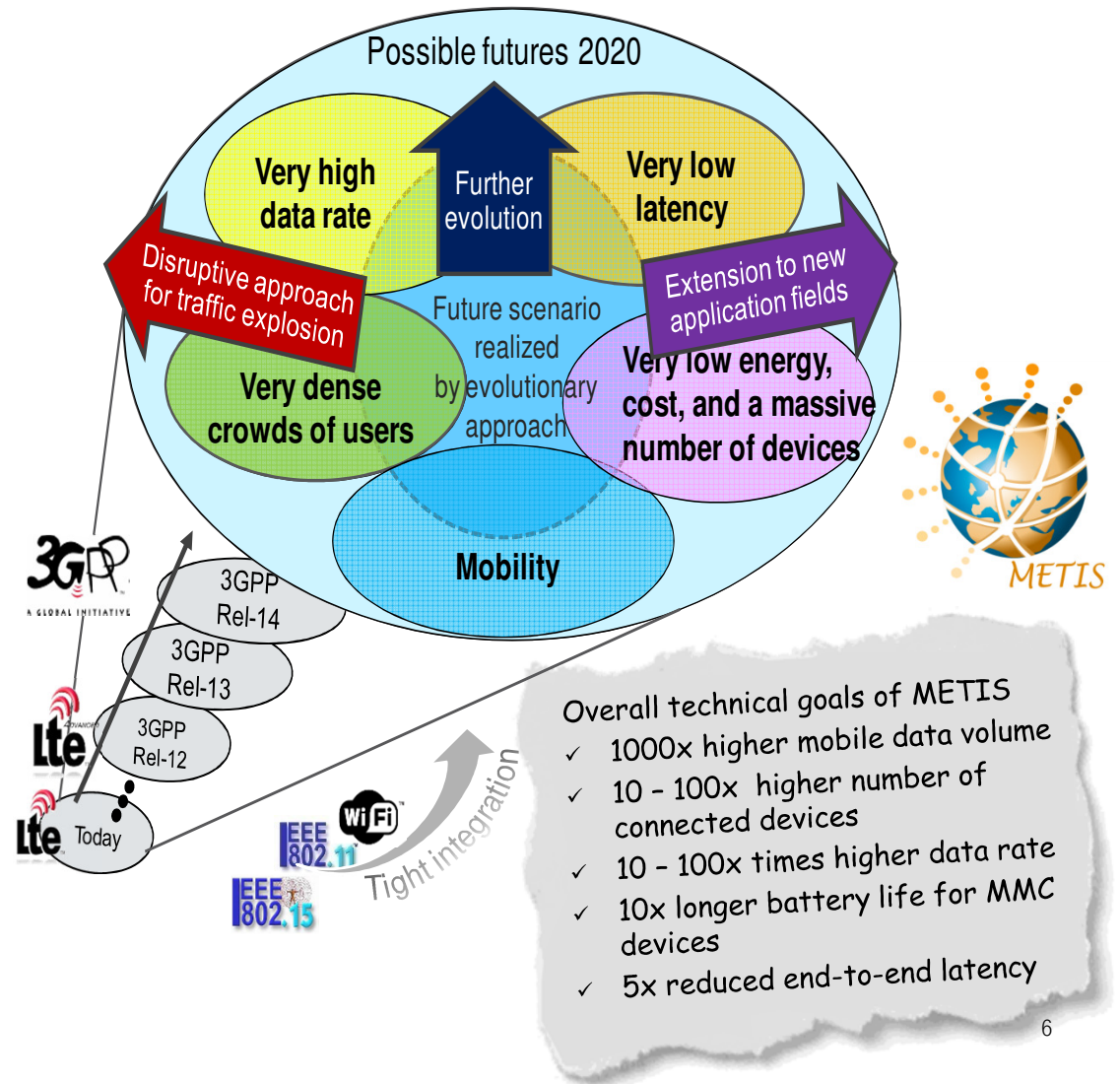


# METIS – ROADMAP FOR 5G SOLUTIONS.

Five challenges addressed by METIS  
(<https://www.metis2020.com/>)

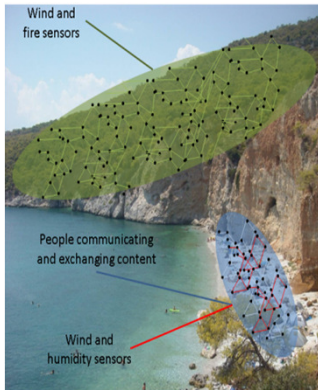
- Fundamental technical difficulties addressed for the 5G mobile and wireless communications system in 2020 and beyond:
  - Very high data rate
  - Very dense crowds of users
  - Very low latency
  - Very low energy, cost, and a massive number of devices
  - Mobility
- Green field development of technical solutions\* → Revolutionary approach!
- Follow-up integration of solutions into standardization processes (3GPP, IEEE, ...) → Evolutionary approach!

\* Avoidance of limitations by backward compatibility issues

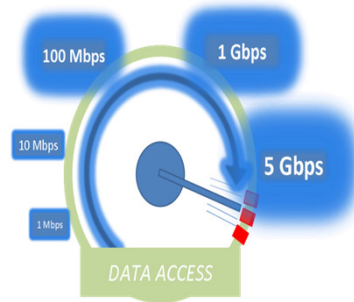


- Overall technical goals of METIS
- ✓ 1000x higher mobile data volume
  - ✓ 10 - 100x higher number of connected devices
  - ✓ 10 - 100x times higher data rate
  - ✓ 10x longer battery life for MMC devices
  - ✓ 5x reduced end-to-end latency

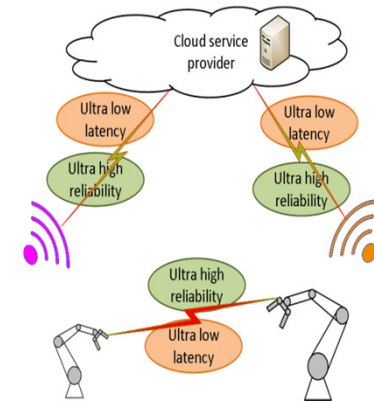
# METIS: SCENARIO SELECTION FOR 2020 AND BEYOND.



“Ubiquitous things communicating”  
(huge number of devices, very low energy & cost, coverage, redundancy)



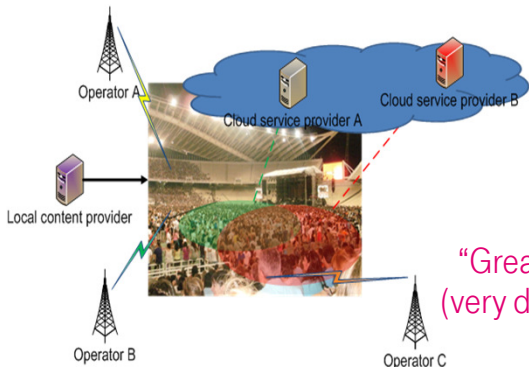
“Amazingly fast”  
(ultra high data rate, low latency)



“Super real-time and reliable connections”  
(strict latency & reliability, new industrial applications, tactile internet)

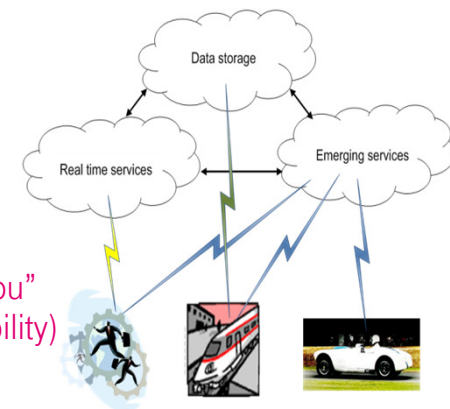
**Five scenarios**

- The scenarios outline the scope of METIS, reflect one specific challenge each
- Each scenario addresses at least one METIS overall goal

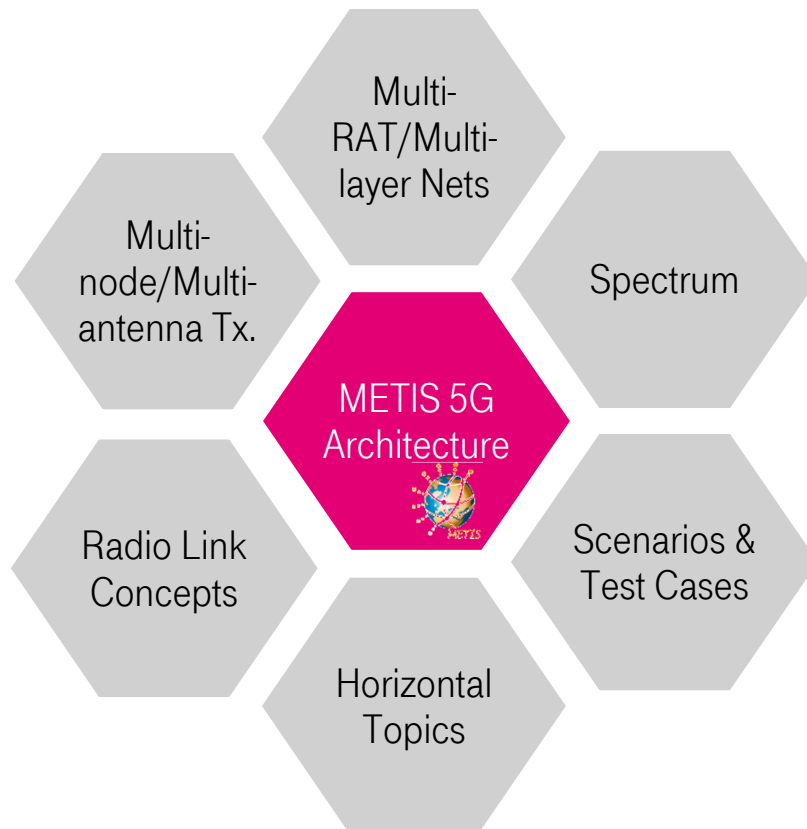


“Great service in a crowd”  
(very dense crowds of users, accessibility)

“Best experience follows you”  
(mobility, coverage, accessibility)



# METIS: 5G SYSTEM ARCHITECTURAL DESIGN.



Consideration of novel architectural trends for techno-economic evaluation of 5G system concept

- **Centralized (C-RAN)/Decentralized or Hybrid Nets**
  - Scalable (centralized) control
- **Network Functions Virtualization (NFV)**
  - Virtualization in RAN, Core & Transport
  - On-demand creation of customized (isolated) virtualized networks using a shared resource pool
- **Software Defined Networks (SDN)**
  - Consolidation of hard & soft network resources
  - Decoupling of control & data planes
- **Software Defined Protocol stacks (SDP)**
  - End-to-end flow delivery
- **Software Defined Content Delivery (SDC)**
  - Information/content management/local caching
- **Cloud Computing**



# SERVICE EXAMPLE: AUGMENTED REALITY



Copyright: Internet (makes it possible)

# MOBILE AUGMENTED REALITY

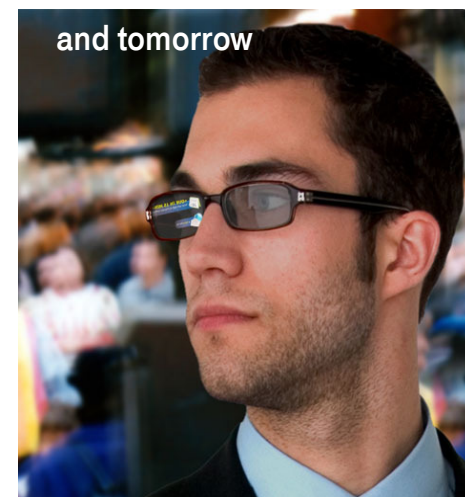
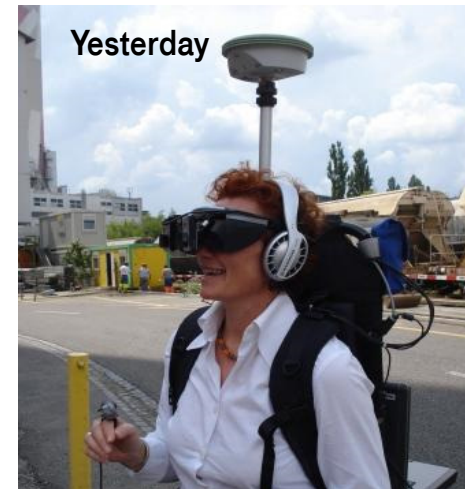
## Requirements for service provisioning

### Mobile Augmented Reality (AR)

- Very small networking and processing time (< 50 ms for data transmission and analysis)
- High update rate (5 - 30 Hz) in order to follow body movements and changes of viewing direction
- Overall data rate (image and context) is 50 kb/s up to 1 Mb/s

### Applications in construction, maintenance, and public security already under development

- ➔ Broad acceptance of AR could increase the mobile data volume by a factor of 2000
- ➔ Latency requirements might require edge computing.



Copyright: Internet (makes it possible)





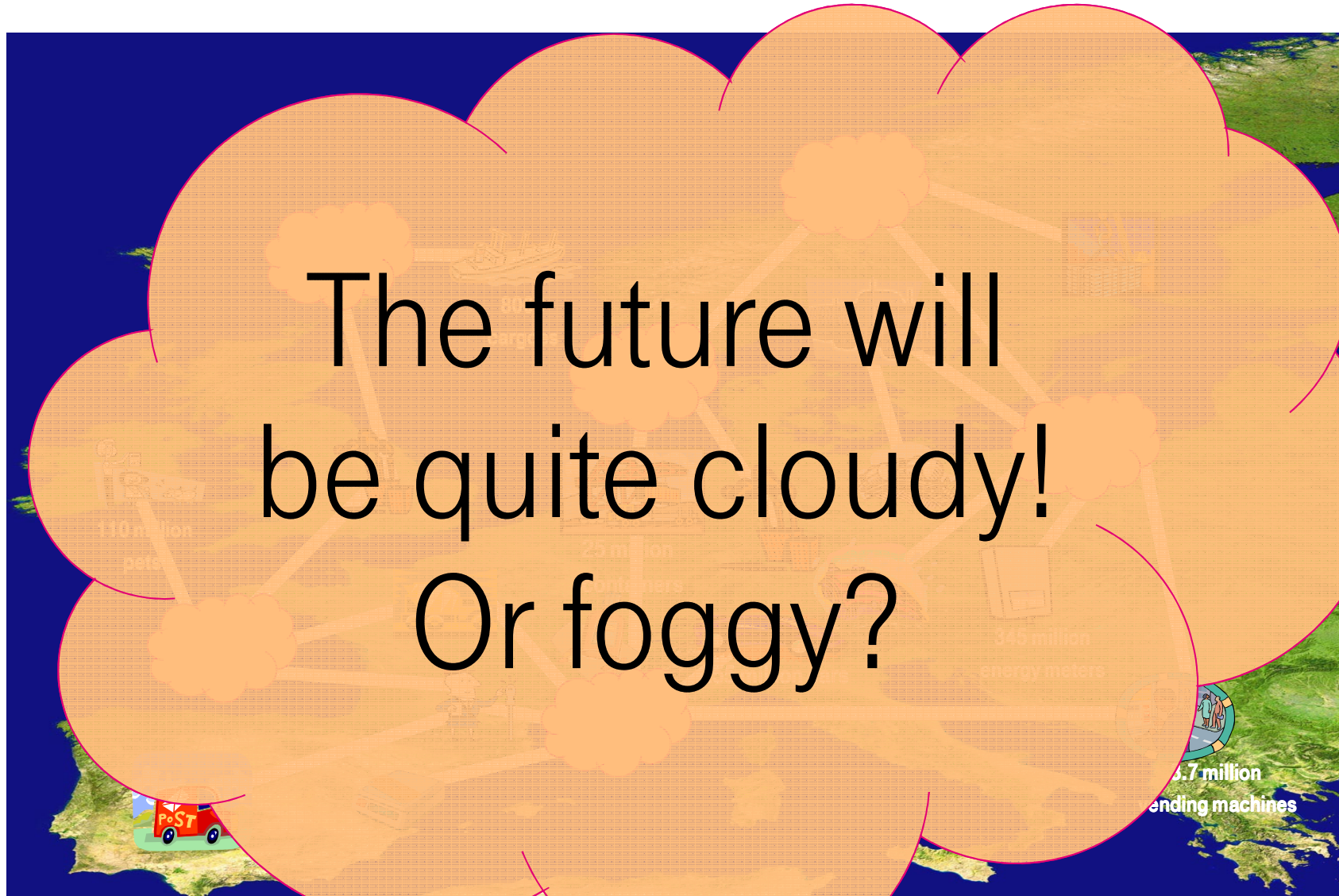




# EVERYTHING WILL BE CONNECTED ...

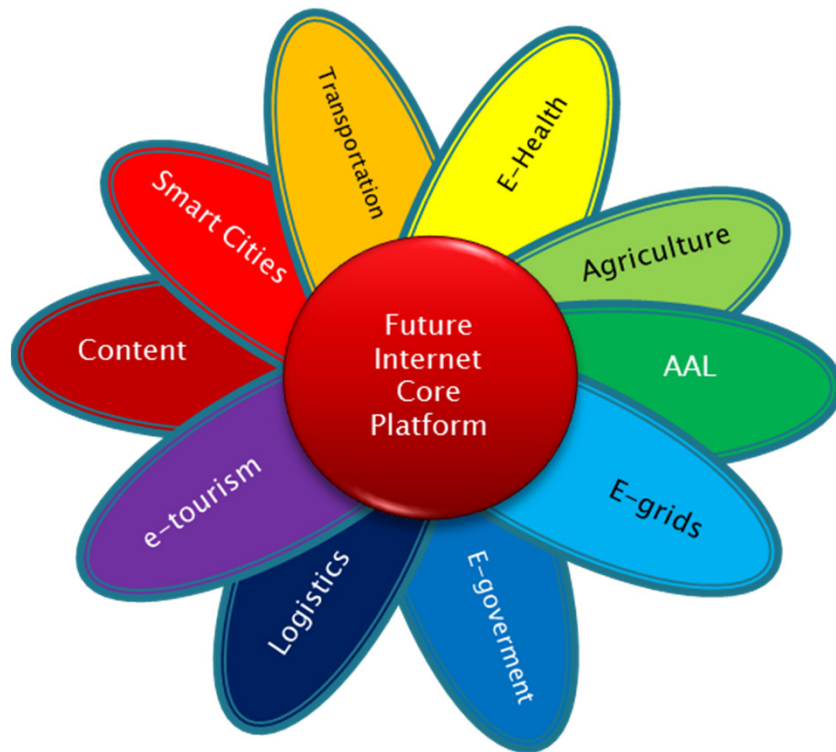


# THE WEATHER FORECAST ...





# FUTURE OF THE INTERNET - NEW APPLICATIONS/ VERTICALS TO BE COVERED



- Internet of Things, logistics  
255 Mio cars, 345 m. e-meters,  
3.7 Mio vending machines (1 10 m pets),  
25 Mio containers, ...
- Gaming
- Personal media clouds
- Cyber-physical systems (automotive, smart  
production & automation, mobile cloud)
- Augmented reality (workers, specialists,  
everybody)
- Mobile applications and mobile devices

# BUSINESS SCENARIOS AND MODELS

## Operator business drivers

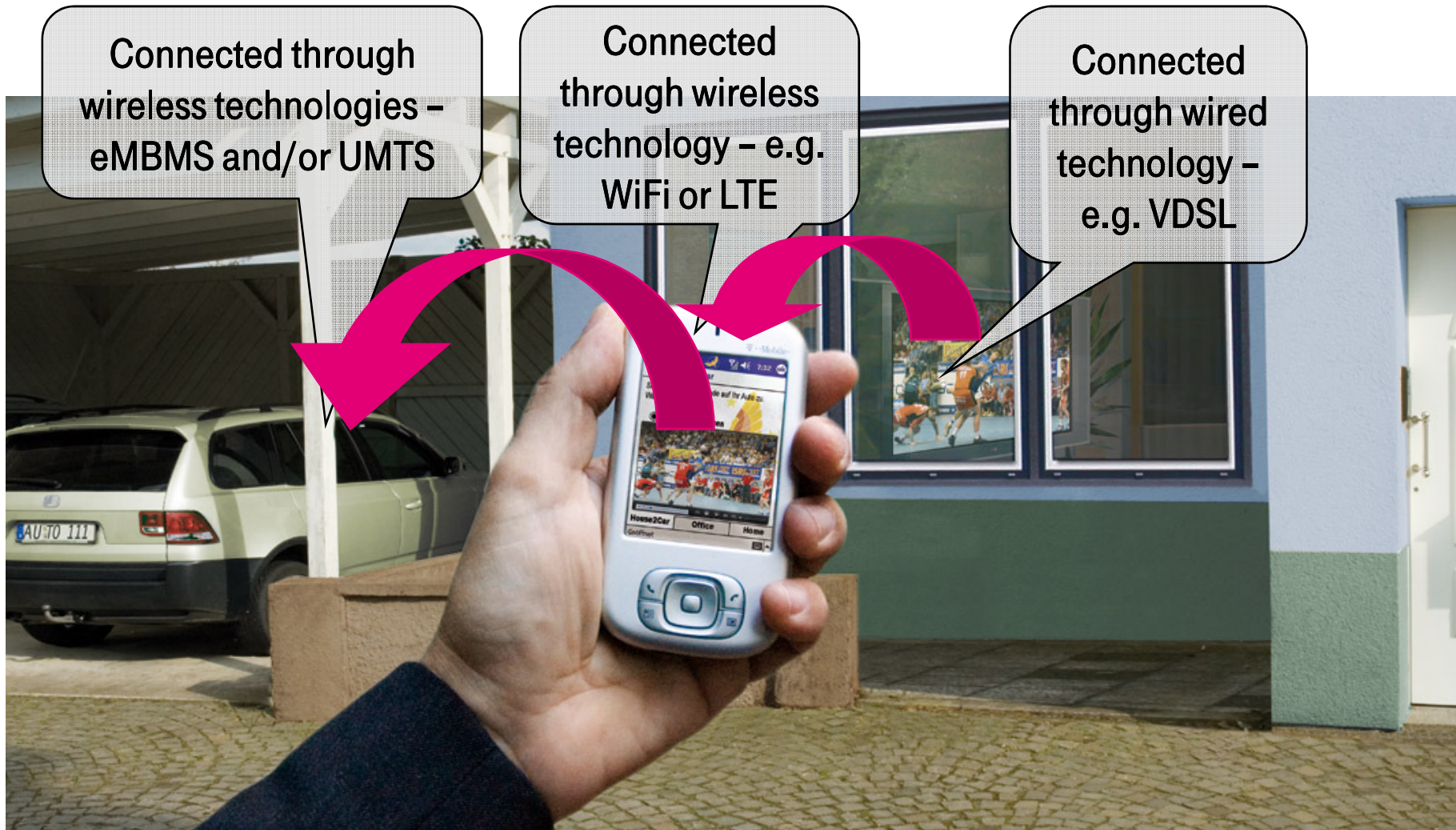
- Enterprise
- Fixed customer – home networks including managing the home networks
- Mobile customers
- Machine type communication
- Network federation
- Network sharing – Virtual (mobile) network operator
- Frequency sharing (e.g. via licensed shared access)
- Network management (orchestration), service infrastructure, infrastructure split
- Roaming (local breakout versus home network control)

**SEAMLESS MOBILITY STARTS NOW**



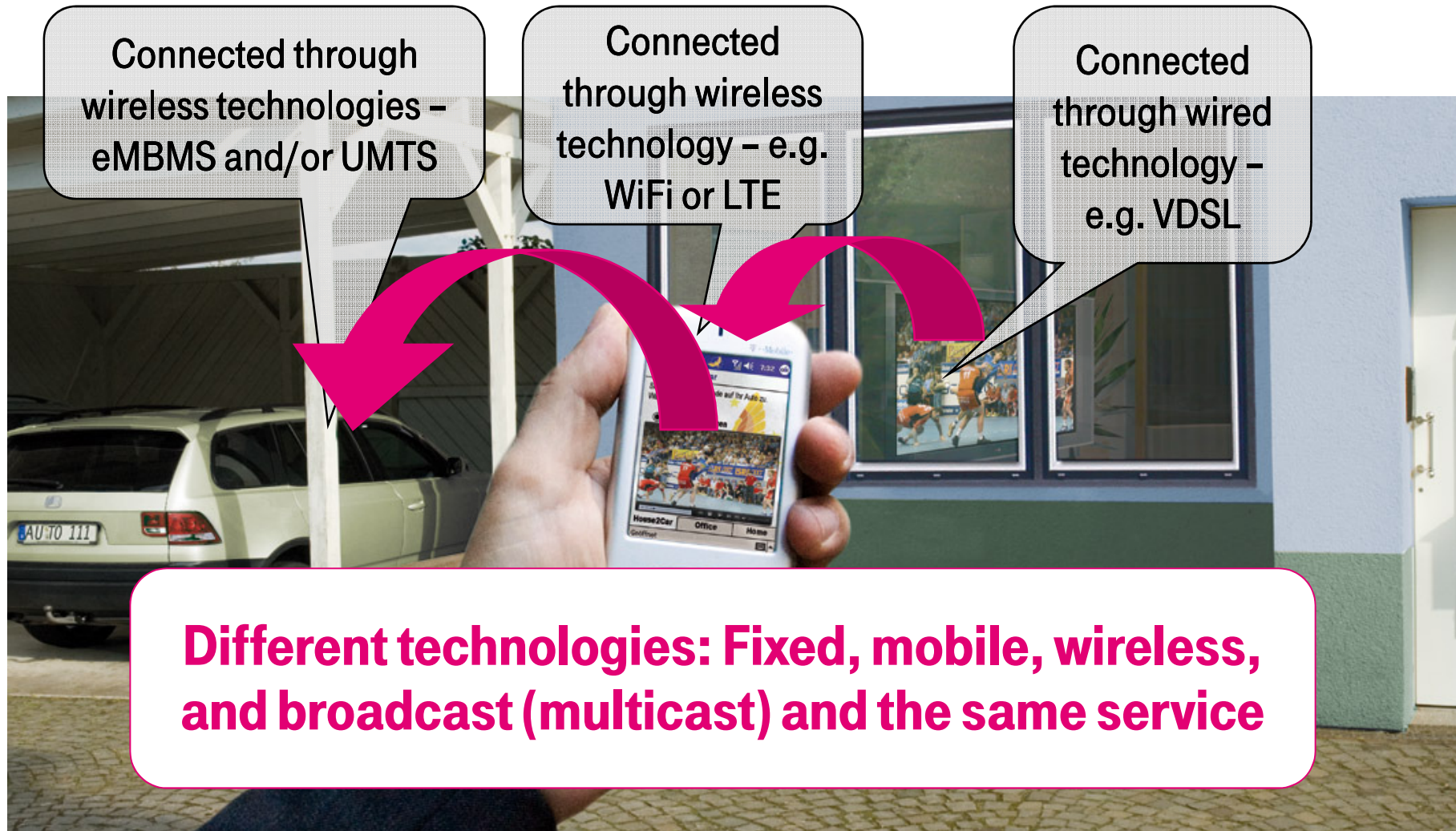
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# FIXED-MOBILE-CONVERGENCE USE CASE.



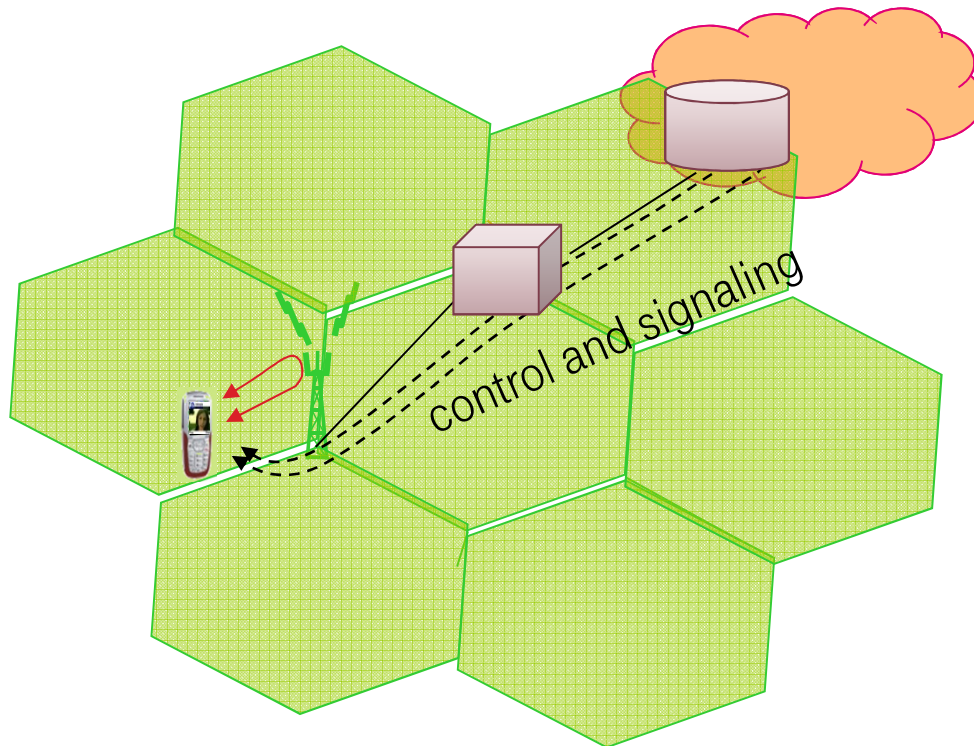


# FIXED-MOBILE-CONVERGENCE USE CASE.





# EDGE COMPUTING



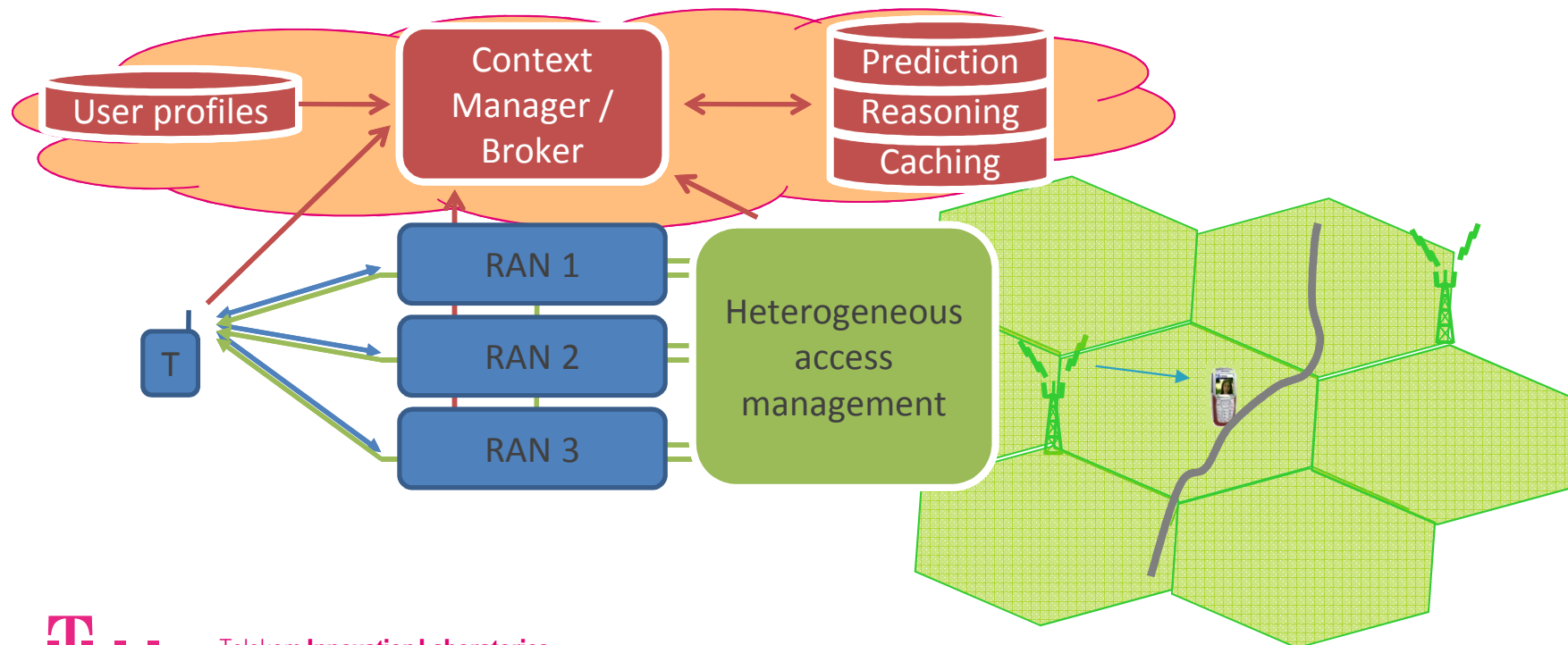
## Extension of the cloud services closer to the mobile terminal:

- Computing and storage capabilities at the edge
- Applications are executed at the edge, can follow the user
- Apps can be “broadcasted” to the access points
- Control, signaling, and AAA can remain in the backbone

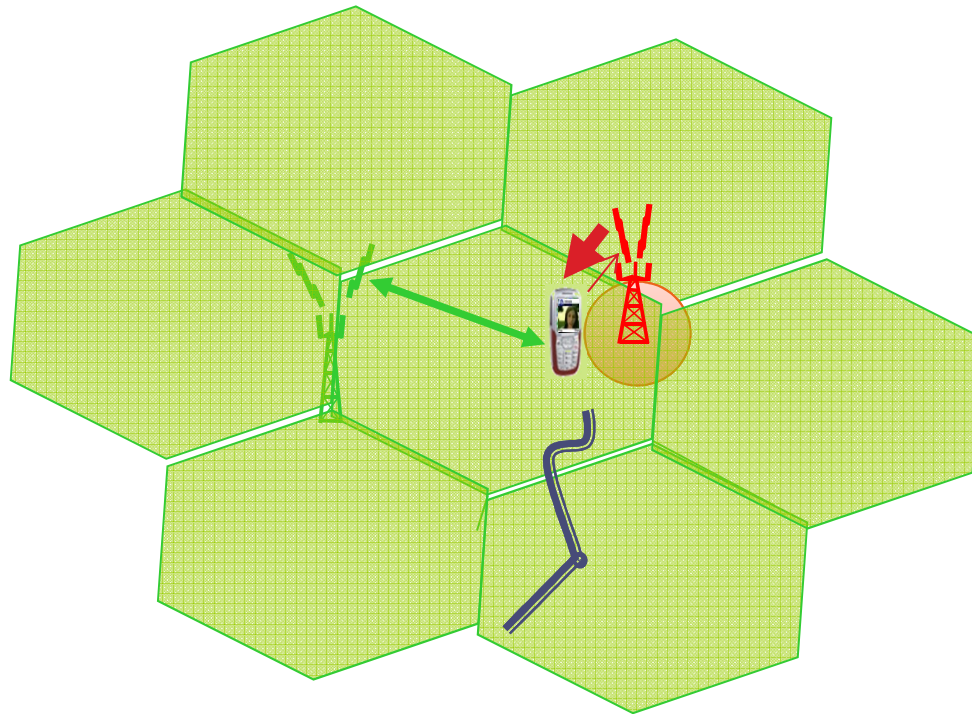
# CONTEXT-AWARE NETWORK SERVICES

Intelligent management and optimizing of network functions and third party support services:

- Mobility support by using terminal movement prediction
- Multicast user group forming by utilizing user profiles and predictions
- Load balancing by exploiting history information



# DOWNLOAD ZONES



## Tight integration of IEEE technologies (802.11x) to the mobile core network:

- Specialized access point for ultra-high data rate (Tb/s) push services (email sync, etc.).
- Low rate full coverage network for signaling, authentication, and access point preparation (context awareness)
- Access point provides only ultra high data rate pipe, but no mobility

# INFRASTRUCTURE CHALLENGES



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# PRESS RELEASES ON 5G INITIATIVES IN EUROPE

heise online > Mobile World Congress-Special > Mobilfunkbranche stellt die Weichen für 5G

24.02.2014 17:21  « Vorige | Nächste »

**MWC Mobilfunkbranche stellt die Weichen für 5G**

 vorlesen /  MP3-Download

Während auf dem MWC in Barcelona alles über LTE redet, laufen im Hintergrund die ersten Vorbereitungen für die nächste Mobilfunkgeneration 5G. Für die EU-Kommission ist das Projekt wichtig genug, um ein paar Millionen auf den Tisch zu legen.

 **MOBILE™**  
**WORLD CONGRESS**

Barcelona | 24 - 27 February 2014

Messe-Info und Termine    An- und Abreise

 **Interactive Workshop**

The International Wireless Consortium™



**5G - Rethinking Wireless Infrastructure**

Exploring Evolutionary and Disruptive System and Technology Concepts

Hosted by:




 **ngmn**  
the engine of broadband wireless innovation

5G mobile and wireless communication systems will require a mix of new system concepts to boost spectral efficiency, energy efficiency and the network design, such as massive MIMO technologies, green communications, cooperative communications and heterogeneous wireless networks. We expect to explore the prospects and challenges of 5G mobile and wireless communication systems combining all of the above new designs and technologies. It is important to recognize revolutionary technology elements and more evolutionary approaches which both will lead to 5G (quote from: Vodafone)


**Mobile Operators work together to define requirements for "5G"**

*Barcelona, Spain – 24<sup>th</sup> February, 2014*

The Next Generation Mobile Networks (NGMN) Alliance is excited to announce the launch of a global initiative for 5G. Inspired by the strong industry collaboration which materially contributed to the success of LTE and its adoption across the world, this initiative will deliver key operator requirements intended to guide the development of future technology platforms and related standards, create new business opportunities and satisfy future end-user needs.

 mobile network technology

February 10<sup>th</sup>  
**Munich**  
Sofitel Bayerpost

 **HUAWEI**

media partner  
**SCIENCE BUSINESS**

5G Europe Summit 2014

Mobile World Congress in Barcelona - Deutsche Telekom Booth (Hall 3, Booth K30)



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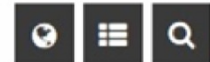
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BUSINESS

Mobile World Congress in Barcelona - Deutsche Telekom Booth (Hall 3, Booth K30)



# 5G-Infrastructure PPP



About Us ▾

How to participate ▾

Plans & Papers ▾

Events ▾

European 5G Actions ▾

Global 5G Actions

Contact ▾

📅 Sunday, 6 April 2014

March 19, 2014

Registration for the 5G-Infrastructure-PPP information day on  
28th April is now open



# GENERAL CHALLENGES 5G INFRASTRUCTURE PPP

## Key numbers for 5G operator – EU triggered public private partnership

- 1000 times higher mobile data volume per geographical area.
- 10 to 100 times more connected devices.
- 10 times to 100 times higher typical user data rate.
- 10 times lower energy consumption
- End-to-End latency of  $< 1$  ms
- Ubiquitous 5G access including in low density areas

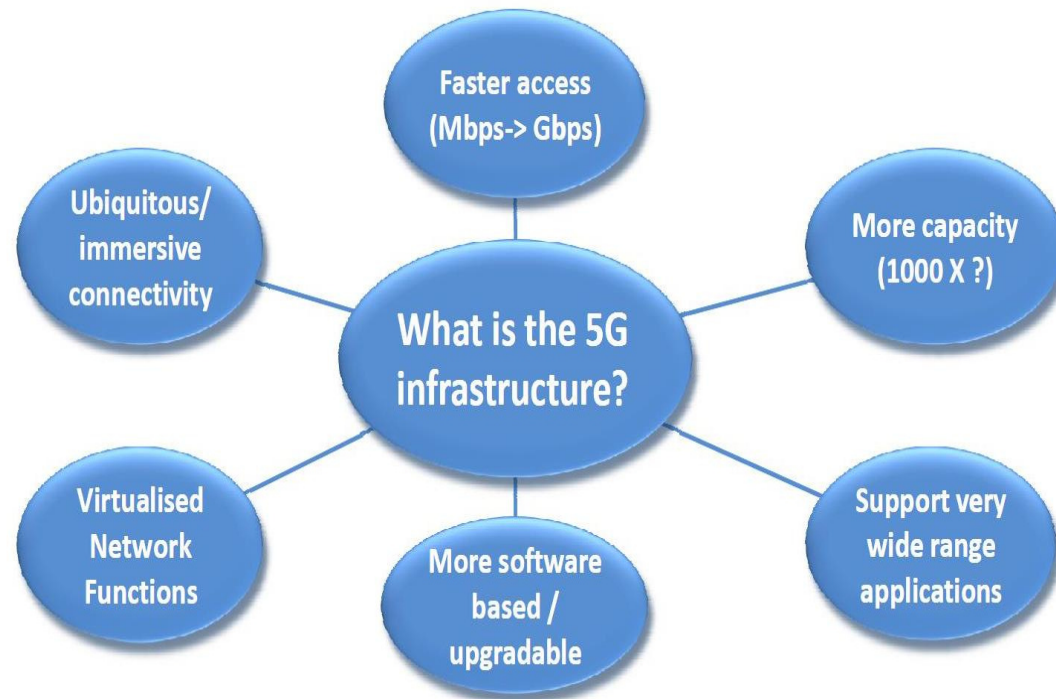


Reference: <http://5g-ppp.eu/>

# CHANGES MEANS INVESTMENTS

## How will we justify the investment: Cost savings!

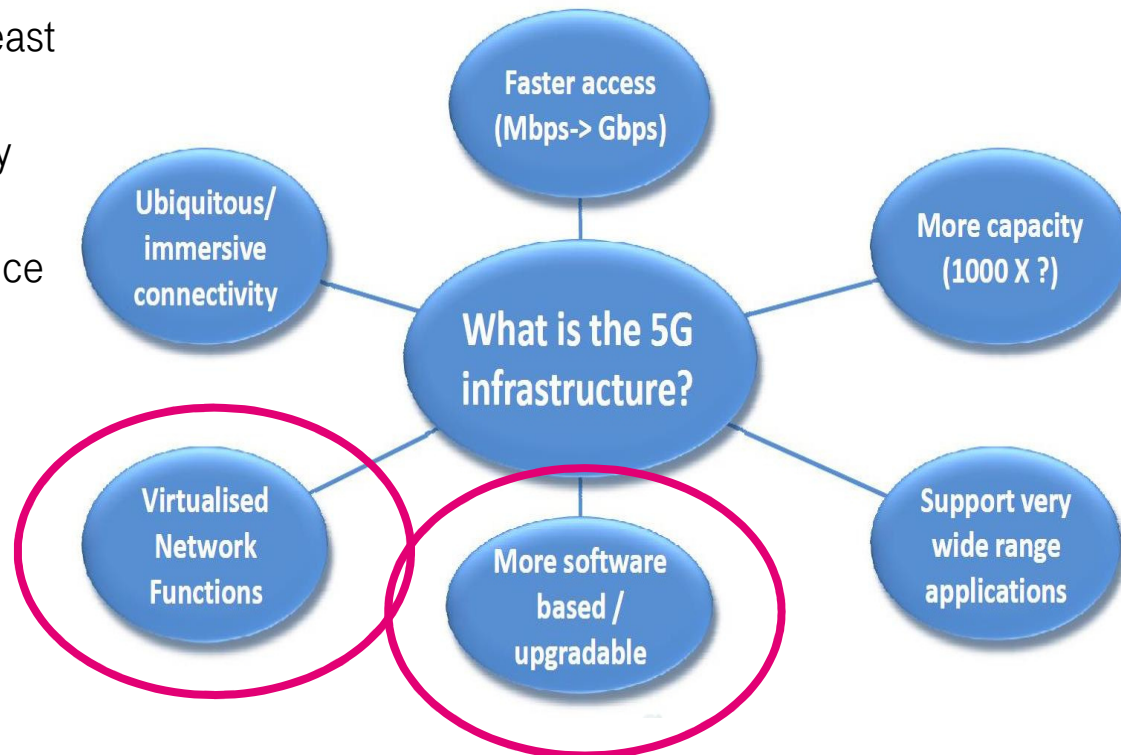
- Reduction of the network management OPEX by at least 20%
- Saving up to 90% of energy per service provided.
- Reducing the average service creation time cycle from 90 hours to 90 minutes.



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# INFRASTRUCTURE – BASES FOR COMMUNICATION

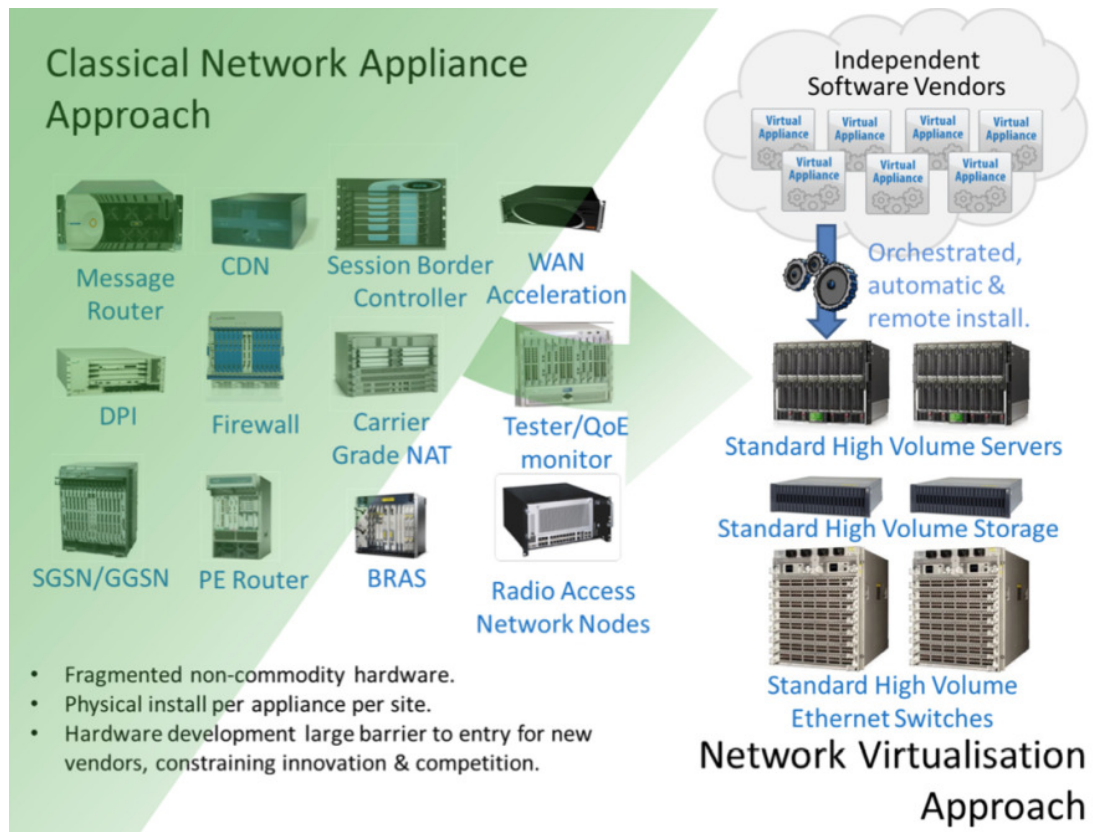
## Well known figure ...

Today's infrastructure:

- Current network equipment designed for special use case

SDN and NFV :

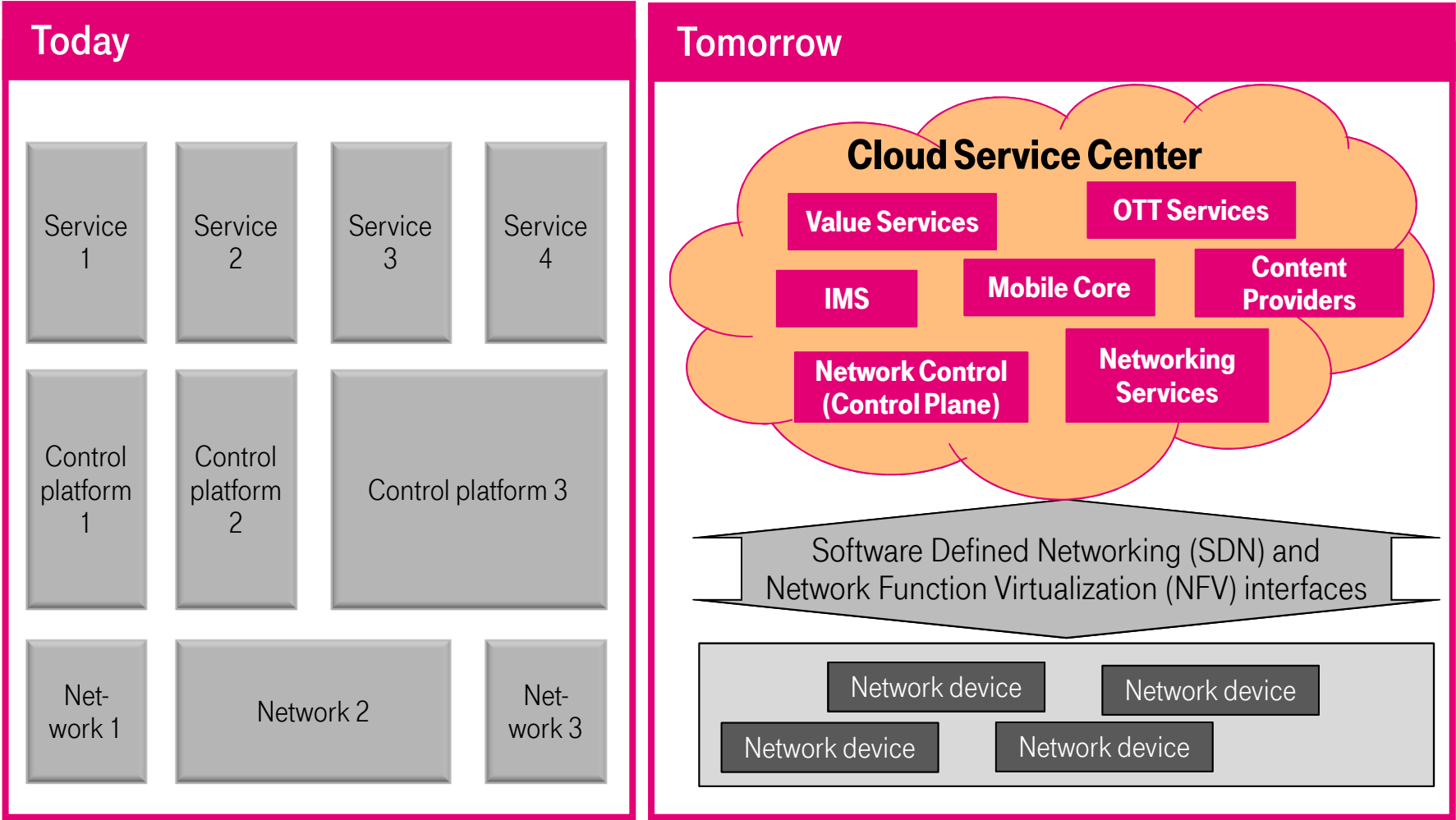
- Special use cases as software release running on top of standard hardware
- Virtualization will become a key issue to reduce OPEX and CAPEX



Copyright: Internet (makes it possible)



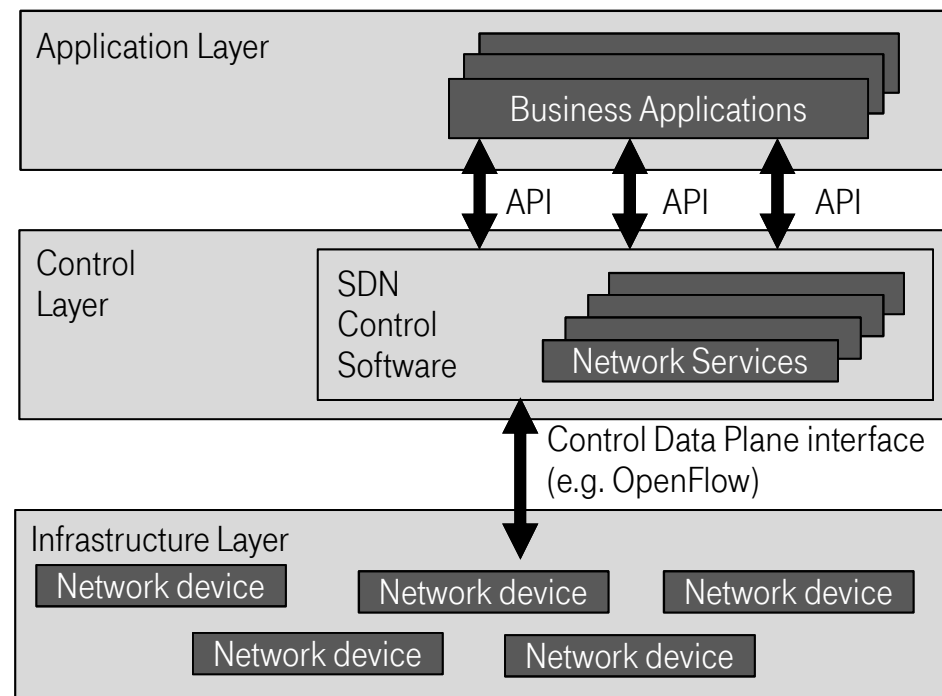
# NETWORK OPERATOR EVOLUTION



# SDN AND NVF IMPLEMENTATION

## Split of the control plane from the user/data plane

- User/data plane implemented by standard uniform equipment
- Control plane implemented in the cloud – Network Function Virtualization – with standardized and open interfaces to business applications
- Software maintained by the operator
- Open question: How is the energy efficiency of the solution?



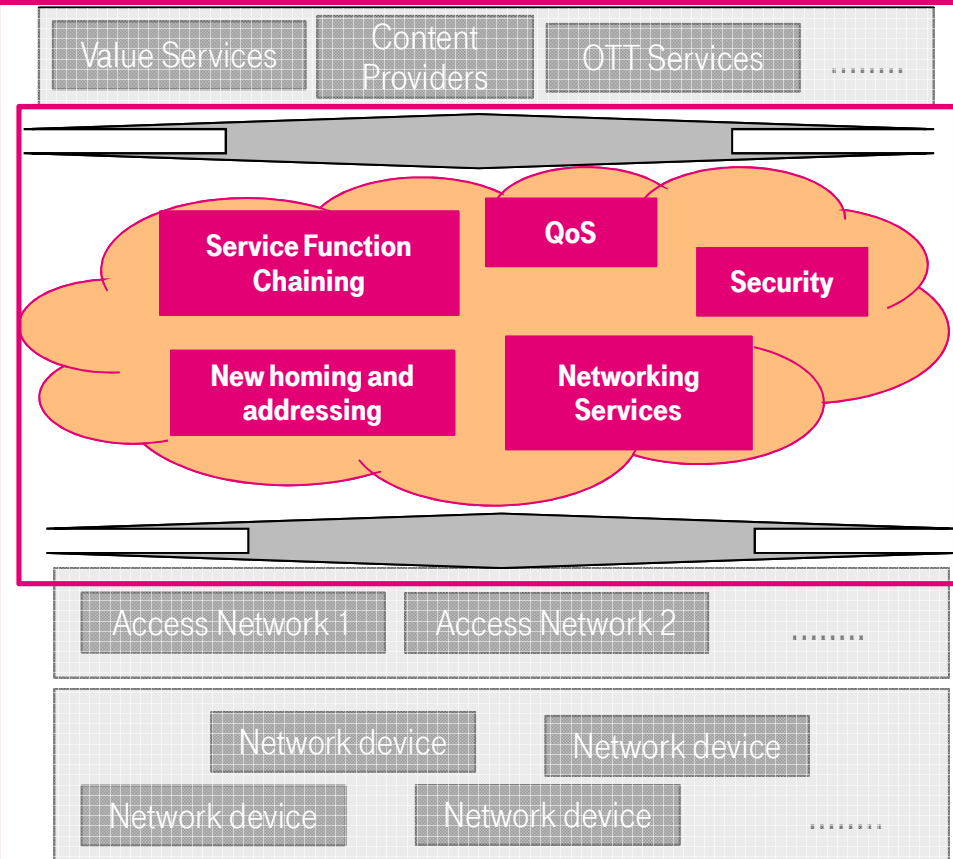
Source ONF (Open Network foundation)

# CHALLENGE SPACE FOR FUTURE RESEARCH

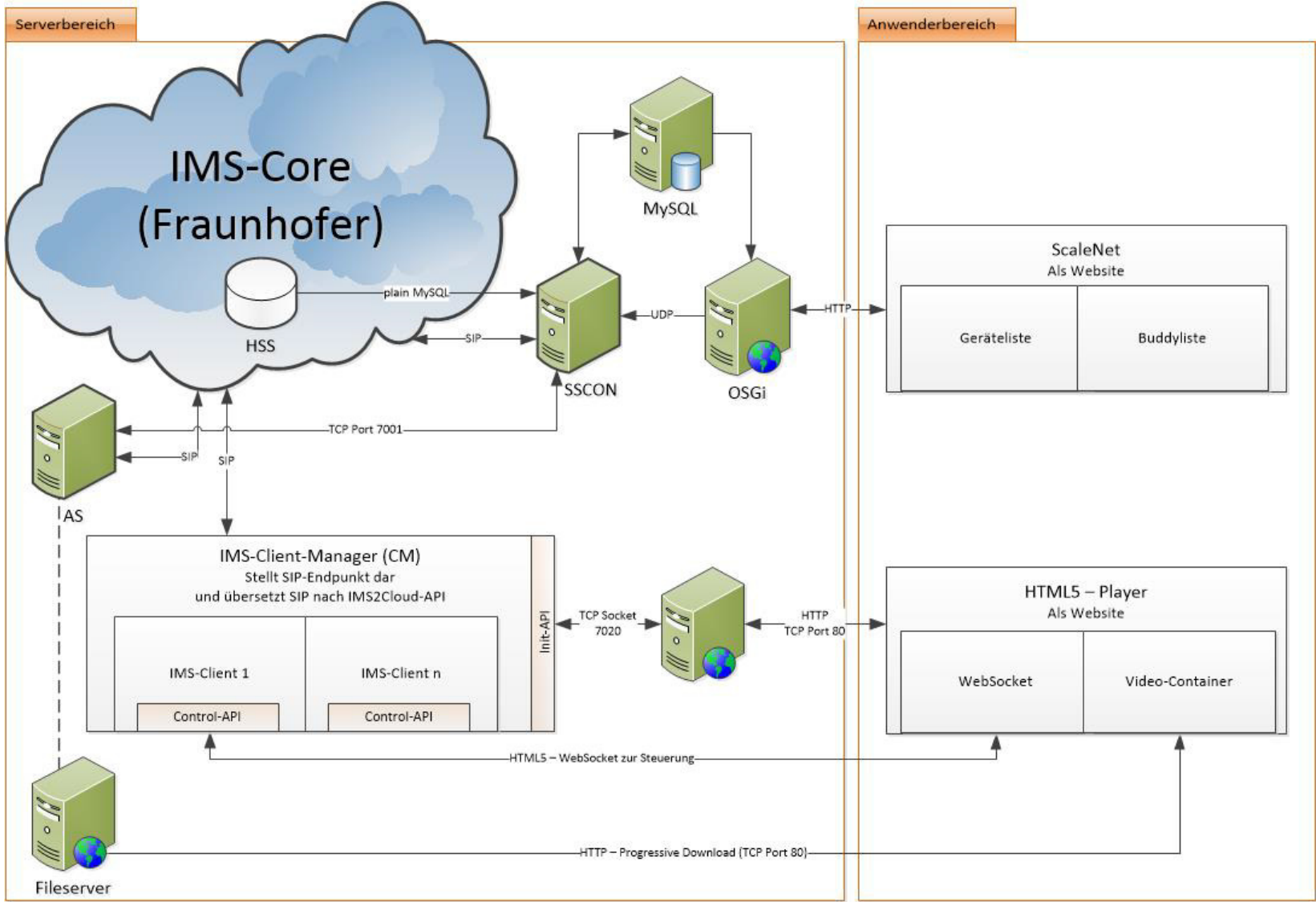
## Open questions

- Local RAN and fixed network control and management?
- Interfaces towards third party and content providers?
- Device remote management?
- Self-x mechanisms?
- Physical and link layer management and cloud RAN aspects?
- Hand-over within a hierarchical technology architecture (macro-small-pico-femto cells)?
- How to implement low latency requiring service support?
- Makes is sense to route all real-time traffic to the home and back in a roaming case?
- How to integrate broadcast services?

## Functional blocks



# IMS2CLOUD – AN EXAMPLE





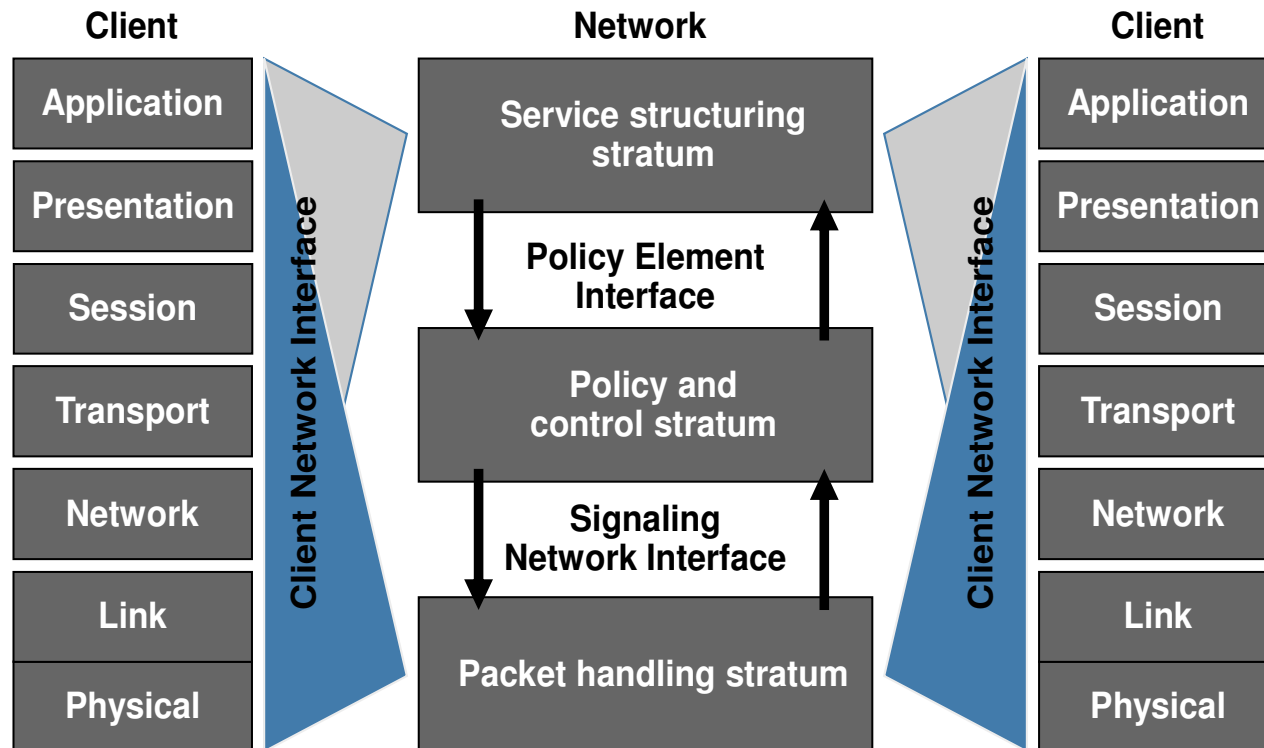
# **NEW COMMUNICATION MODEL – EVOLUTION OR REVOLUTION?**



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# HOW TO START WITH AN COMMUNICATION MODEL?

## Strata model from IPsphere

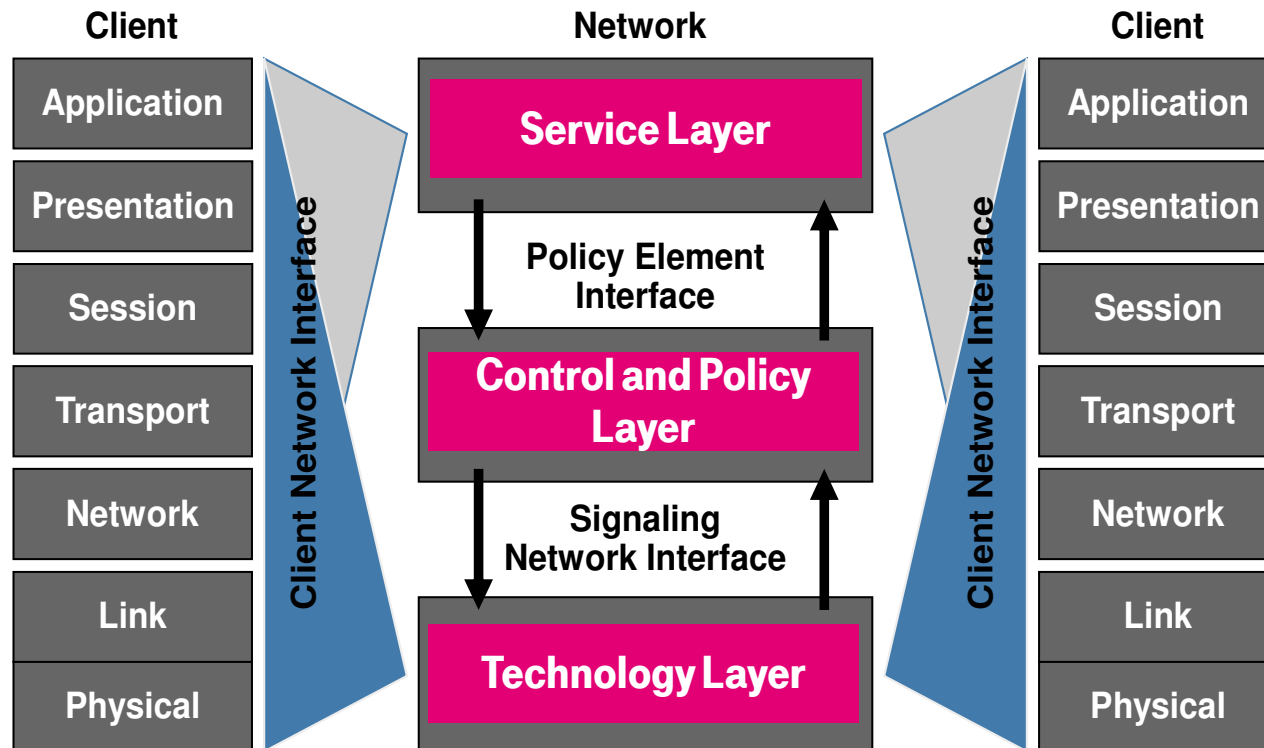


- Stratum can be seen as “Layer” in a reduces OSI-Layer protocol stack
- Strata model can by seen as overlay model in network concepts

T. Nolle, “A New Business Layer for IP Networks”, July 2005 Issue of Business Communications Review, 999 Oakmont Plaza Drive, Suite 100, Westmont, IL 60559, 630/986-1432, [www.bcr.com](http://www.bcr.com) - [http://www.ipsphereforum.org/Files/A New Business Layer for IP Networks – TN1.pdf](http://www.ipsphereforum.org/Files/A%20New%20Business%20Layer%20for%20IP%20Networks%20-%20TN1.pdf).

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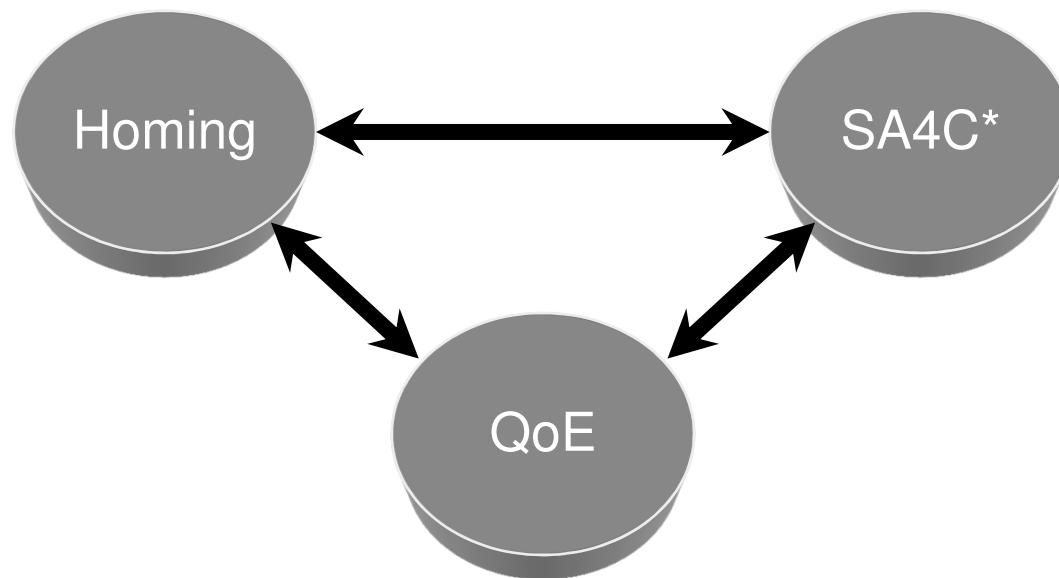
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# BASIC BUILDING BLOCKS FOR USER SERVICES



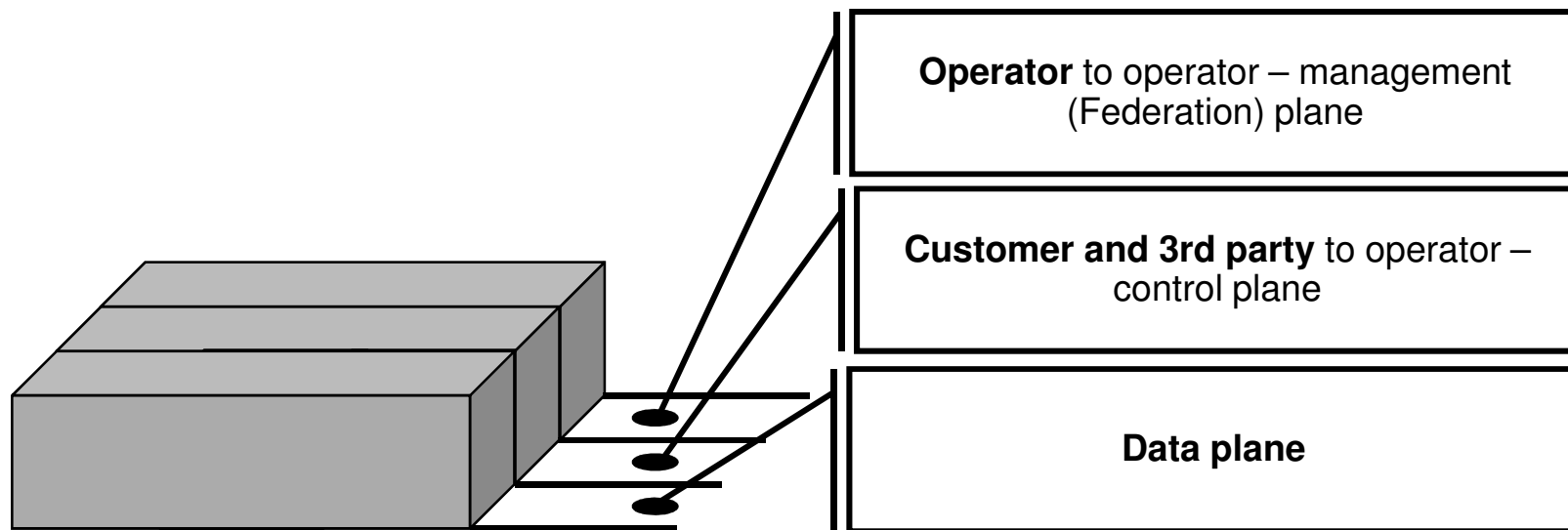
- Building blocks (called “scope”) to offer user the best network service possible
- Not all building blocks have to be used for network service offering
- Results were found in EU-project Moby Dick and Daidalos I and II



\*SA4C: Security, Authentication, Authorisation, Accounting, Auditing, Charging

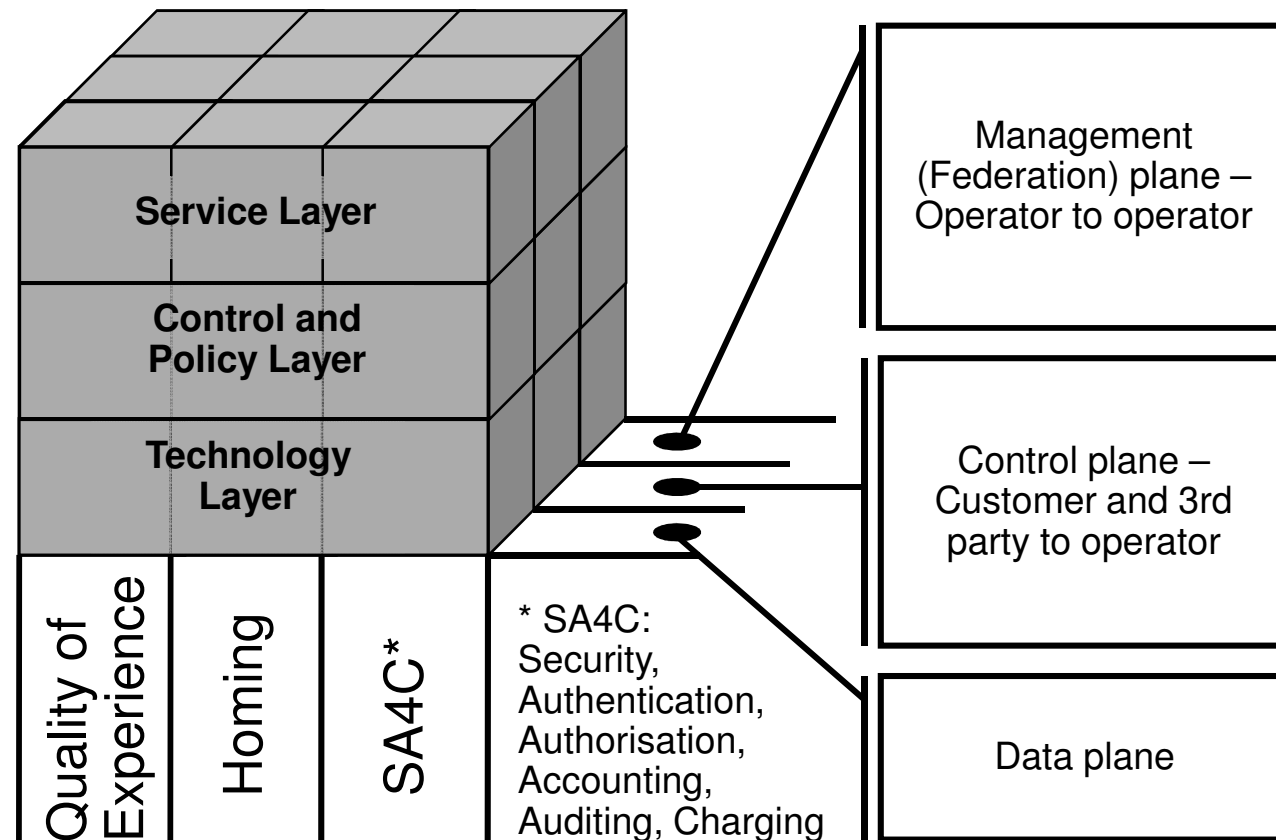
# BUSINESS RELATIONS AND MANAGEMENT PROCESSES

- Planes defined by Next Generation Networks (NGN) principles
- Business relation included in the planes
- Planes describes the execution time of the respective processes





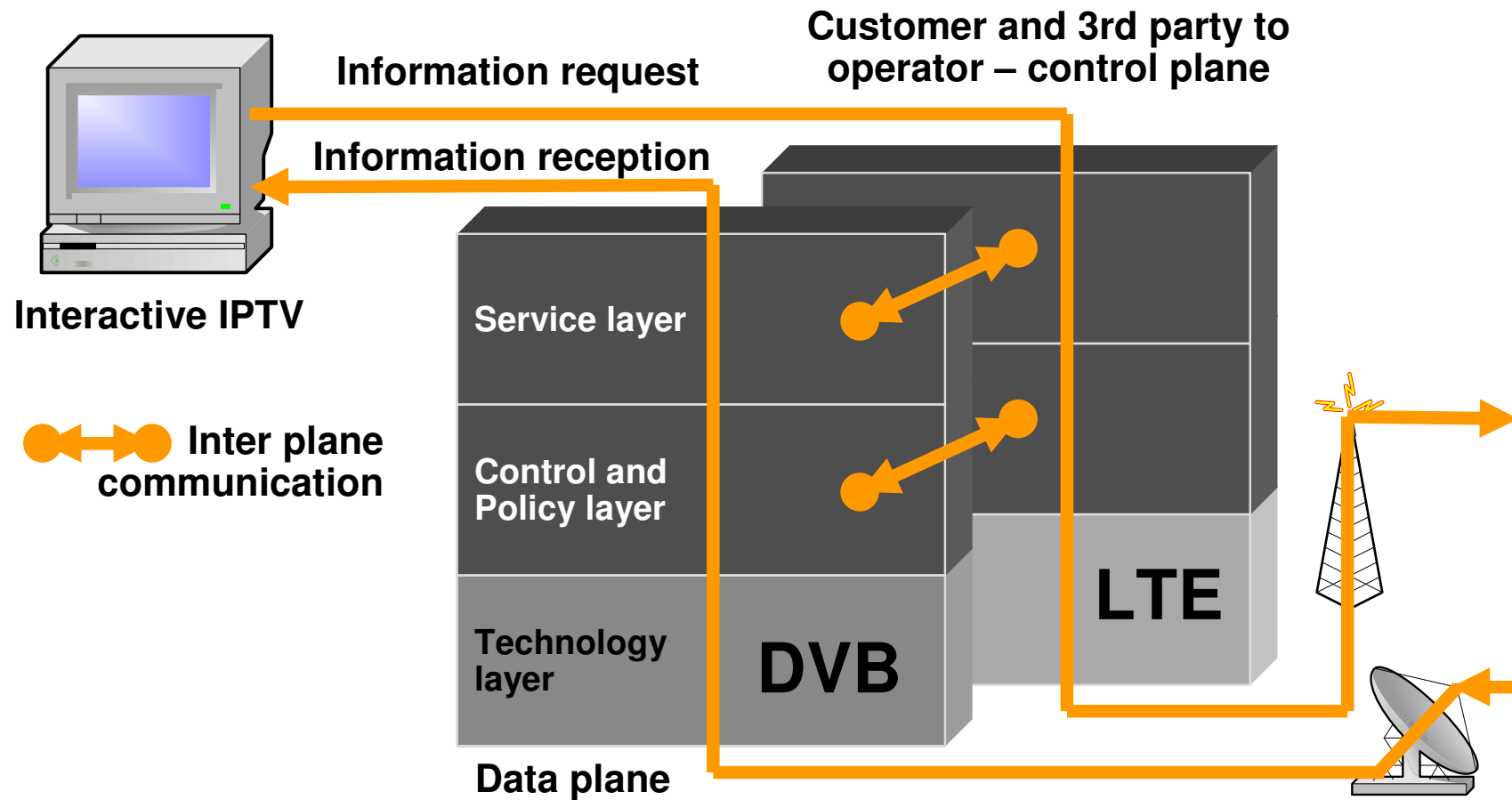
# BRINGING EVERYTHING TOGETHER: THE “CUBE”



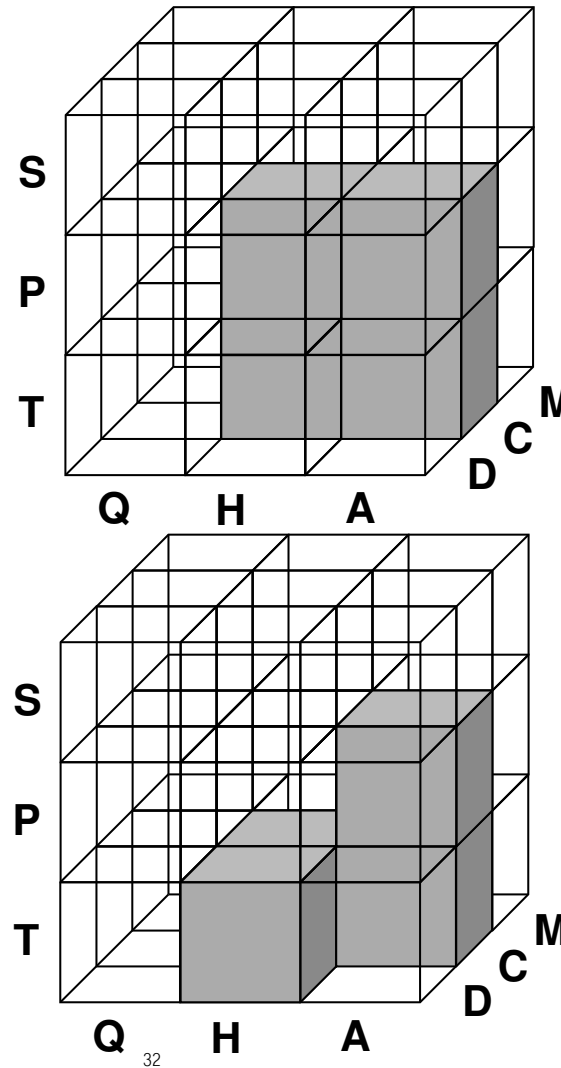
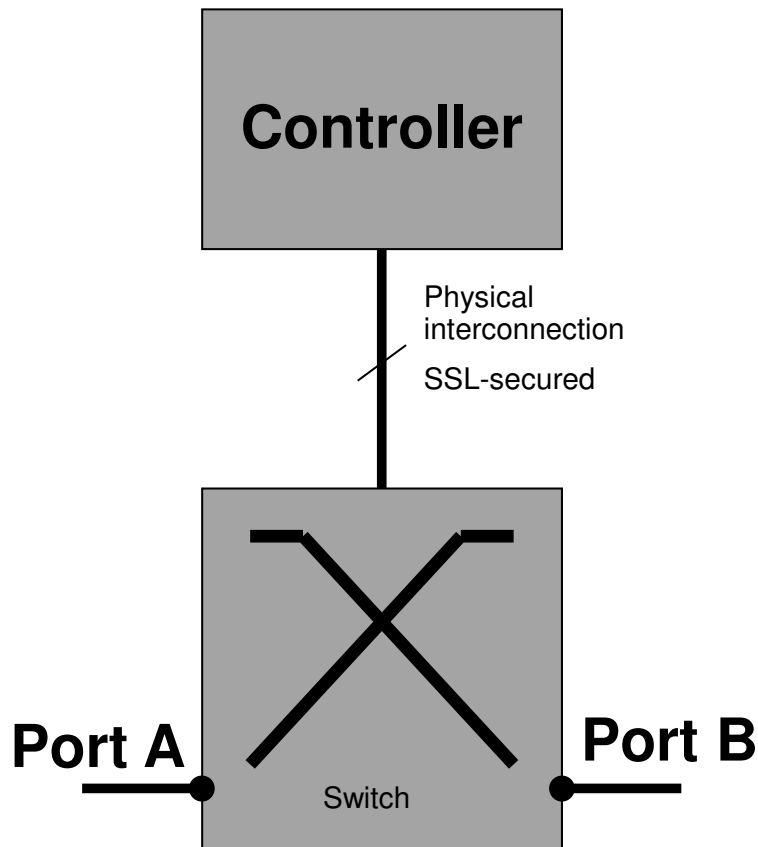
- 27 “Cublets” as modules for the implementation of network services
- The “Cube” can be used to explain network business and services as well for implementation of network nodes
- The clue will be respective interfaces between the “Cublets”

Please check: P2056 - Unified Standardisation Framework for Telecommunication Network Enablers (<http://www.eurescom.eu/services/eurescom-study-programme/list-of-eurescom-studies/studies-launched-in-2010/p2056.html>)

# EXAMPLE FOR THE "CUBE" - BROADCAST SERVICES



# EXAMPLE FOR THE “CUBE” – OPEN FLOW SWITCHING



Scope:

- QoE-Q
- Homing-H
- SA4C-A

Layers

- Technology-T
- Control and policy-P
- Service-S

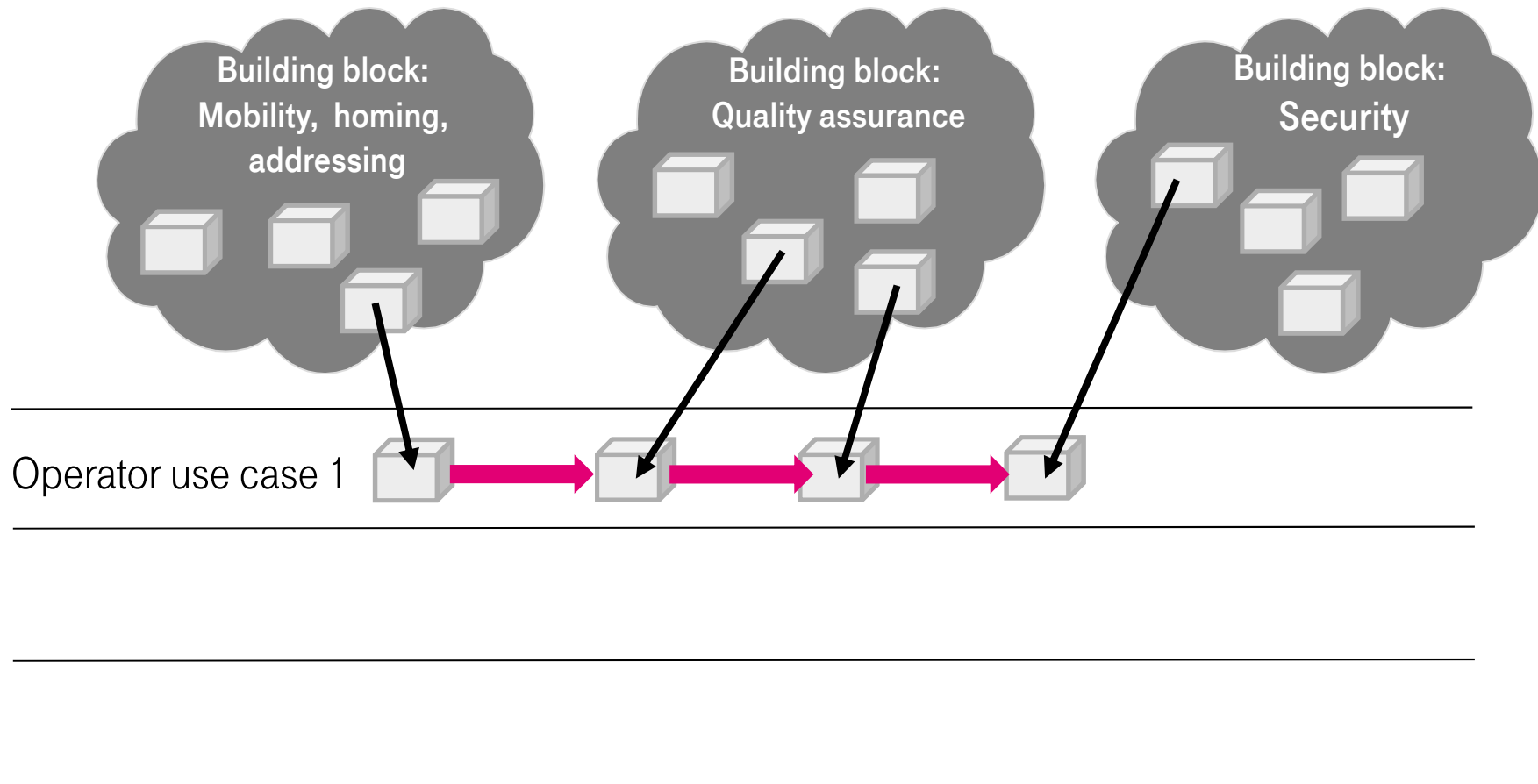
Planes

- Data-D
- Control-C
- Management-M.



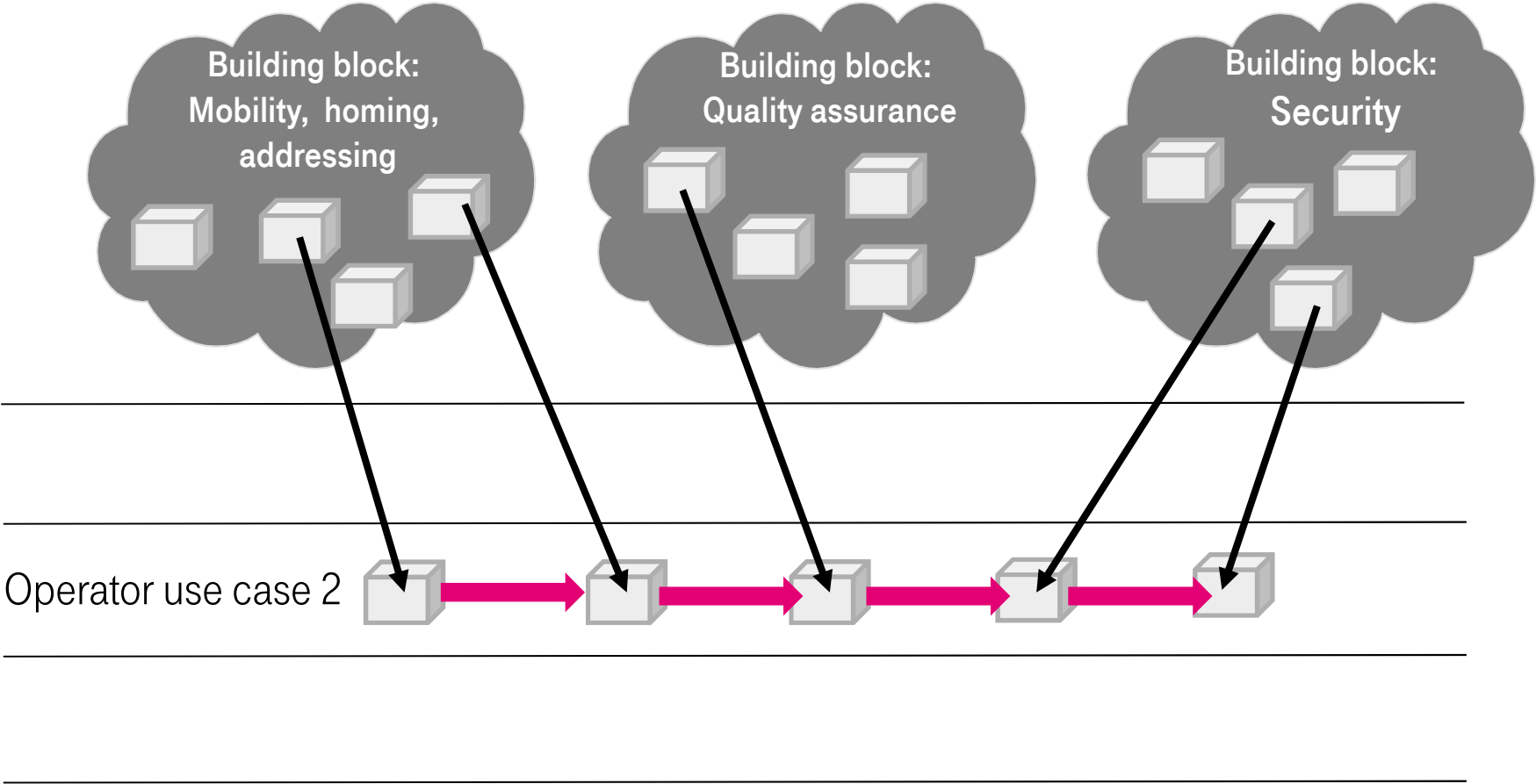
# “CUBE” FOR DEFINING 5G NETWORK SERVICE

## Example: Control Plane / Control and Policy Layer



# “CUBE” FOR DEFINING 5G NETWORK SERVICE

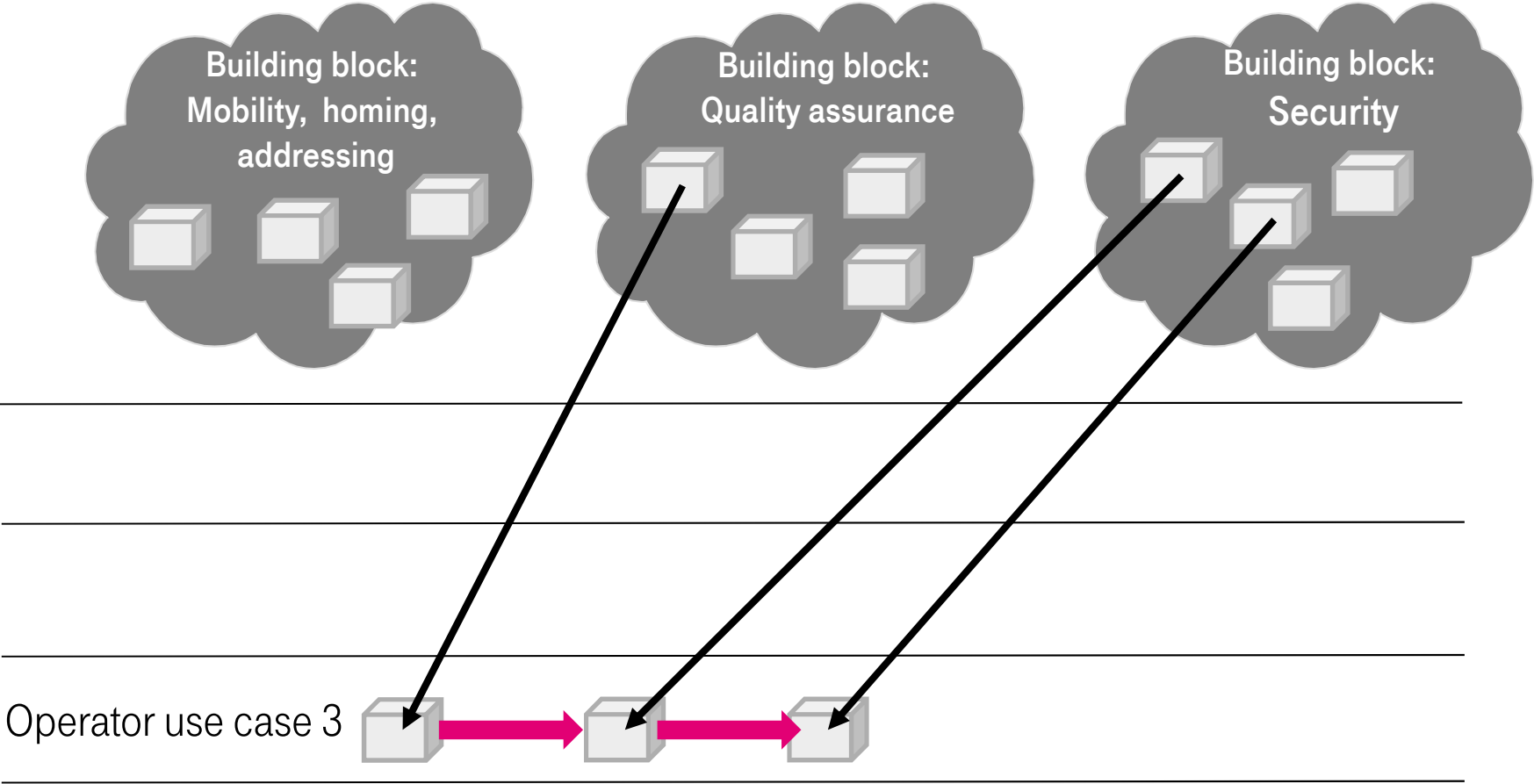
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Example: Control Plane / Control and Policy Layer

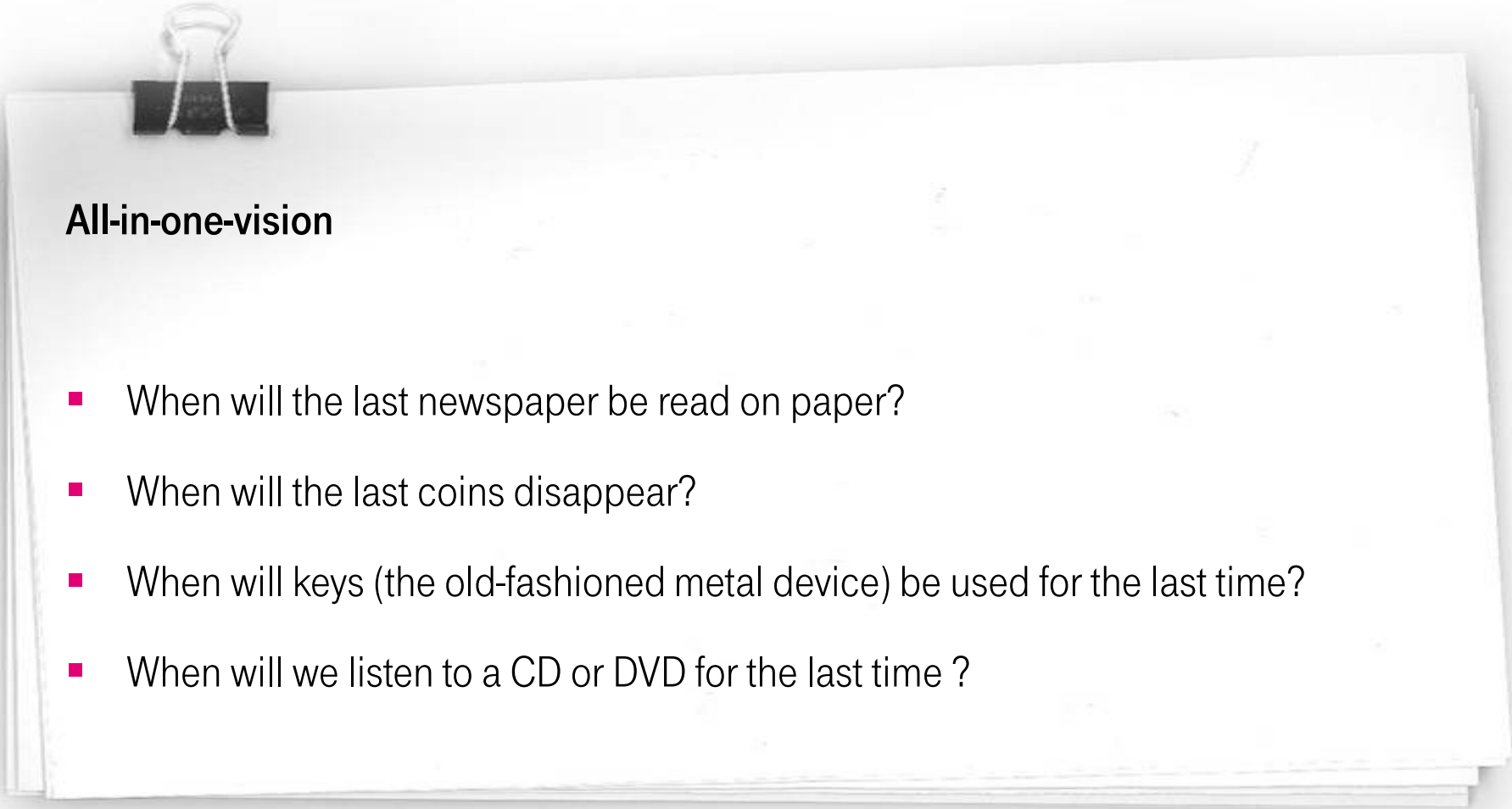


# THE FUTURE OF THE DEVICES



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# CHALLENGES IN OUR DAILY LIFE



## All-in-one-vision

- When will the last newspaper be read on paper?
- When will the last coins disappear?
- When will keys (the old-fashioned metal device) be used for the last time?
- When will we listen to a CD or DVD for the last time ?

# ALL-IN-ONE EXPECTATION

Five years from now, do you think your mobile phone will replace any of the following?

- 54% GPS
- 54% iPod or MP3 player
- 52% Digital camera
- 31% Credit card
- 27% Personal computer
- 27% Video recorder
- 24% Car keys
- 22% e-Reader
- 18% Personal identification card
- 16% Television



Source: Oracle

Copyright: Internet  
(makes it possible)

1966-1969



Copyright: Internet (makes it possible)



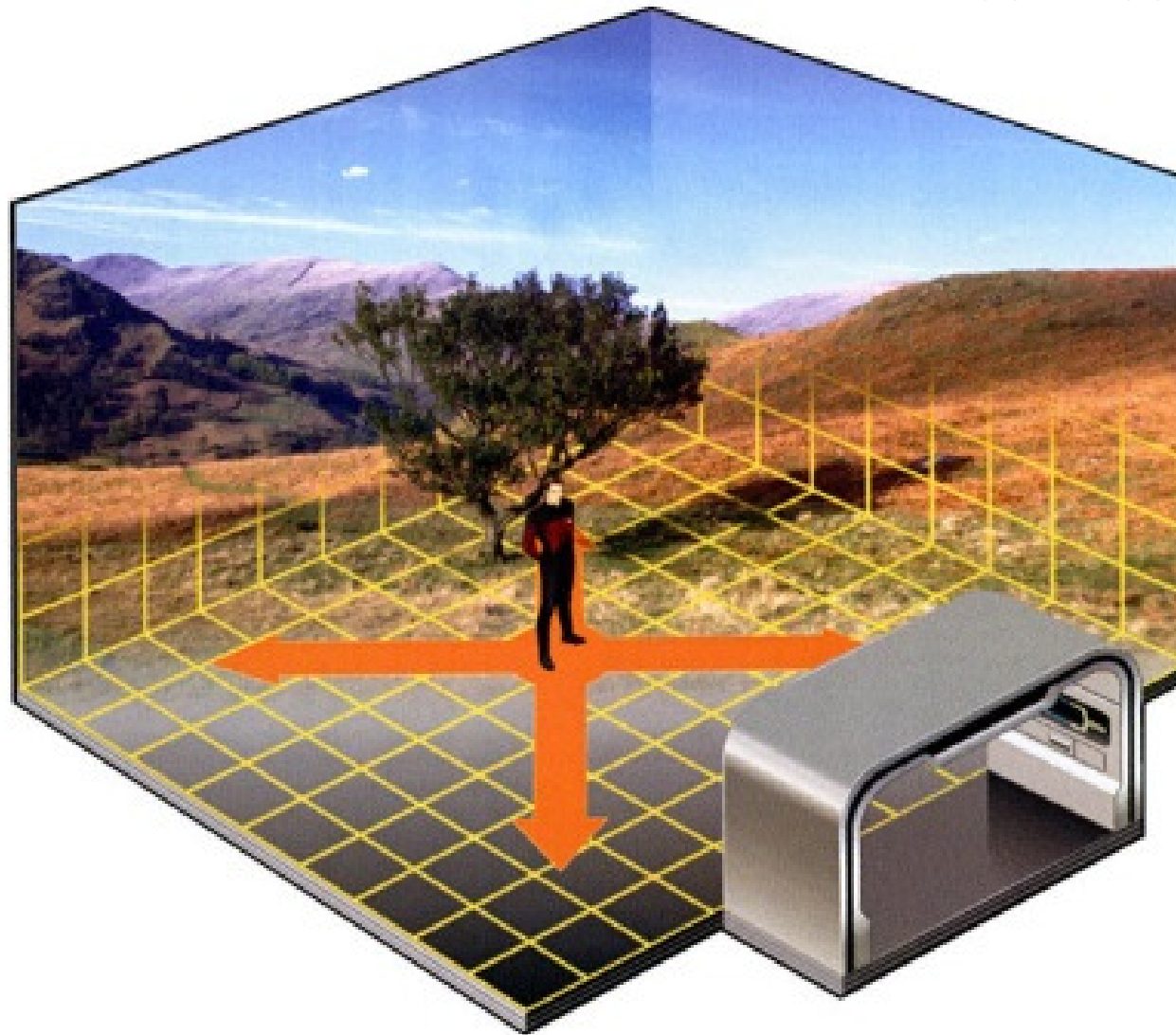
1992-1999



Copyright: Internet (makes it possible)



1987-1994



Copyright: Internet (makes it possible)







Copyright: Internet (makes it possible)



# **R&D&I ACTIVITIES IN THE EU FOR FUTURE INTERNET SERVICES AND TEST FACILITIES**



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# FI-WARE serving usage areas

## TARGET SERVICE AREAS



- MANUFACTURING**
- M2M Platform
  - Apps repository
  - Semantic tools
  - Virtual Sensors (CDVA)

- ENERGY**
- Bigdata
  - M2M Platform
  - Things abstraction
  - Semantic tools
  - Virtual Sensors (CDVA)

- LOGISTICS**
- Bigdata
  - M2M Platform
  - Cloud solutions
  - Apps repository
  - Semantic tools

- SMARTCITIES**
- Bigdata
  - M2M Platform
  - Things abstraction
  - Apps repository
  - CEP
  - Semantic tools
  - Virtual Sensors (CDVA)

- E-HEALTH & SAFETY**
- Bigdata
  - M2M Platform
  - Semantic tools
  - CEP
  - Virtual Sensors (CDVA)

- TOURISM & ENVIRONMENT**
- Bigdata
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  - Virtual Sensors (CDVA)

# FI-WARE Catalogue

<http://catalogue.fi-ware.eu/>

The screenshot displays the FI-WARE Catalogue website interface. At the top, there is a navigation bar with 'Home', 'Enablers', 'Tools', and 'Forum' on the left, and 'Account' and 'FI-WARE Catalogue' on the right. Below the navigation bar, the main content area is titled 'Access Control - THA Implementation' and 'Security Monitoring'. A breadcrumb trail shows 'Home / Generic Enablers / Security Monitoring'. There are tabs for 'Overview', 'Documentation', 'Downloads', 'Instances', and 'Terms and conditions'. The 'What you get' section describes the Security Monitoring GE as part of the overall Security Management System in FI-WARE. It lists two services: MuVAL Attack Paths Engine and Service Level SIEM. The 'Why to get it' section explains that MuVAL Attack Paths Engine and Service Level SIEM (SLS) contribute to risk management of IT infrastructure. The page also includes a 'Chapter: Security' section with a version of 2013-06-11, a rating of four stars, and contact information for Daniel Gidoïn and Antonio García-Vázquez. A sidebar on the left contains a vertical list of other generic enablers: Application Mashup, BigData Analysis - C, Cloud Edge, Complex Event Proc, Compressed Domain, Configuration Mana, and Publishing a Ge.





## Home

- About XIFI
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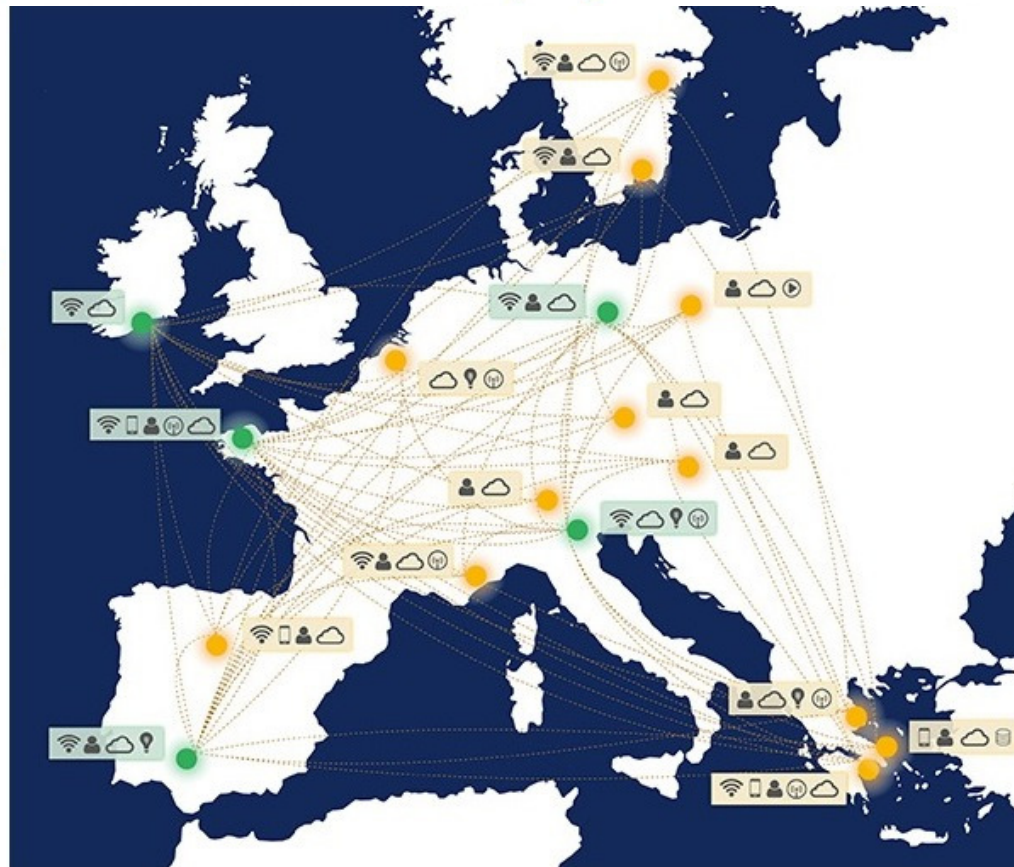
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## Welcome to the XIFI project website



## XIFI Blog

Stay tuned for XIFI news  
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## EVENTS

**Major Cities of Europe - Annual Conference**  
2-4 June 2014, Zurich, Switzerland [\[more\]](#)

**5th European Summit on the Future Internet**  
12-13 June 2014, Luxembourg [\[more\]](#)

<https://www.fi-xifi.eu/home.html>

**THANKS FOR YOUR ATTENTION.  
QUESTIONS?**



# CONTACT

LET'S SHAPE THE FUTURE

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