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Packet Core Network Evolution in regard to Future Internet Research – *From Mobile Next Generation Networks to the Mobile Future Internet*

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Abstract of the ICME 2011 Tutorial

This half day workshop will provide an overview of the Packet Core Network evolution starting with the introduction of global fixed and mobile next generation network standards and outlining its evolution in regard to the emerging Future Internet, which is driven by international research programs, such as GENI in the US, FIRE in Europe and Akari in Japan. The main focus will be on the network and service control options and optimization within the 3GPP Evolved Packet Core (EPC) forming today the common packet core architecture for various broadband access networks, including LTE and WiMAX. The tutorial will outline the EPC architecture and address potential EPC application domains, including IP Multimedia Subsystem (IMS) based VoIP as well as internet over the top service architectures with their own service layer control capabilities.

Starting from here the tutorial looks at the emerging Future Internet, comprising different research views, such as the internet of things, the internet of services, and the network of the future. Here we introduce the current visions and research topics related to cross-layer functional composition and network virtualisation.

The tutorial terminates with outlining how FI concepts could be exploited in NGN/EPC evolution and introducing related software toolkits and experimental platforms of TU Berlin / Fraunhofer FOKUS, namely the OpenEPC (www.openepc.net) and the FUSECO-Playground (www.fusecoplayground.org) enabling comprehensive prototyping in the context of academic and industry research.

Agenda

- Introduction
- IP Multimedia System (IMS) as Uniform All-IP Operator Service Platform
- Evolved Packet Core (EPC) Overview
- Future Internet (FI)
- Summary - Relating EPC, IMS, SDPs, and FI
- Q&A

Agenda

1. Introduction

- All-IP Network Convergence Pushing for Smart Bit pipes and Seamless Services
- The Data Highways: fixed and mobile Next Generation Networks (NGNs) for what?
- Future Operator Telco Services vs. domain specific Over the Top Applications vs. Service Enablement
- Back to the Future: IN vs. Service Enablement in NGNs and the emerging Future Internet (FI)
- How Smart will the Smart Bit pipe be? Best Effort vs. Connectivity plus PCC vs. IMS vs. Open APIs
- Implementing Open APIs (BONDI, GSM ONE, WAC) on top of which platforms?
- NGN2FI Evolution: The role of open toolkits and testbeds for open innovation

2. IP Multimedia System (IMS) as Uniform All-IP Operator Service Platform

- IMS Standards review
- IMS Key Capabilities and Services (VoIP, RCS, IPTV, and ?)
- IMS Challenges – IMS vs. SDPs, vs. Web 2.0
- IMS Limits: SIP vs. HTTP Services and Enablement
- Lessons learned from the FOKUS IMS and Open SOA Telco Playgrounds

Agenda

3. Evolved Packet Core (EPC) Overview

- Mobile Broadband Drivers and Challenges
- 3GPP Evolved Packet System (EPS)
- Long term Evolution (LTE) vs. Evolved Packet Core (EPC)
- EPC Standards and Capabilities
- Services above EPC – Operator Services (VoIP, RCS, IPTV, WAC) vs. ABC OTT
- EPC Challenge: Voice Options (CSFB, VoLGA, VoLTE)
- Relating EPC and IMS and SDPs/Open APIs
- Towards EPC as universal all-IP service control platform
- Lessons learned from the Future Seamless Communications (FUSECO) Playground

Agenda

4. Future Internet (FI)

- FI Principles and global status quo
- Service Provision Principles in FI – Cross layer functional composition
- Towards FI Enablement: emerging FI Core platforms for FI Enabler
- Comparing Telco and FI Enablement principles
- Positioning EPC within the FI context
- Introduction of the FOKUS NGN2FI Evolution Lab

5. Summary - Relating EPC, IMS, SDPs, and FI

- Why IMS will be for seamless VoIP only and why EPC will become the universal all-IP service control platform
- Research Challenges ahead

Q&A

About the Speaker

Prof. Dr. Ing. habil Thomas Magedanz

Thomas Magedanz (PhD) is professor in the electrical engineering and computer sciences faculty at the Technical University of Berlin, Germany, leading the chair for next generation networks (Architektur der Vermittlungsknoten – AV) supervising Master and PhD Students

In addition, he is director of the "NGNI" division at the Fraunhofer Institute FOKUS, which provides toolkits for NGN/IMS as well as Next Generation of Fixed and Mobile Networks /EPC test and development tools for global operators and vendors. Prof. Magedanz is one of the founding members of FOKUS (1988) and member of the management team.

Furthermore he is principal consulant of Direct Link Consult e. V., a FOKUS Consulting spin off focussing on professional services, strategic studies and technology coaching.

Prof. Magedanz is a globally recognised technology expert, based on his 18 years of practical experiences gained by managing various research and development projects in the various fields of today's convergence landscape (namely IT, telecoms, internet and entertainment).

He acts often as invited tutorial speaker at major telecom conferences and workshops around the world.

Prof. Magedanz is senior member of the IEEE, editorial board member of several journals, and the author of more than 200 technical papers/articles. He is the author of two books on IN standards and IN evolution.

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About the Speaker

Dipl. Inform. Julius Müller

Julius Müller studied computer science at the Freie Universität Berlin and obtained his diploma in 2009.

In his university studies he concentrated on computer networks, distributed systems and mobile communications.

He worked as student researcher at the Fraunhofer Institute FOKUS in the competence center Next Generation Network Infrastructures (NGNI) in the field of optimized service provision in Next Generation Networks (NGNs) and particularly the IP Multimedia Subsystem (IMS). Here he also worked in some European projects, such as the EU project Vital++.

In this context he also wrote his diploma thesis about NGN/IMS and Peer to Peer (P2P) system integration.

In 2009 he joined the chair "Architektur der Vermittlungsknoten (AV)" in the electrical engineering and computer sciences faculty within the Technische Universität Berlin as PhD researcher, where he is working within the German BMBF project G-Lab DEEP-G.

His scientific work and PhD, supervised by Prof. Thomas Magedanz, focuses on the evolution of NGNs towards the Future Internet (FI). Particularly he is investigating Evolved Packet Core (EPC) optimization and Cross-Layer Composition within NGNs and the FI.

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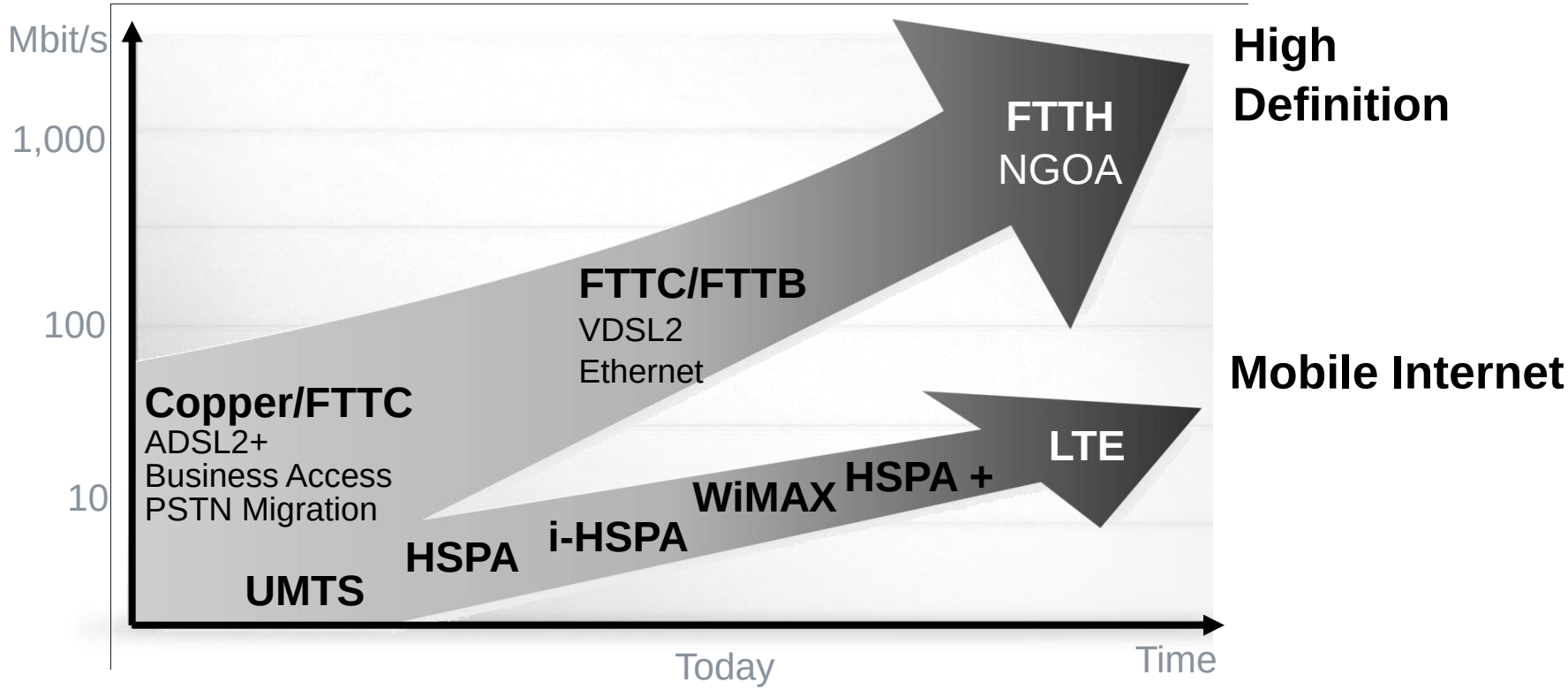
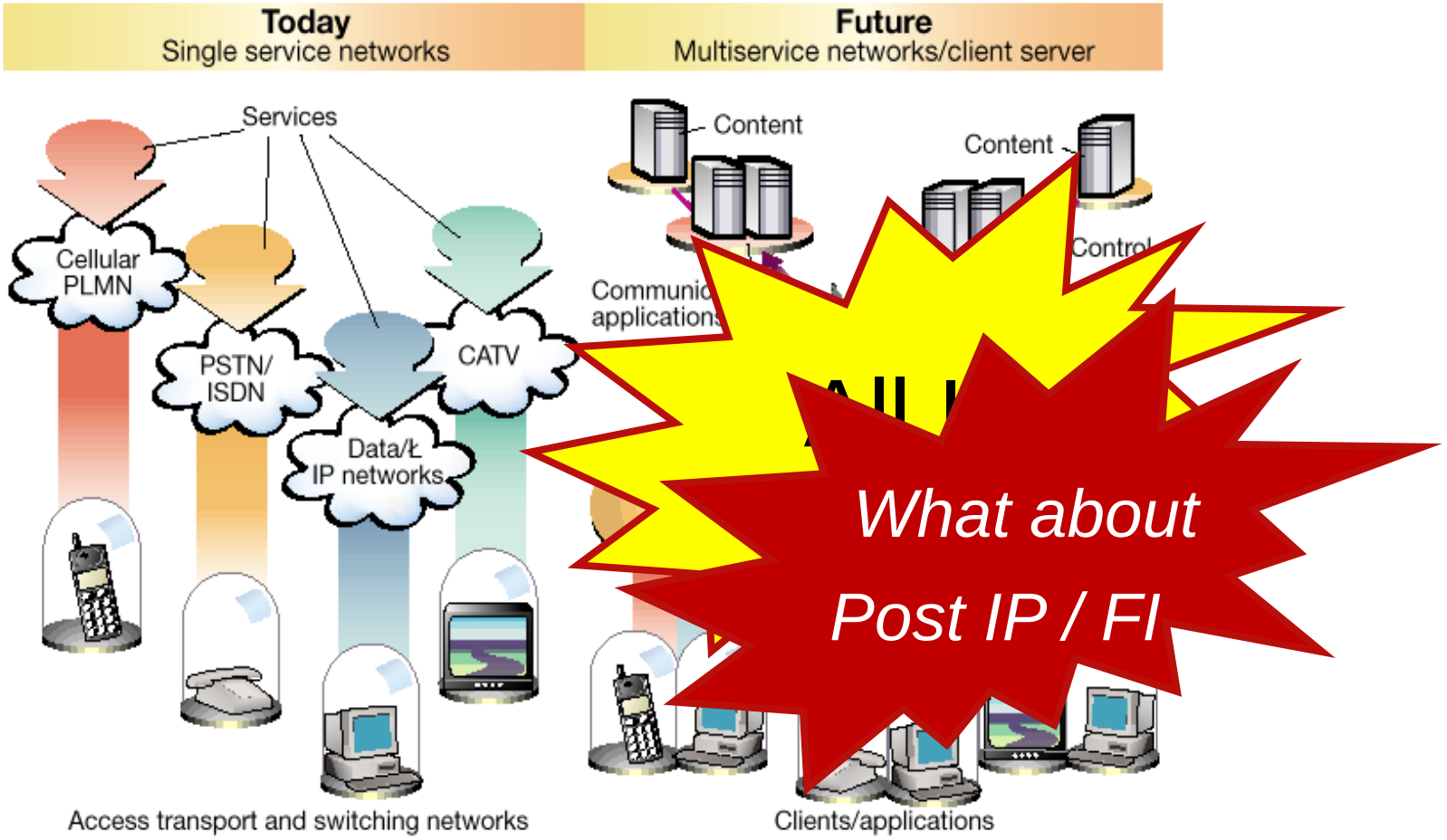
Broadband Technologies - Fixed and Wireless



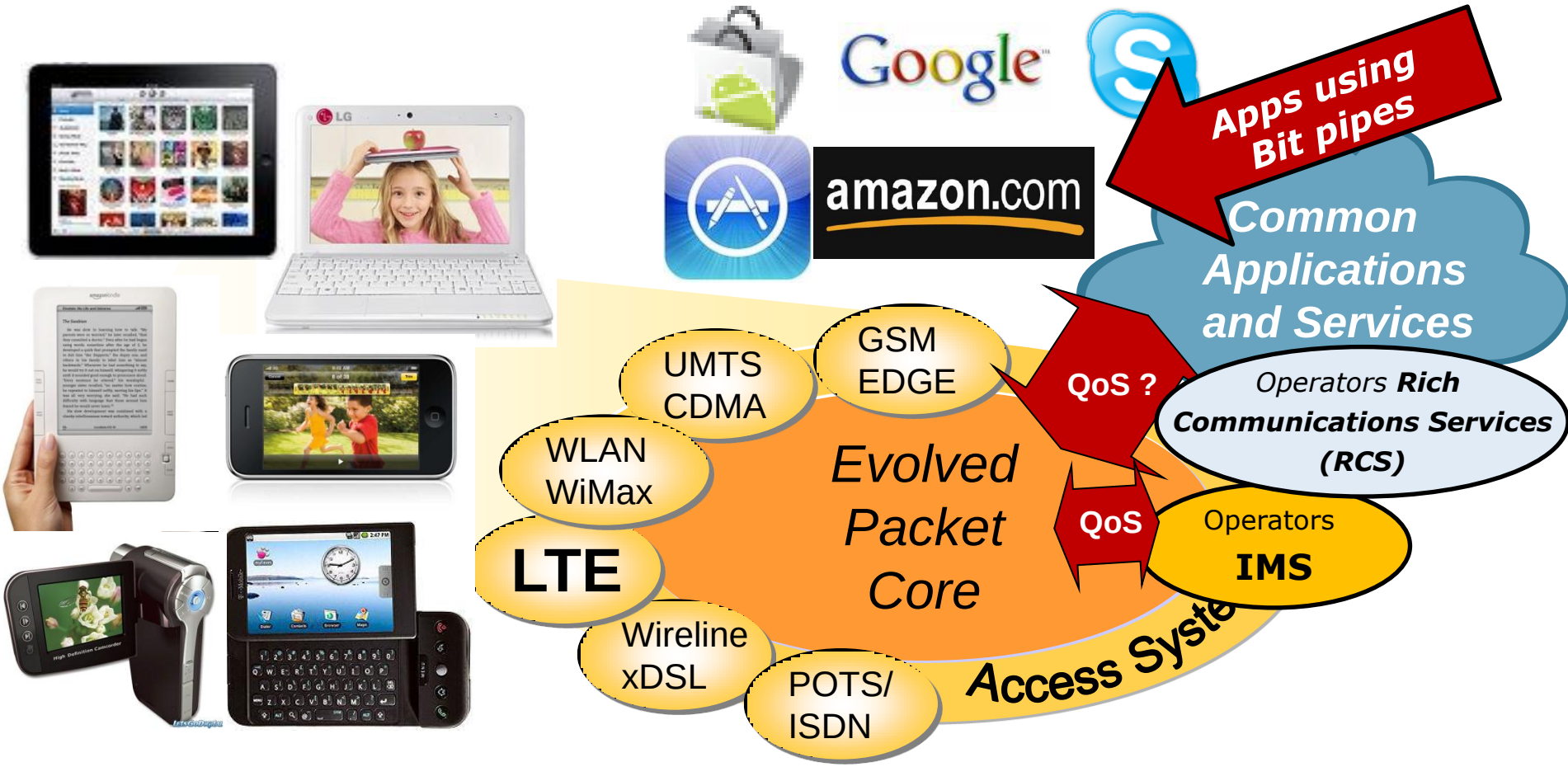
From specific to unified next generation Multi-Service networks

Individual networks = individual services vs. Multi service networks

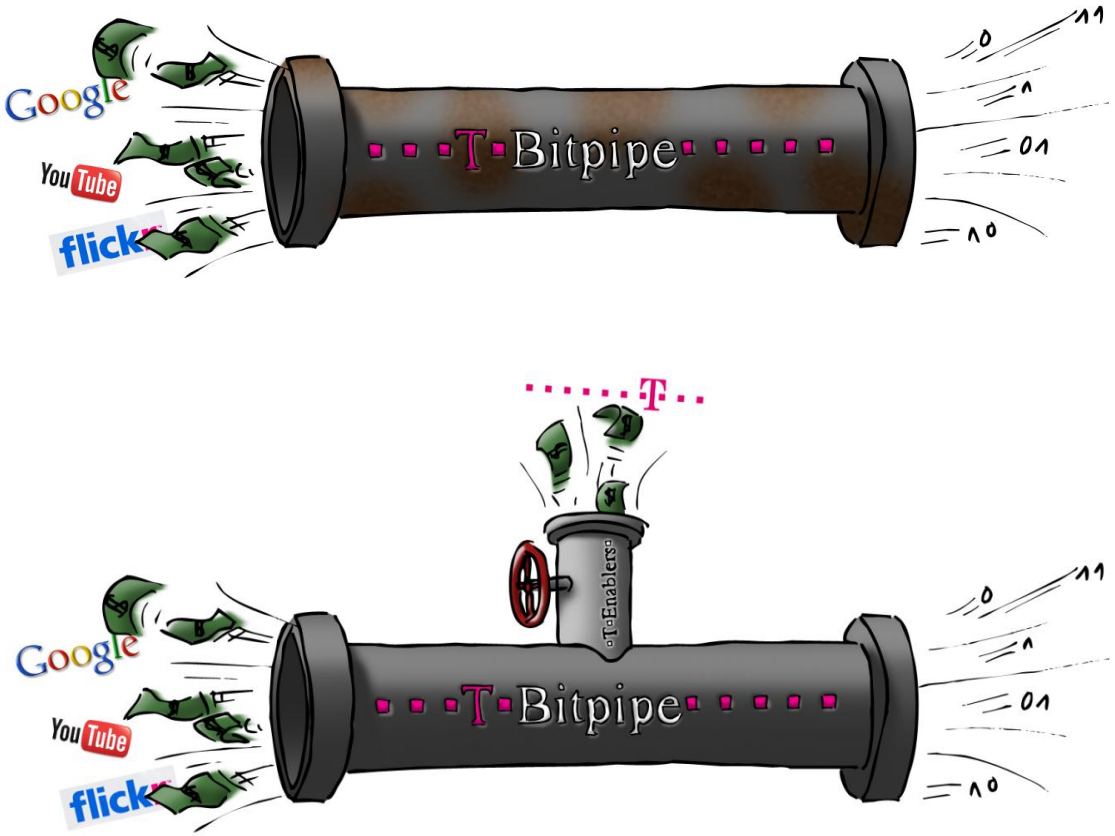


Consequence: Changed Value Chain in Telecommunications

- Communications (Voice/Messaging) vs. Connectivity Services (QoS) versus Multimedia Content (Games, Videos, eBooks, Clouds, etc.)

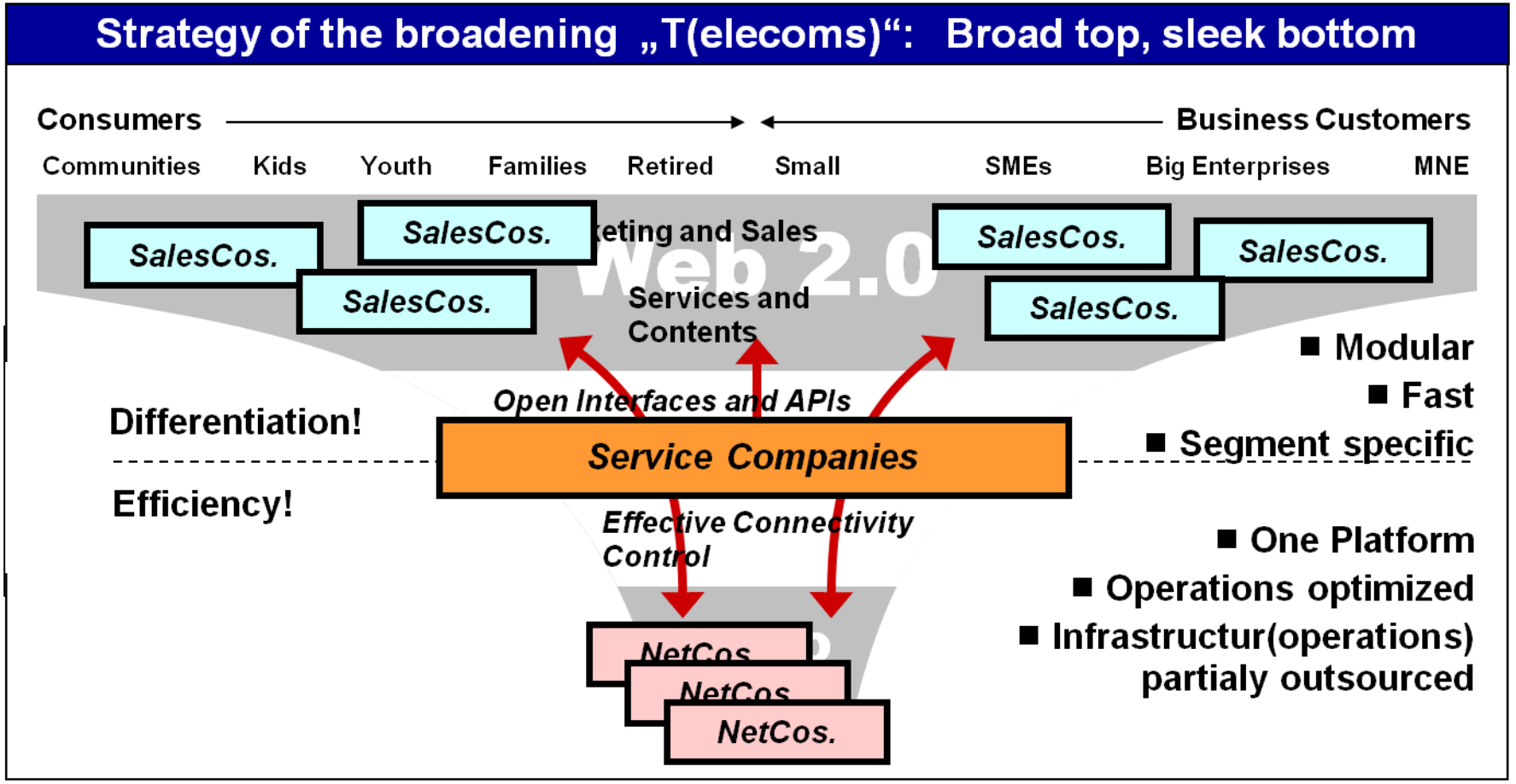


Telco 2.0 – Is there any chance to optimize the bit pipe?

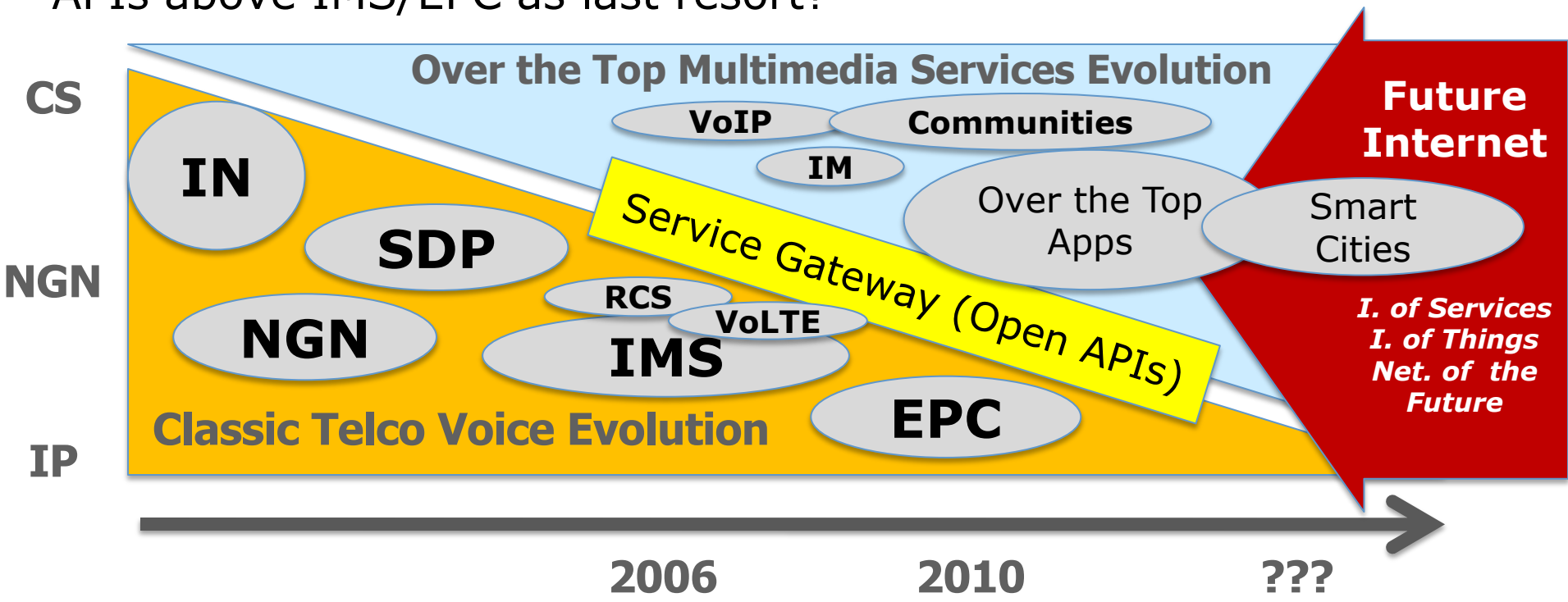


Source: Enabler Platform – The Telcos Response to a Changing Competition: A Study by Center for Digital Technology and Management (TU Munich)

New Eco System demands Federation and Open APIs



The control domain of Telcos is getting smaller – APIs above IMS/EPC as last resort?



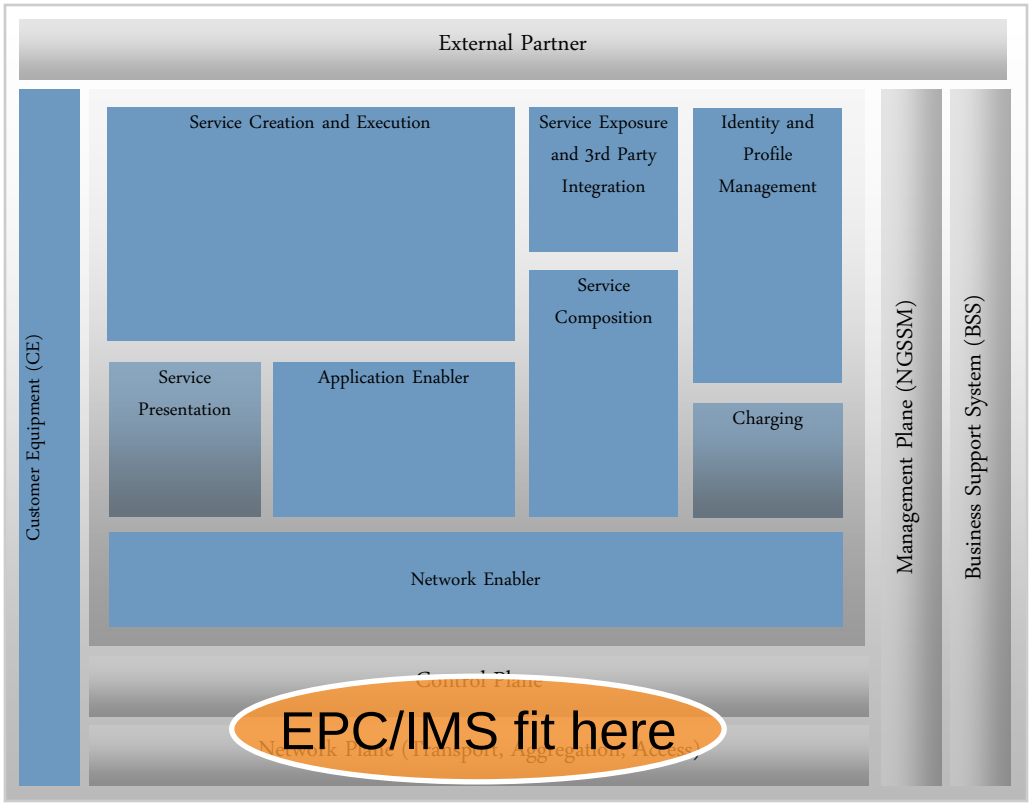
- ✓ Fixed and mobile All-IP Networks will pave the road for seamless Over the Top (OTT) Applications
- ✓ Evolved telecom platforms will provide revenue potentials via Service Gateways (open APIs), VoIP/VoLTE and RCS over IP Multimedia Subsystem (IMS) and Smart mobile bit pipe approaches (Evolved Packet Core - EPC)

The Challenge: Network Abstraction and Service Composition

- Multi domain environment – how to be managed
- Support of different business models (best effort vs. QoS-based apps)
- Technology evolution
- Network abstraction through open application programming interfaces (APIs) helps to separate services from underlying network specifics
- Resource Control interfaces are key (perfomance, scalability, reliability, QoS)
- Charging interfaces are key (QoS-based Charging)
- Granularity of programmability/abstraction: Simplicity versus Performance!
- Where to place programmability of services and their execution control / which level of abstraction (service overlays) is best for what:
  - *Application server / Service Broker – Service Delivery Platform (SDP)*
  - *SIP Server / SIP service overlay – IP Multimedia System (IMS)*
  - *Core Network / Deep Packet Inspection – Evolved Packet Core (EPC)*
  - *Virtual machines on routers / network virtualisation– Future Internet*

- Service creation, service composition, functional composition vs. service execution

Service Architectures Evolution: Network abstraction is key Focus shift from Network to Application Plane

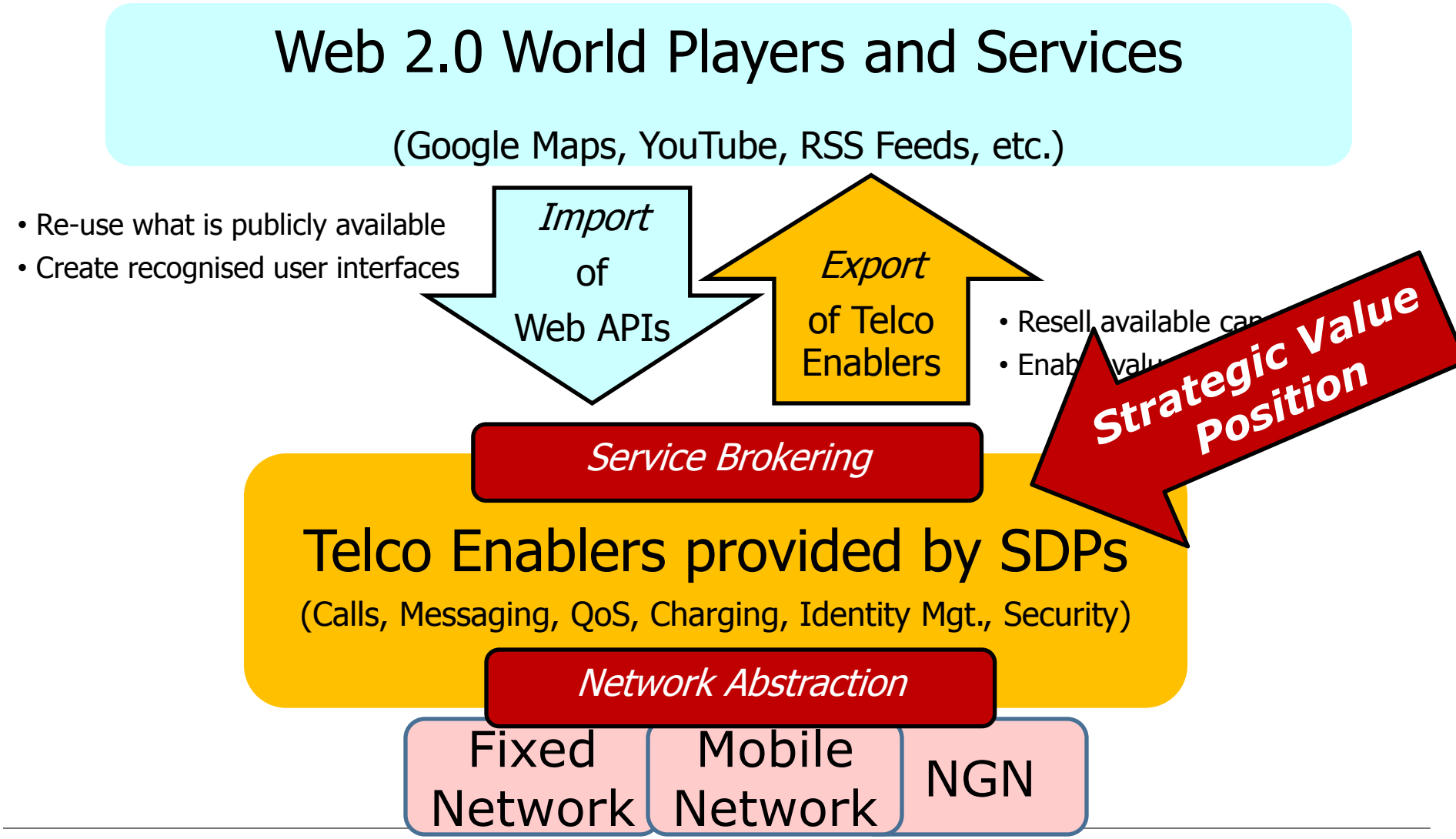


The service architecture of the application plane is the focal point of current operator investigations

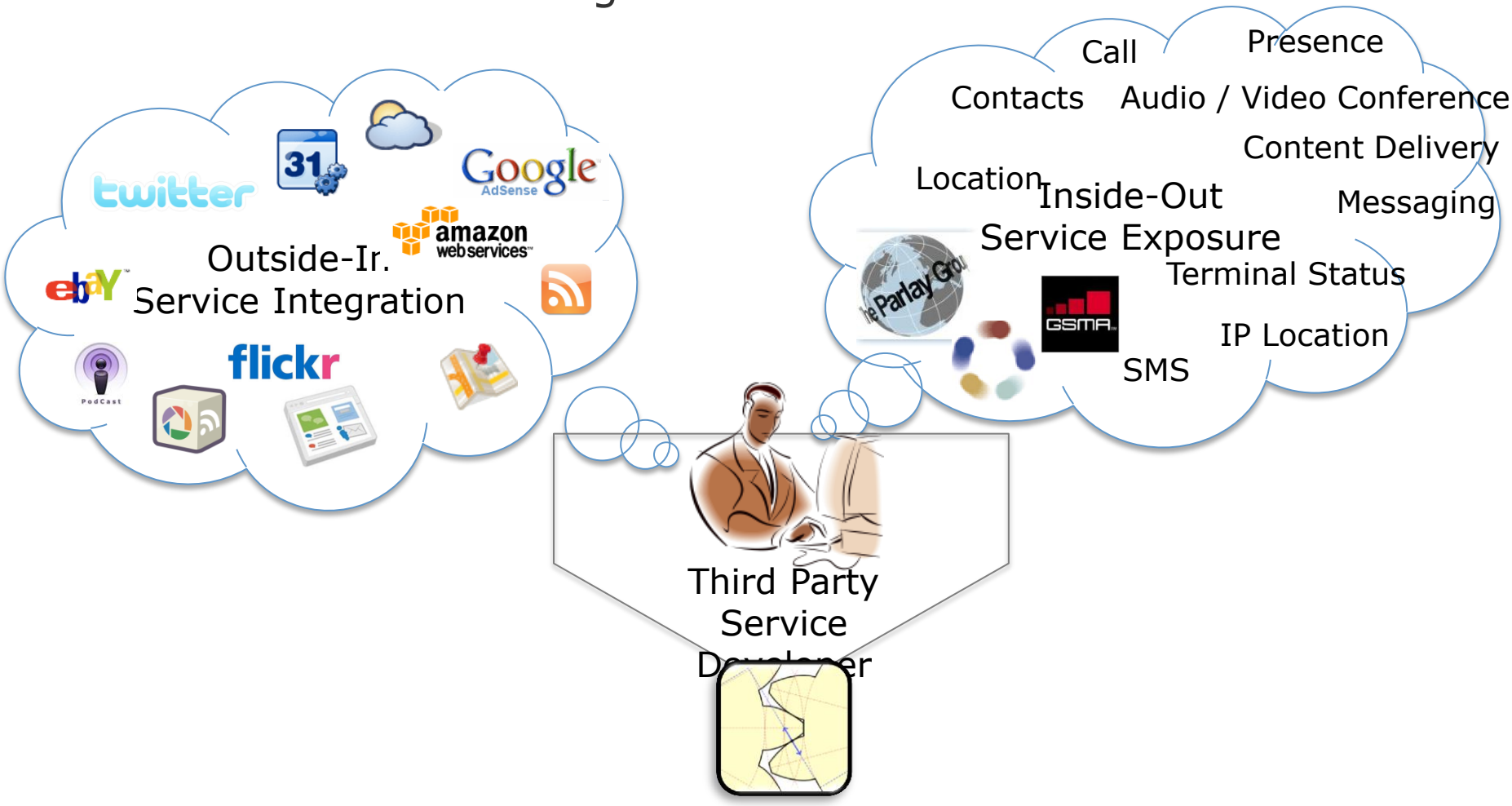
In particular, architectural consideration is on:

- Enabling bidirectional services to and from 3rd parties.
- shaping the enabling services portfolio.
- supporting user centricity and leveraging customer equipment for service deployment and visibility.

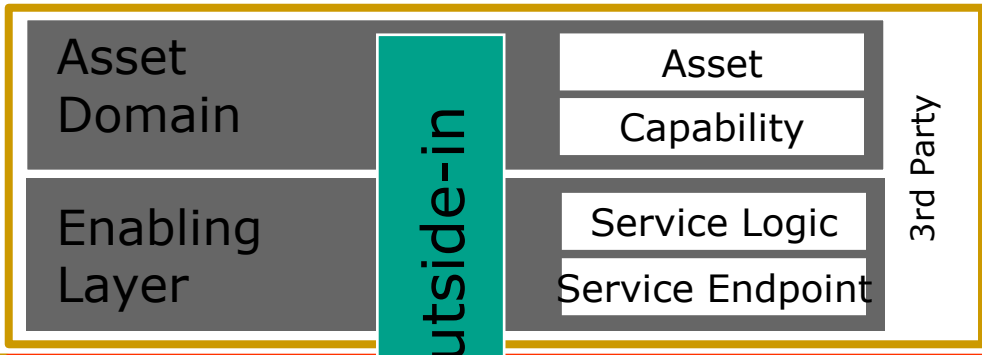
Open Network APIs: Import and Export of „Services Enablers“

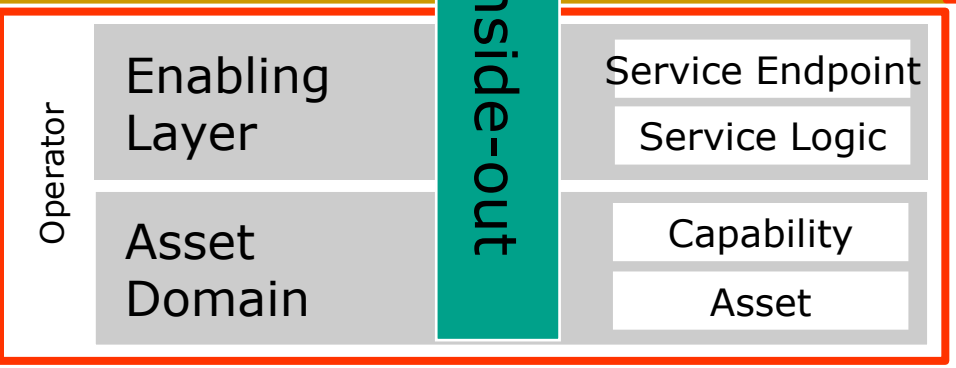


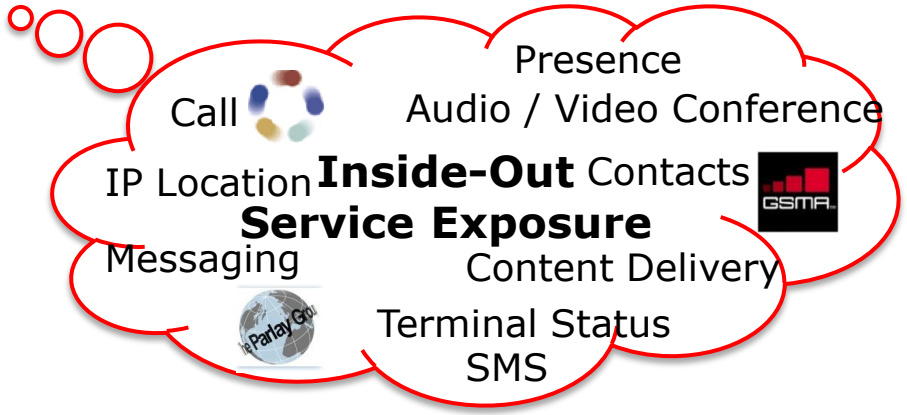
A way forward?
Bidirectional Service Integration of Telco and Web 2.0 Services



Bidirectional Service Integration has two directions

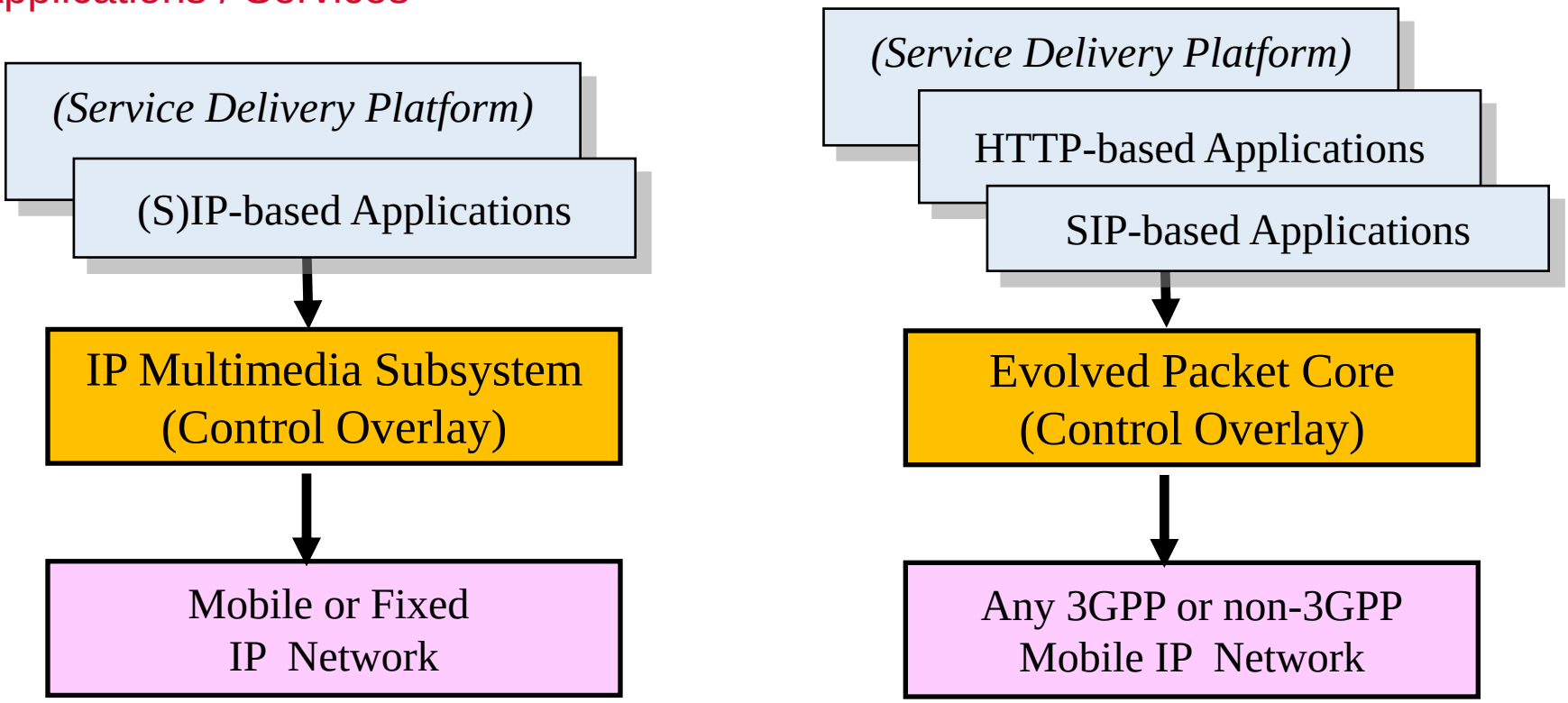






IMS Concept Evolution toward EPC

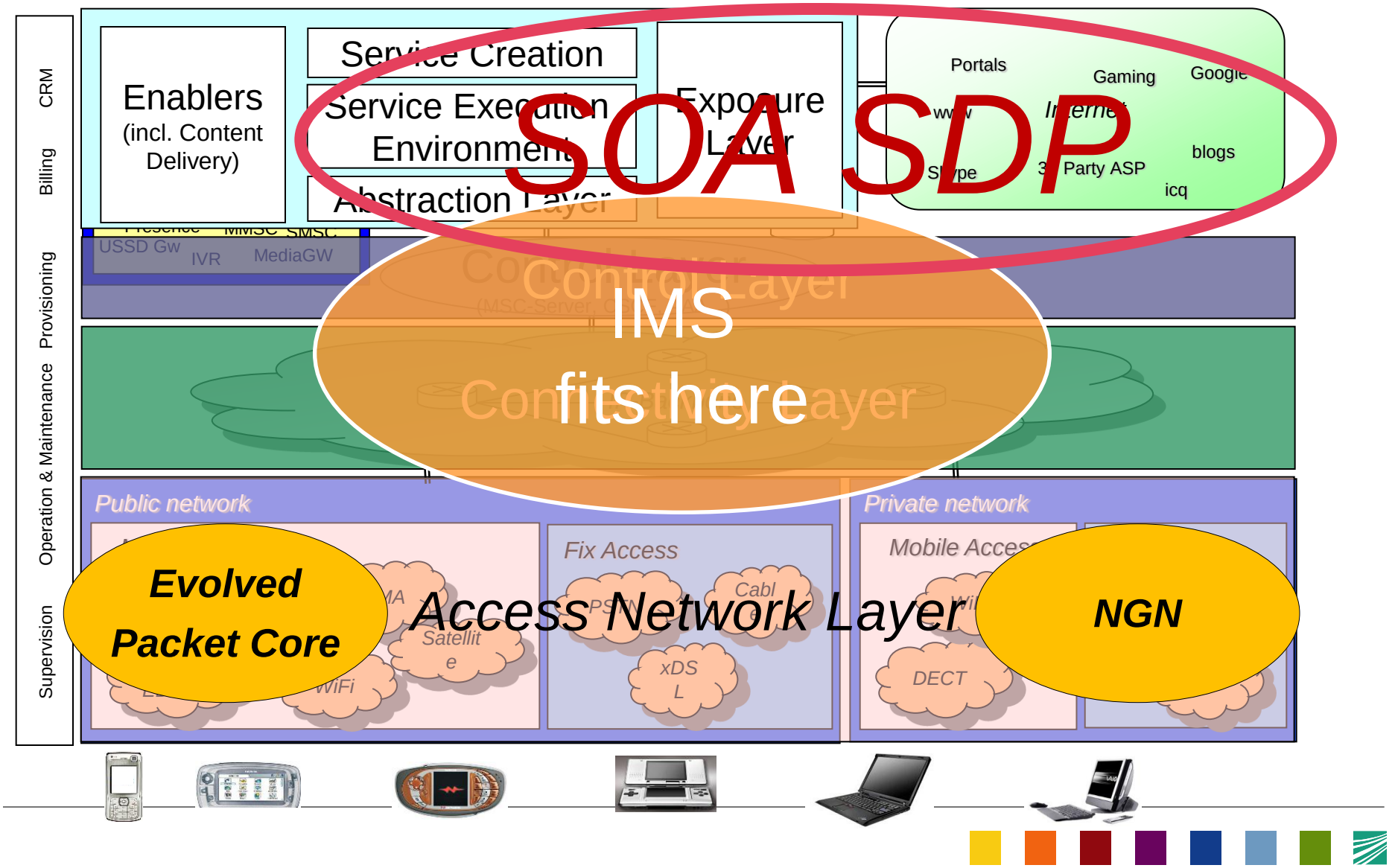
Main Idea: Common Control Overlay Architecture abstracts from underlying IP network technology and provides common platform capabilities for any IP-based Applications / Services



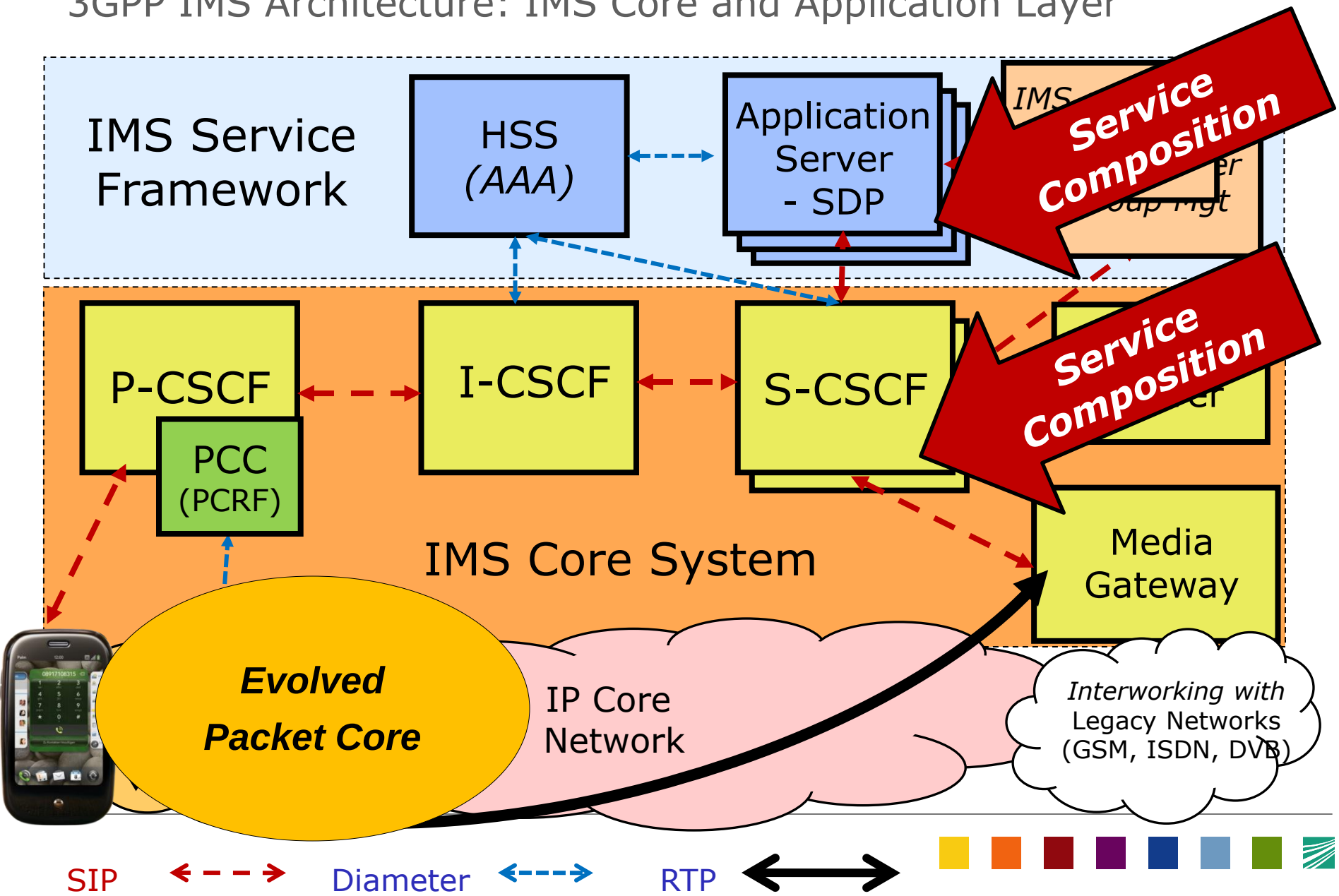
Packet Switched Telco Domain (NGN)

Mobile Packet Switched Telco Domain

NGN/EPC/IMS Positioning within an SDP Environment

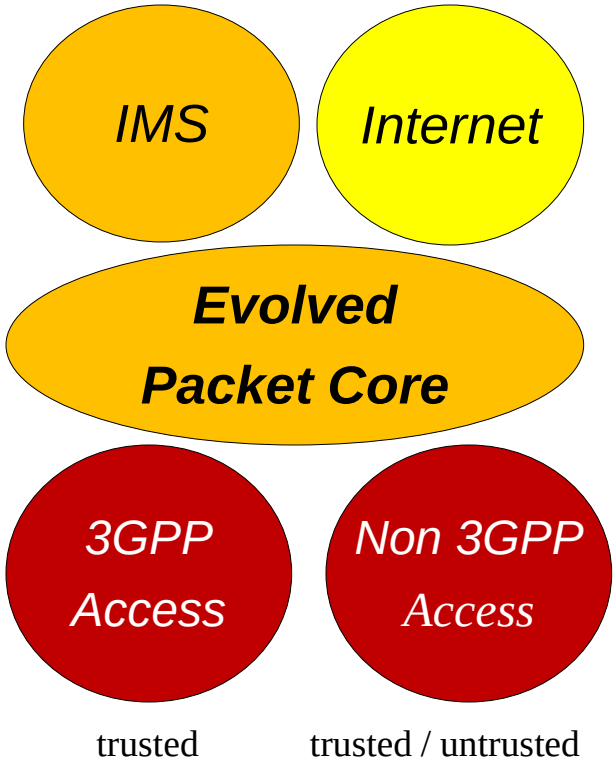


3GPP IMS Architecture: IMS Core and Application Layer

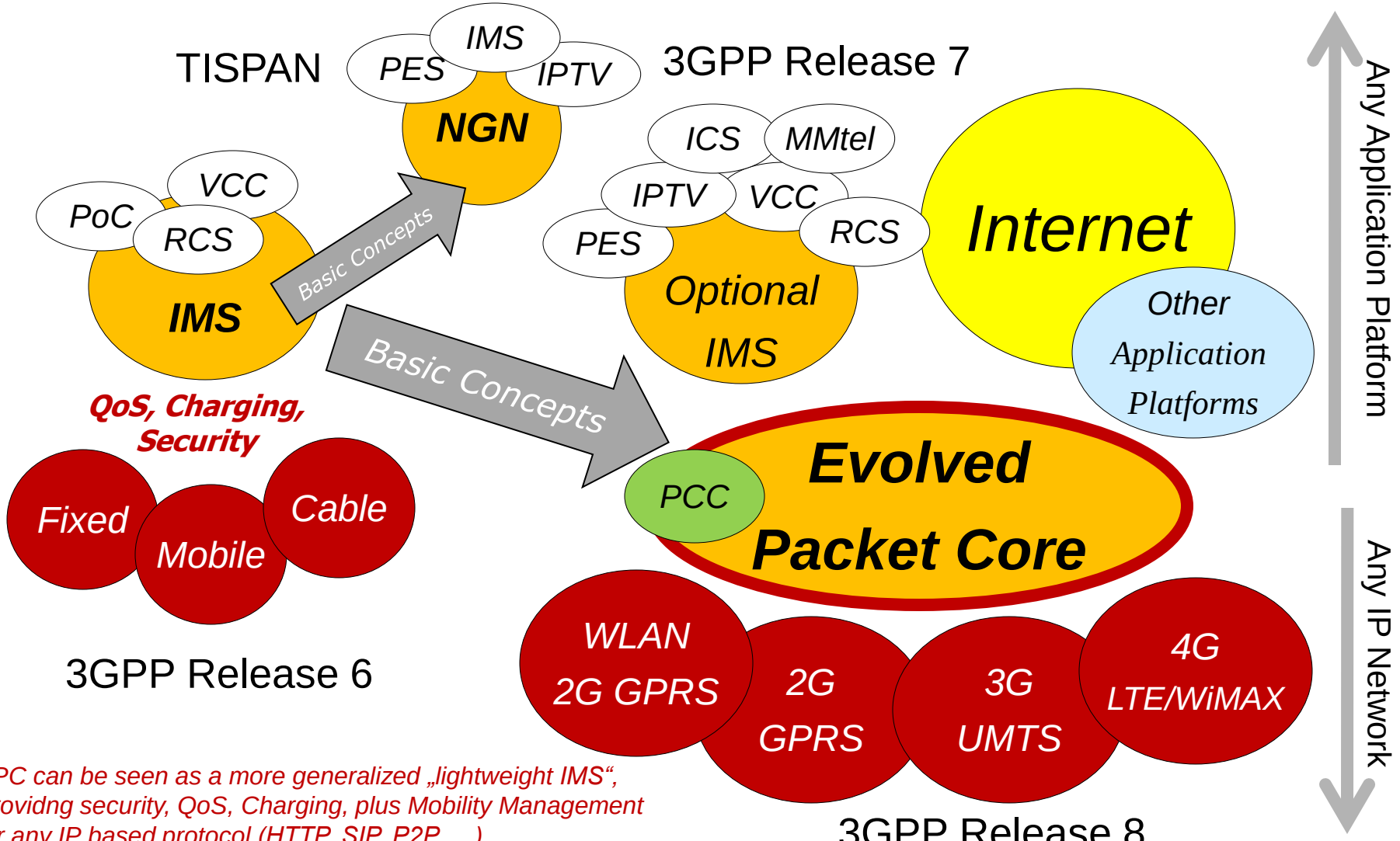


Evolved Packet Core (EPC)

- The EPC is a multi-access core network based on the Internet Protocol (IP) one common packet core network for both
  - trusted networks including
    - 3GPP Access (LTE-E-UTRAN, UMTS-UTRAN, GPRS-GERAN)
    - Non 3GPP Access (WIMAX, CDMA2000/HRPD)
  - and untrusted networks including
    - Non-3GPP Access (WLAN)
- EPC provides connection to IP service domains
  - IMS
  - Internet (or others, e.g. P2P etc.)
- Important EPC functions include:
  - NAS and security (AAA)
  - mobility and connectivity management
  - policy QoS control and charging (PCC)

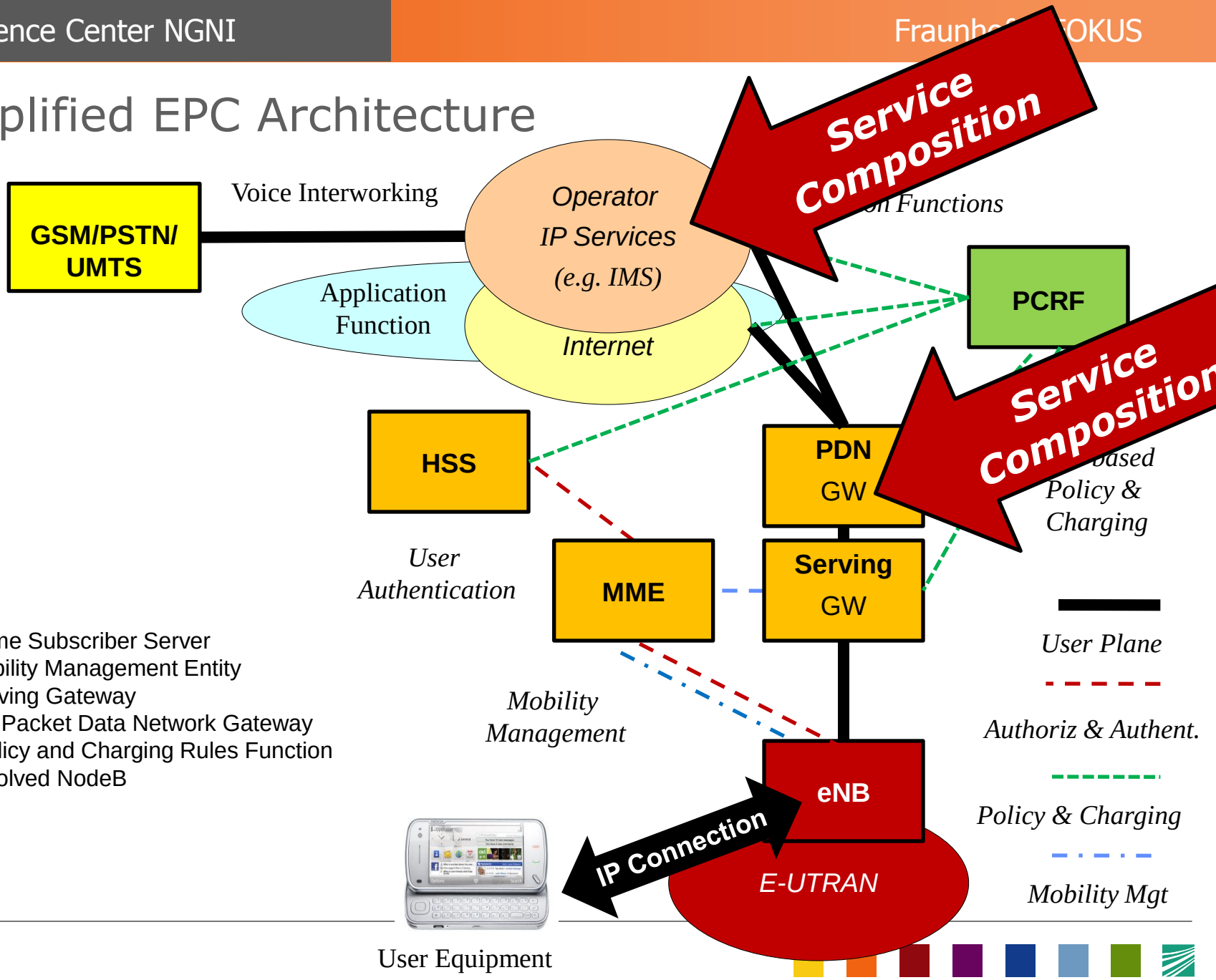


Concept Reuse: From IMS for NGN to EPC for all-IP



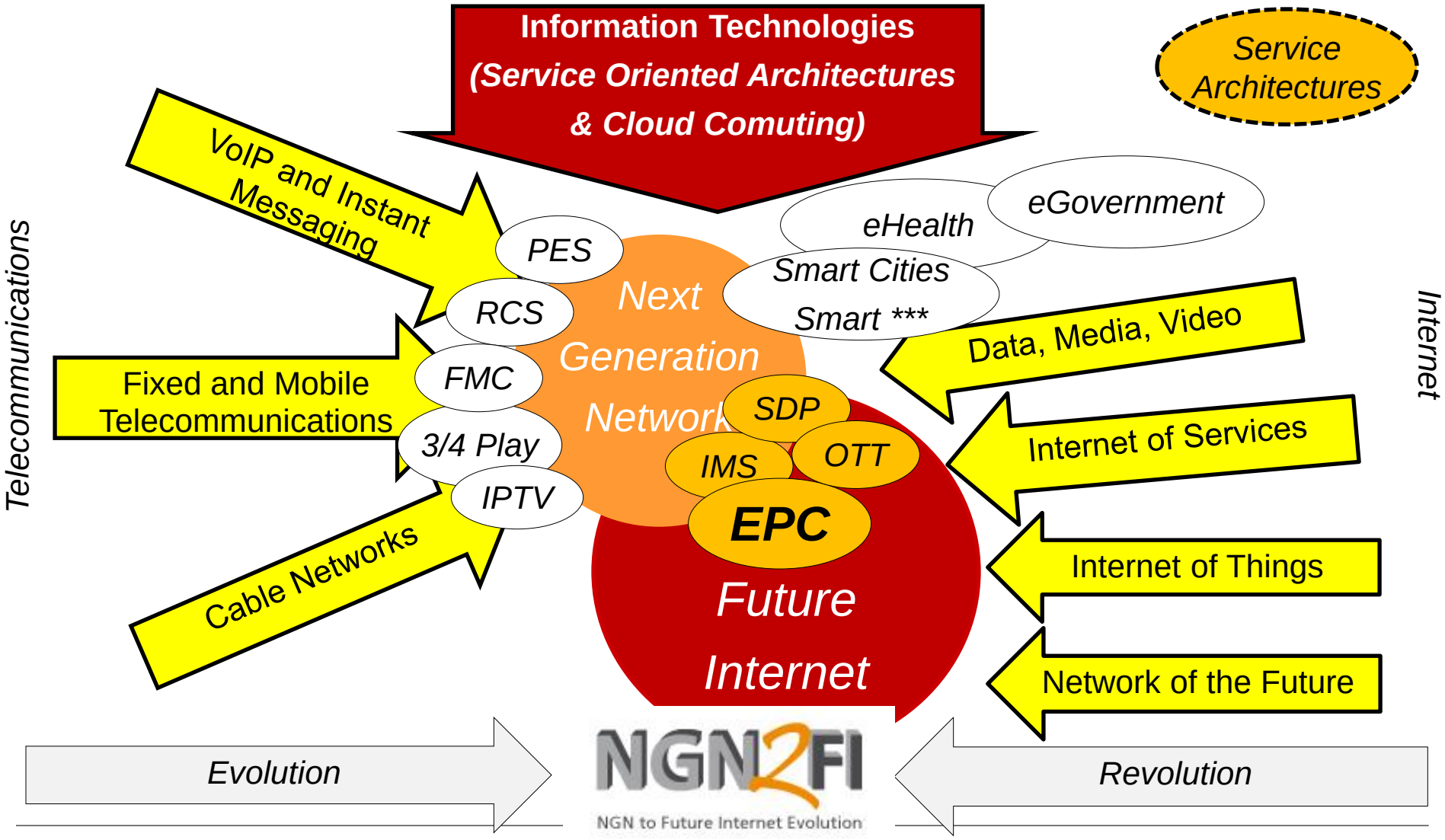
EPC can be seen as a more generalized „lightweight IMS“, Providng security, QoS, Charging, plus Mobility Management for any IP based protocol (HTTP, SIP, P2P, …)

Simplified EPC Architecture



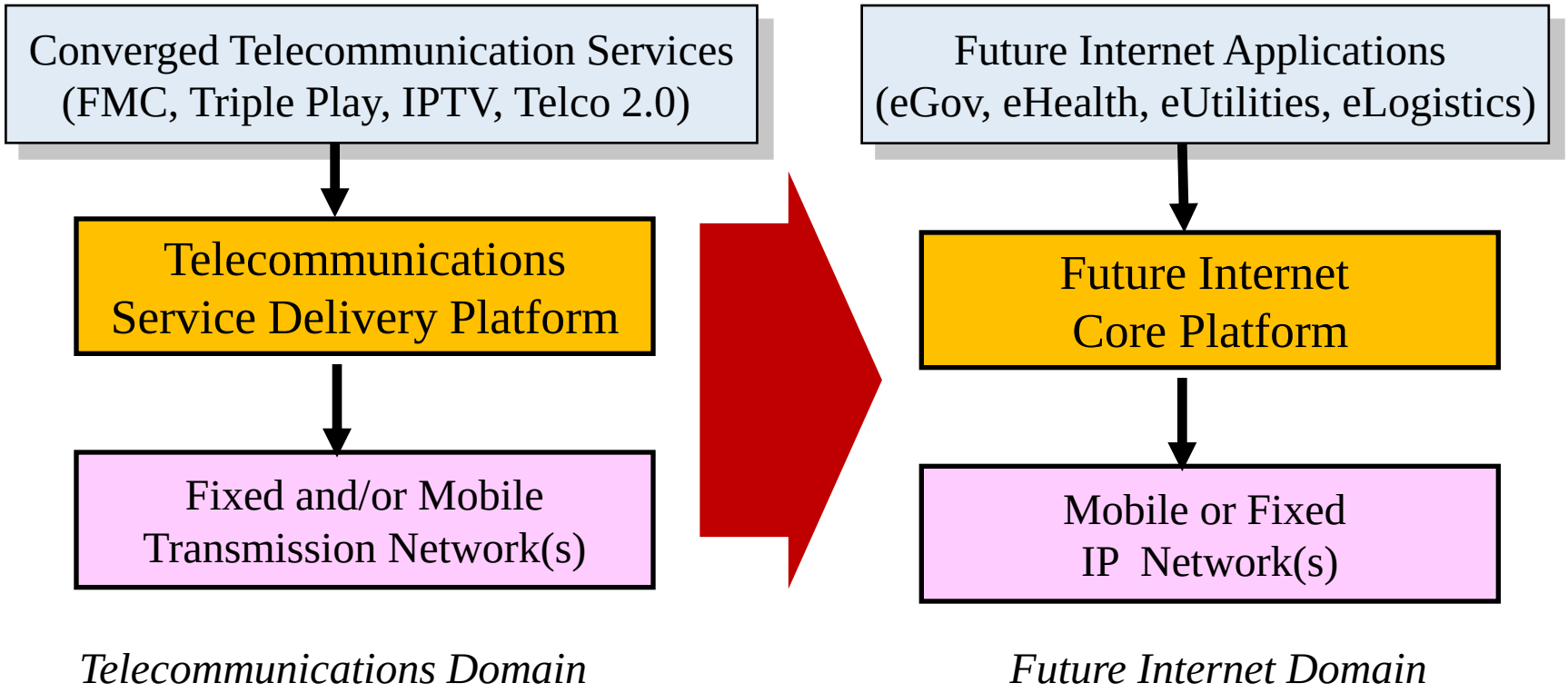
HSS - Home Subscriber Server
MME - Mobility Management Entity
SGW - Serving Gateway
PDN GW - Packet Data Network Gateway
PCRF - Policy and Charging Rules Function
eNB – Evolved NodeB

Evolution of the Core Network is in between the two time horizons



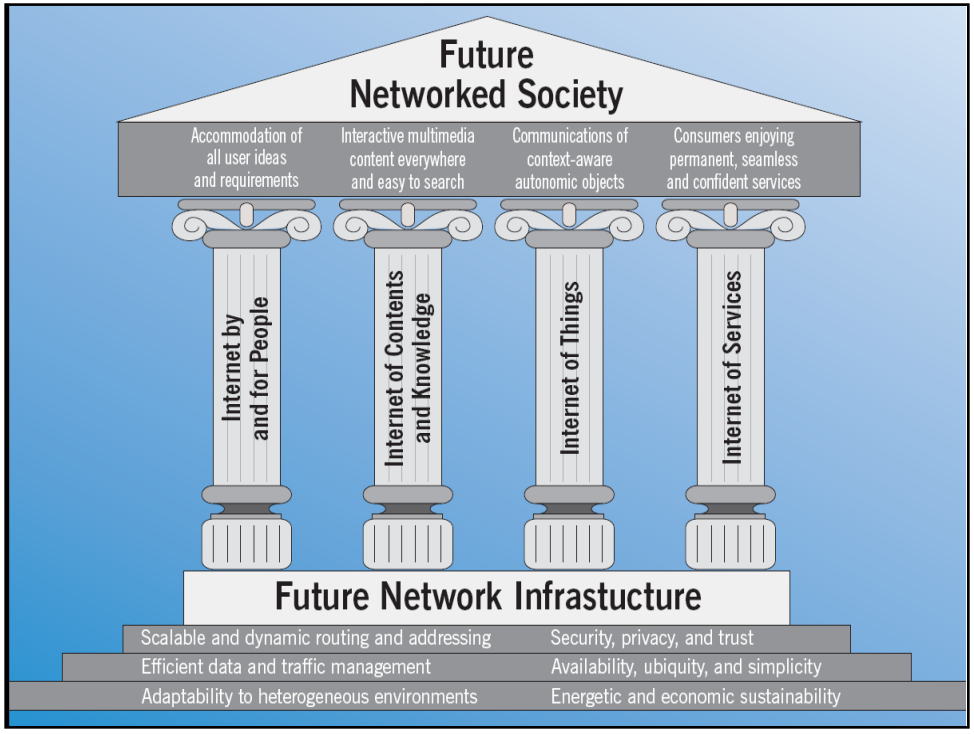
From Telecommunications toward the Future Internet

Main Idea: A Core Platform provides reusable capabilities (➔ Enablers) for multiple applications hiding the details of underlying technologies



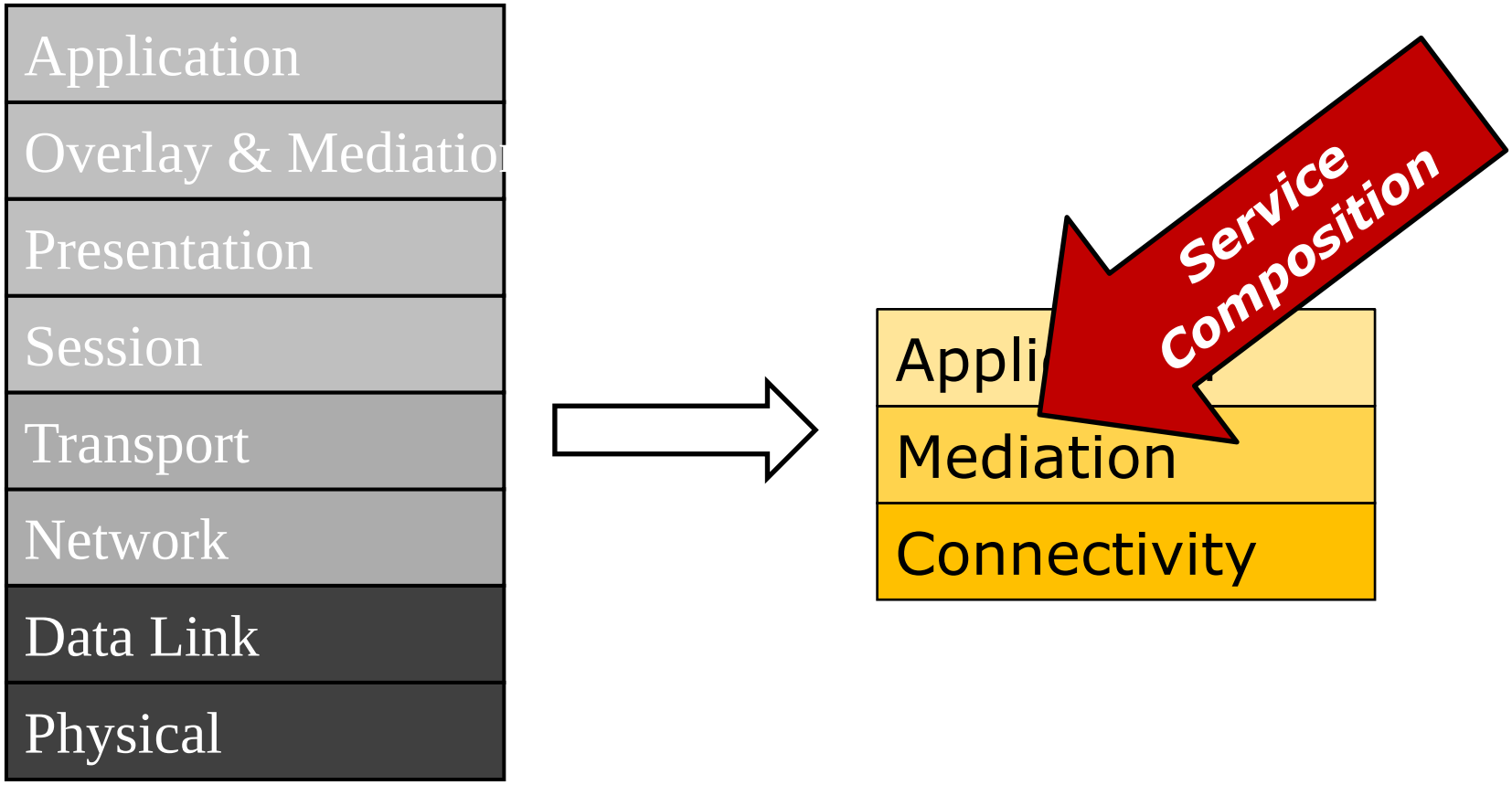
Dimensions of the Future Internet

- Future Internet Pillars
  - Network of the future
  - Internet of Content
  - ***Internet of Things***
  - ***Internet of Services***
- Infrastructure Foundation:
  - Network infrastructure / substrate that supports the pillars
  - Shall support capacity requirements of Future Internet

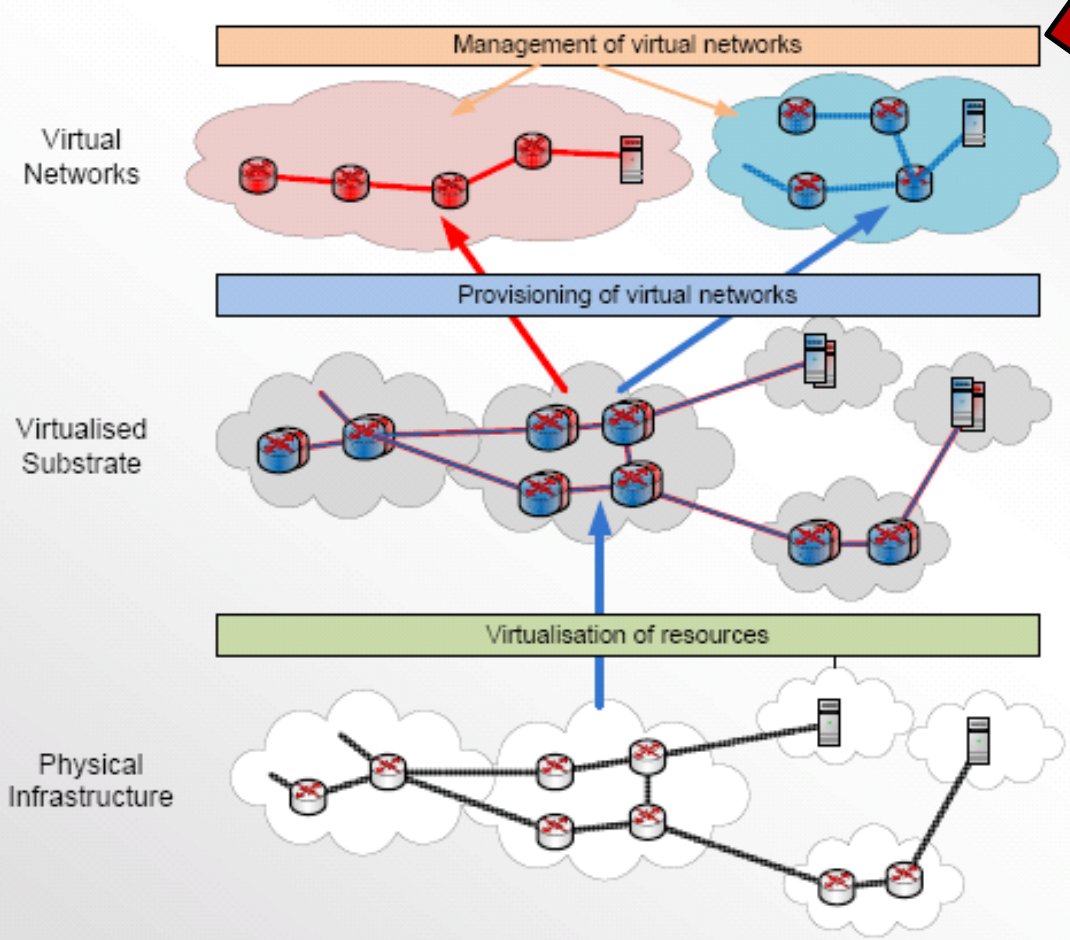


Future Internet, The Cross-ETP Vision Document, Version 1.0, 2009

Network of the Future: Towards Application oriented Protocol Stacks Forming Application specific Overlays



Decoupling Networks from Infrastructure



Service Composition ??

Independent, isolated VNs, running different protocols, packet formats, management tools, etc.

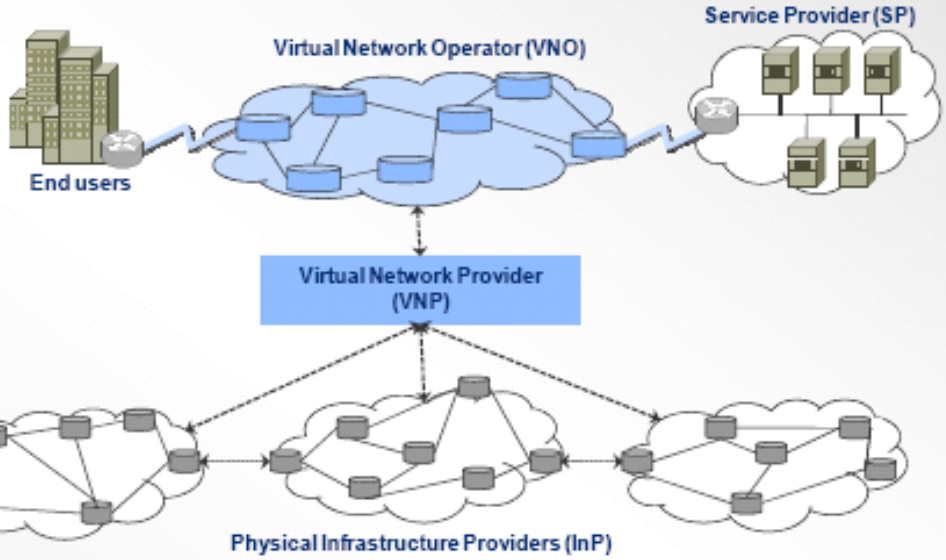
Collection of virtual resources, aggregated to build virtual networks

Service Composition ??

Infrastructure made of virtualizable network resources

Source: EURESCOM Project P1956

Roles and Players

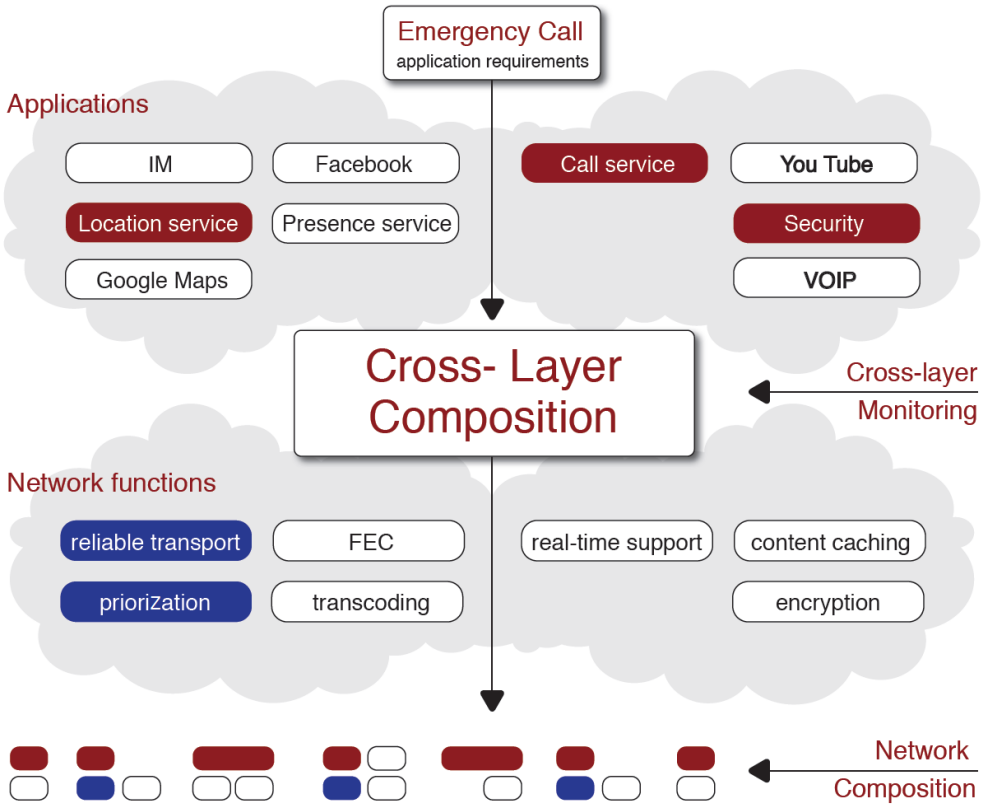


- **InP** owns, controls and administers physical resources, which may be used, or offered to 3rd parties, to build custom-tailored VNs.
- **VNP** (optionally) assembles a VN, according to a given description, based on resources from one or more InPs. Likely to be the case when a VN spans multiple InP domains.
- **VNO** establishes, manages and operates VNs; handles end user attachment.
- **SP** provides services to end users; NV is supposed to be invisible from the SP perspective.
- **End user** is the user of the service offered by the SP (or directly by the VNO if a distinct SP does not exist as such).

P1956 Network Virtualization – Opportunities and Challenges 6

Source: EURESCOM Project P1956

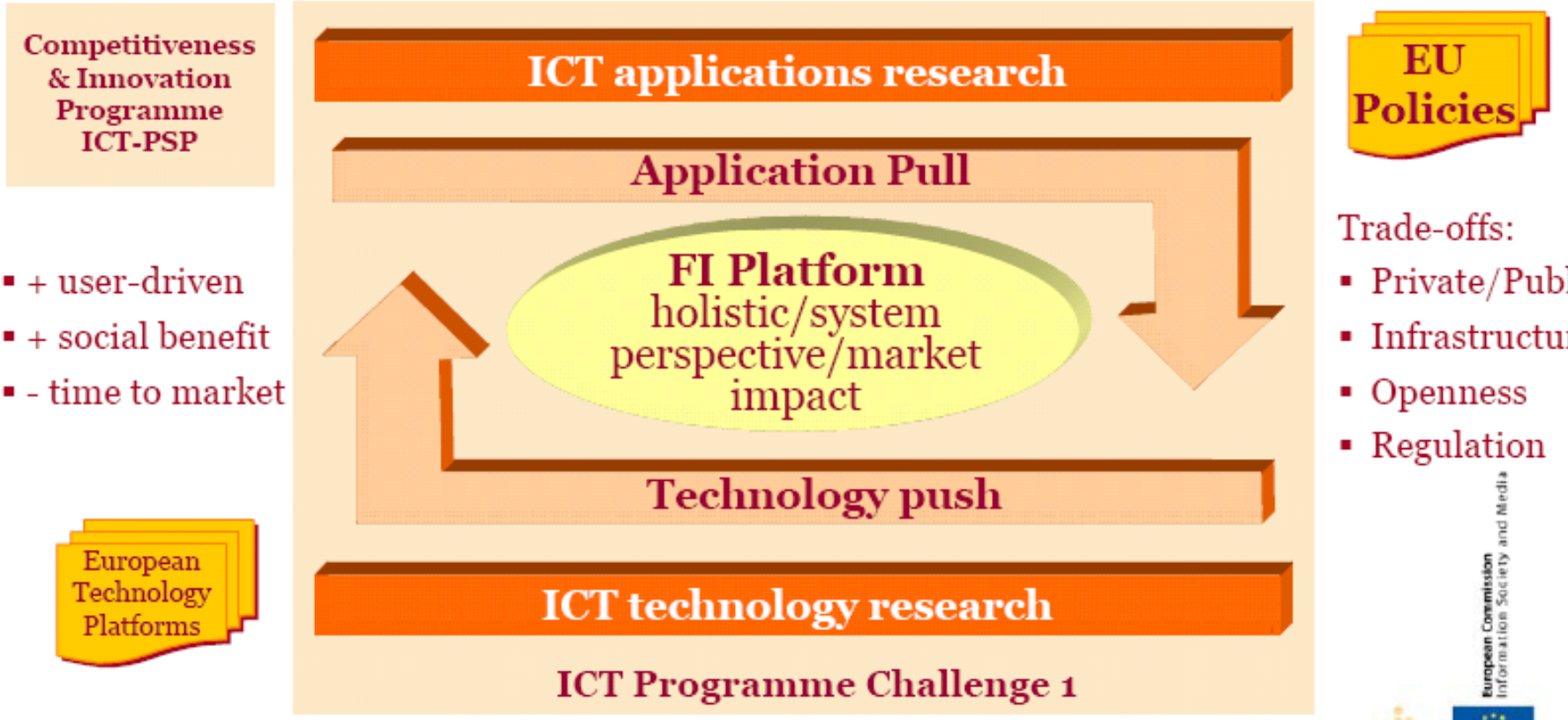
Cross-Layer Composition



- Service Composition offers:
  - Combined services to customers
  - Customer based personalization of the composed services
- Functional Composition offers:
  - Same SOA model on the network layer
  - Combined functional blocks which offers flexibility on selecting the appropriate blocks
- Cross Layer Composition:
  - Triggered at both layers (service and network) by customer requirements.
  - Decomposition of requirements in service and network requirements.
  - Accordingly selection and composition of services, respectively functional blocks
  - Mediation between the two layers.

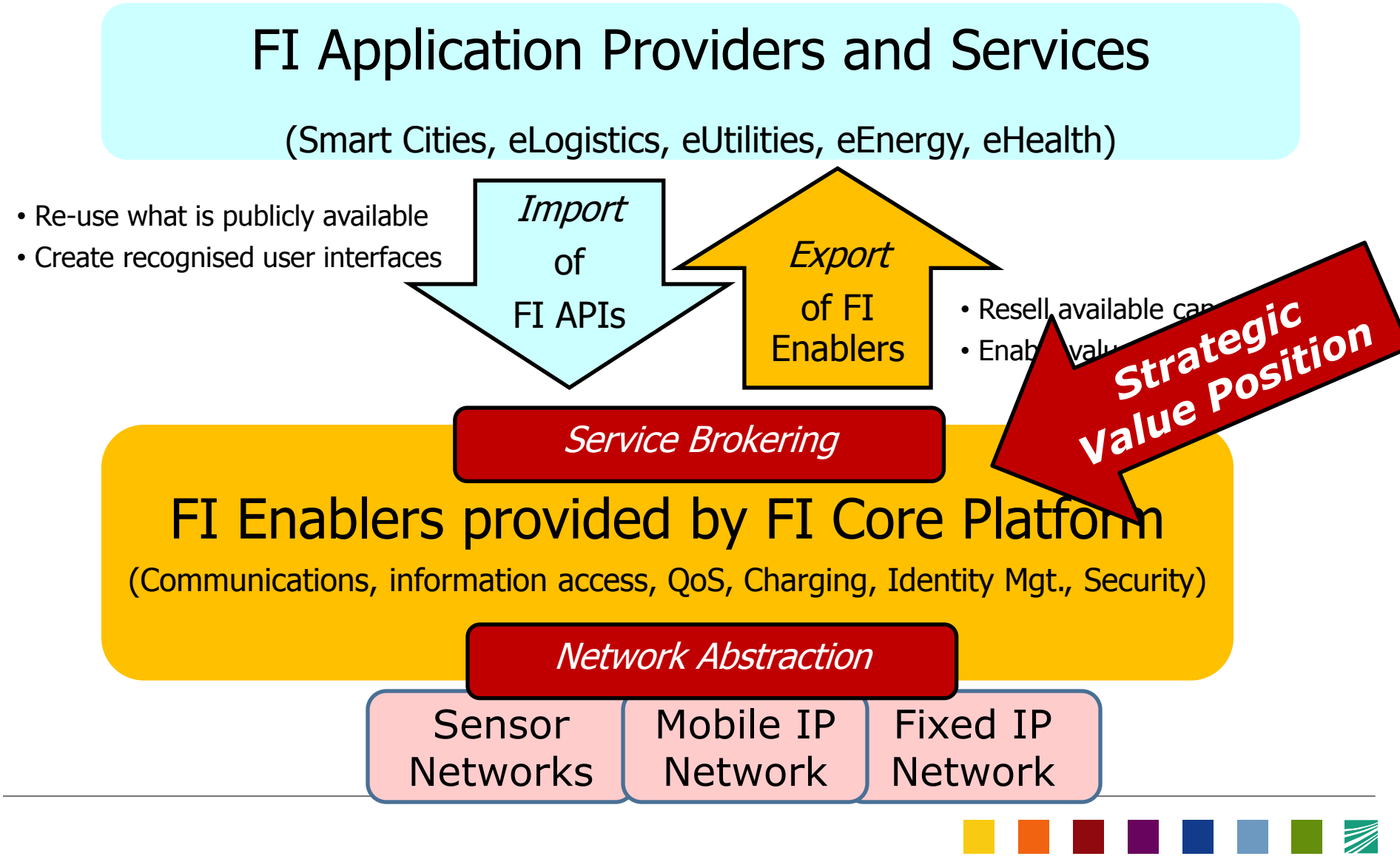
Towards a European Future Internet Platform

Making the world 'smarter' and accelerate sustainable innovation



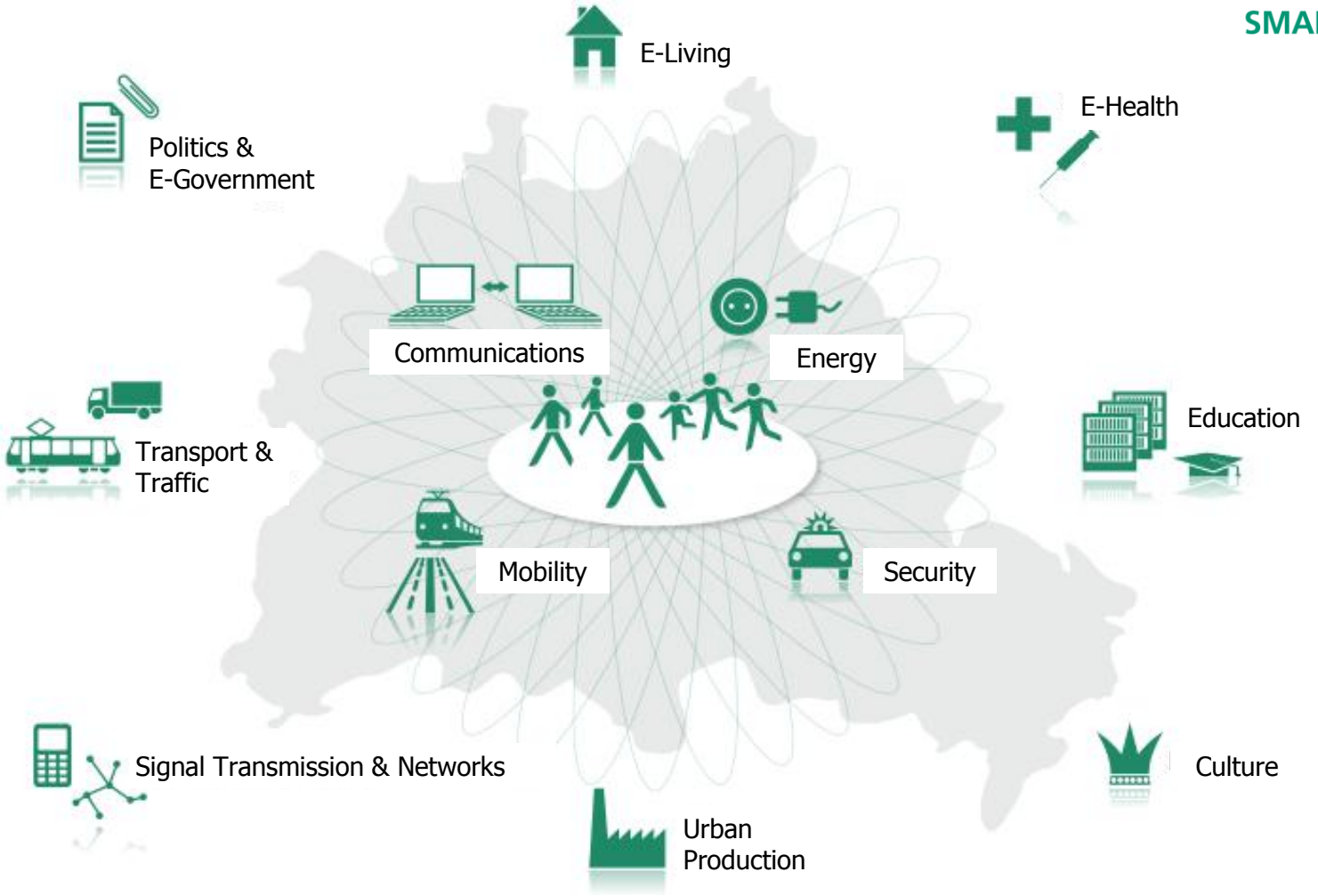
Making Europe a world leader in Future Internet technologies

APIs / Enablers in the FI Context …

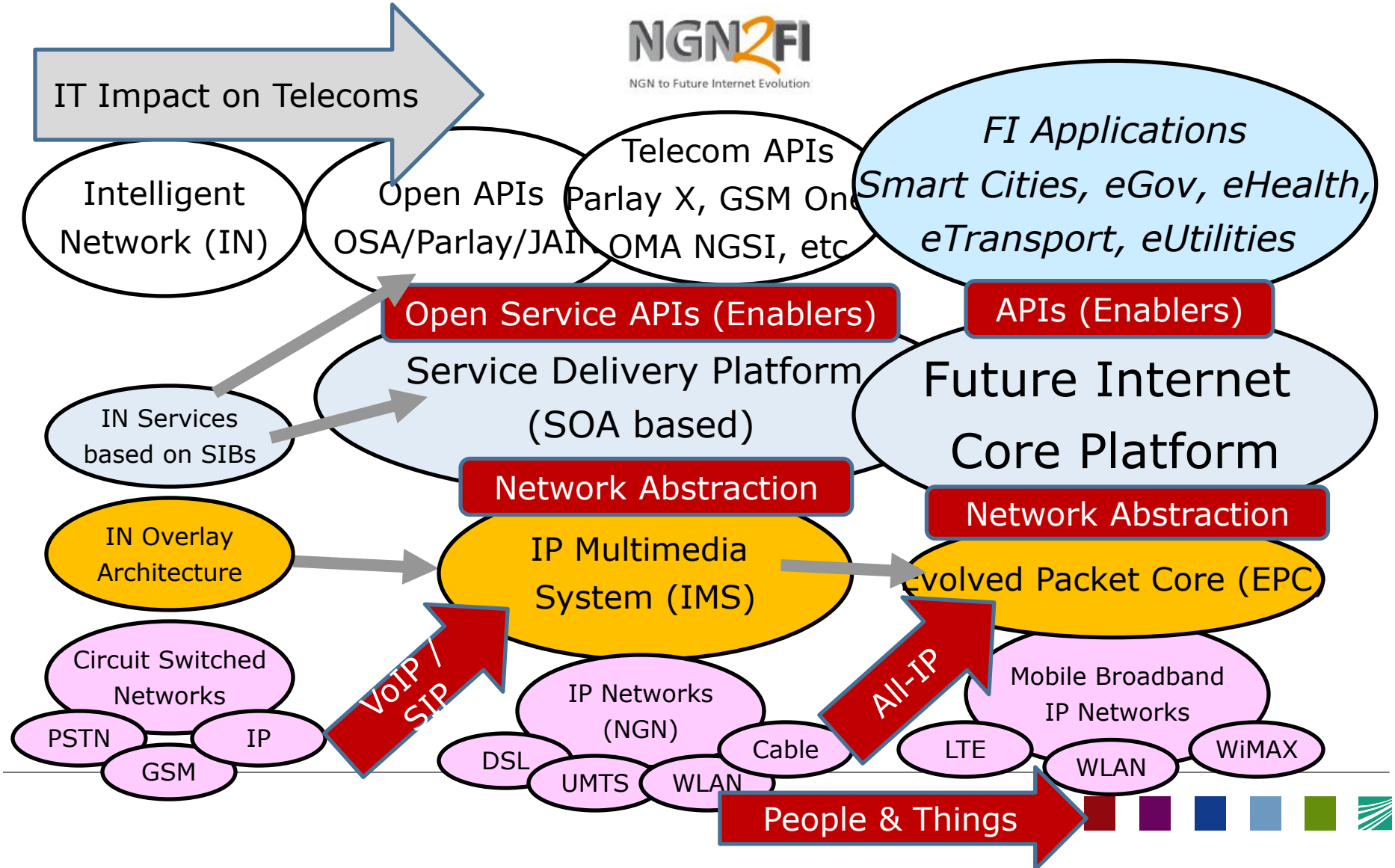


Future Internet … to make our cities smart
Open and Secure Platforms Are Needed

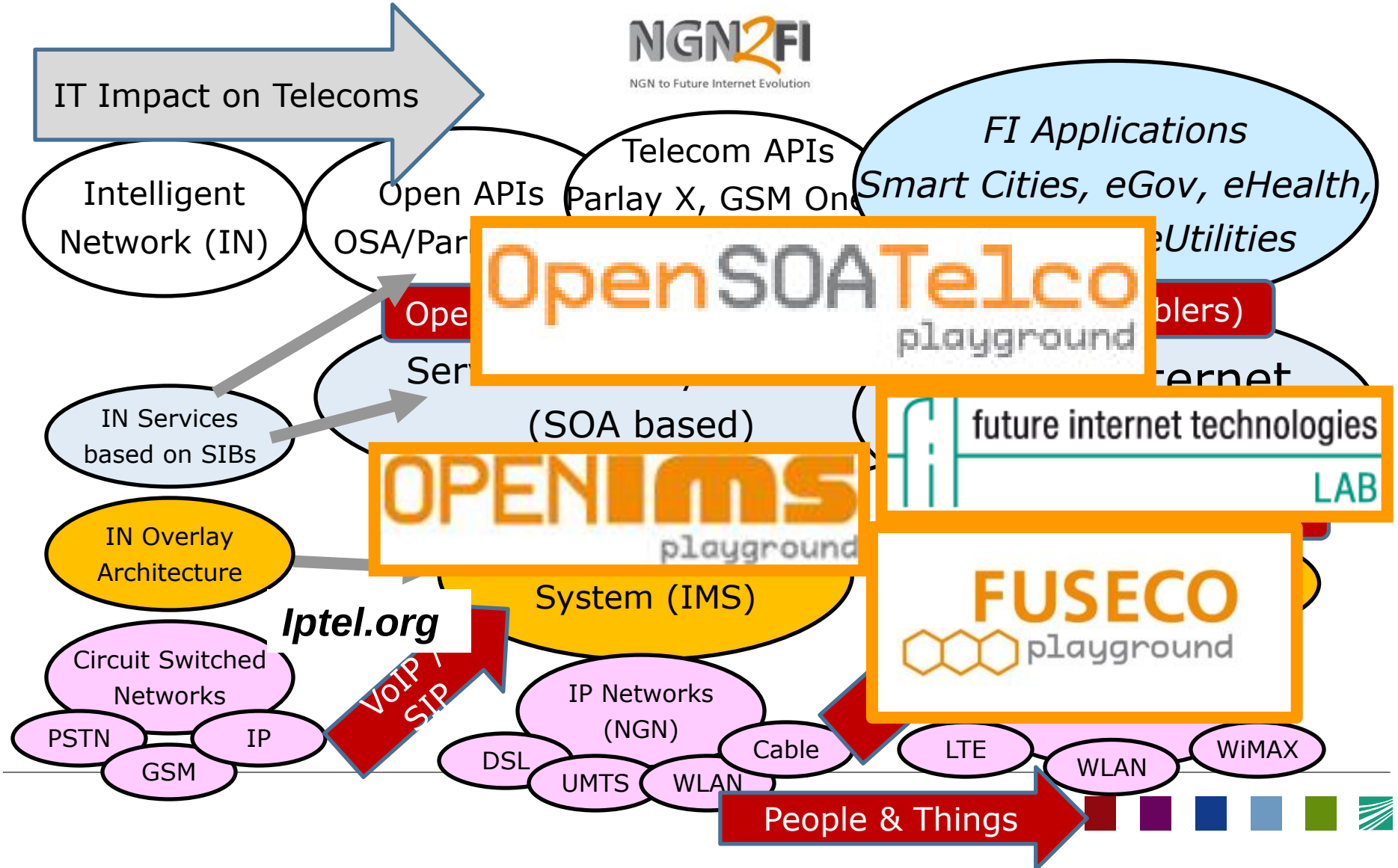
Fraunhofer SMART CITIES



Evolution of Telecommunication Platforms toward Future Internet



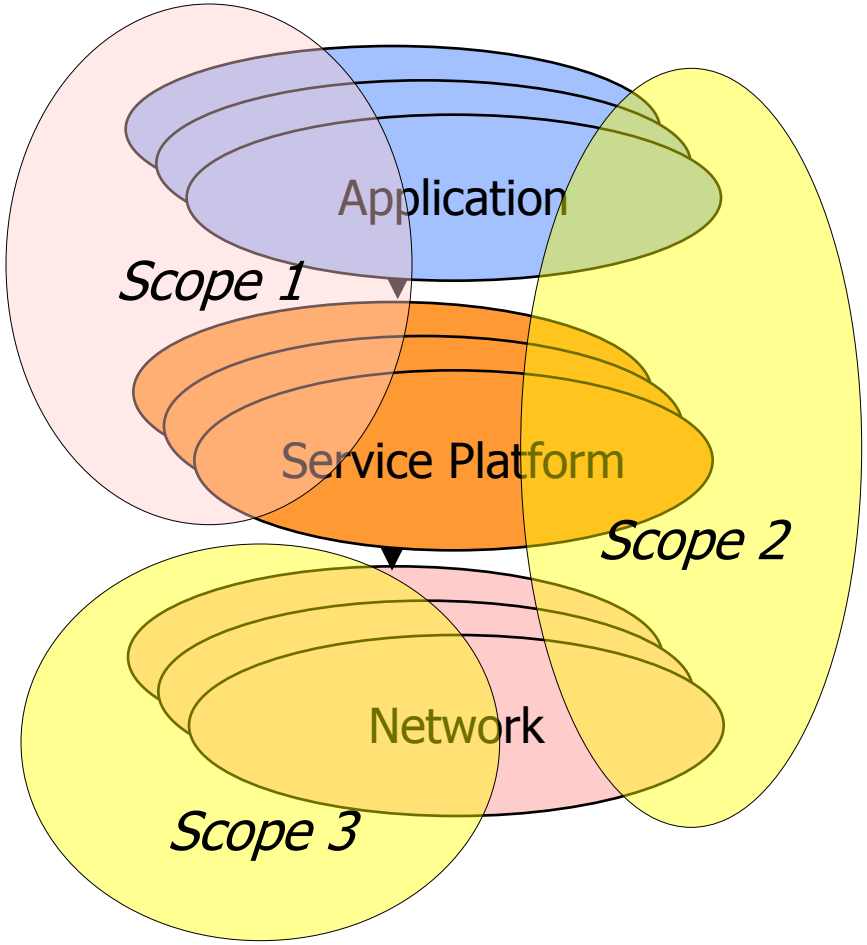
Related FOKUS Testbed Evolution



The Challenge of Testbeds and their potential Federation

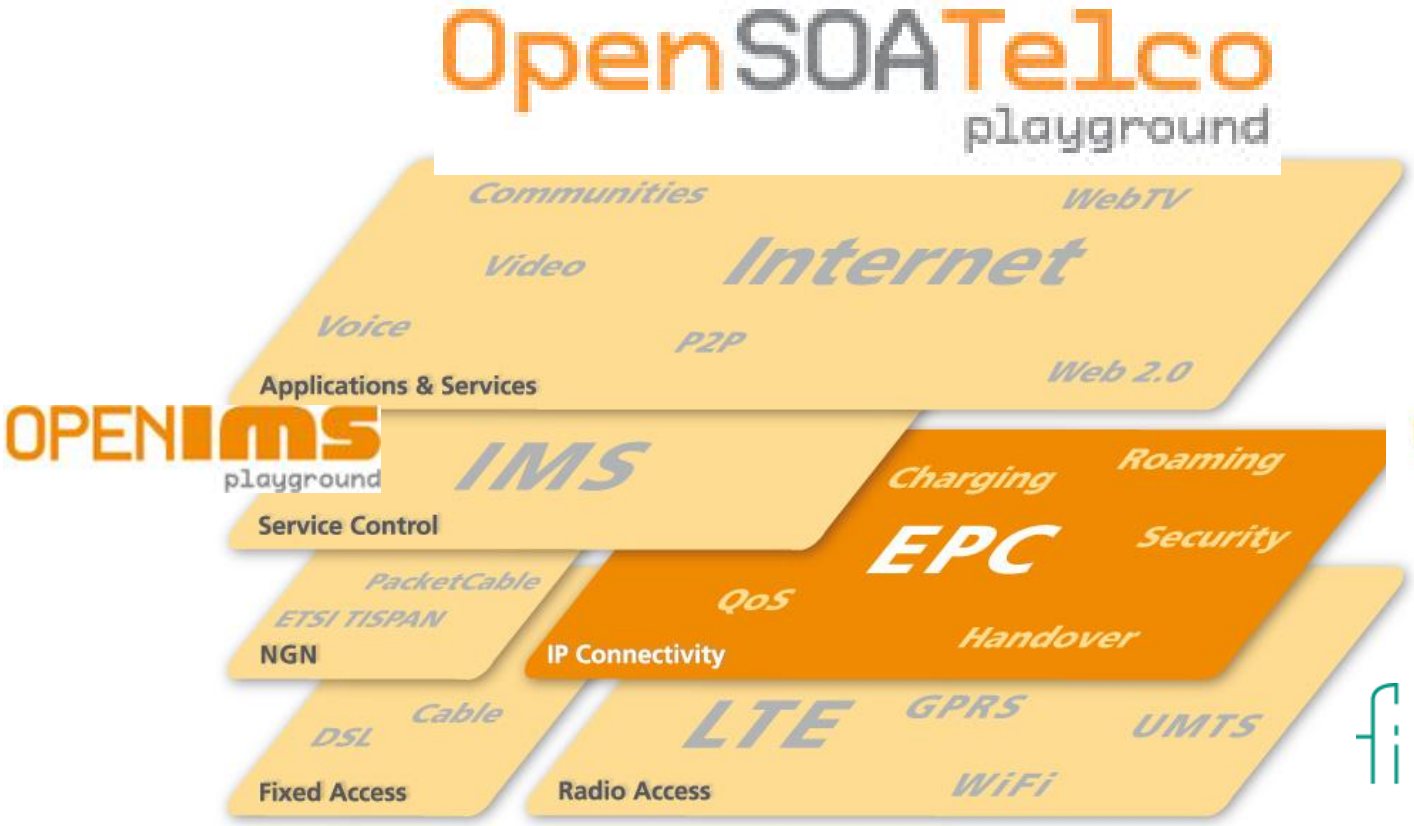
Different Application and Testbed Scopes

- Innovative multimedia applications
  - eHealth, eGovernment, e/mCommerce, interactive TV, web 2.0, telco2.0, etc.
- Service delivery platforms
  - IP Multimedia System, P2P systems, broadcasting systems, etc.
- Network technologies
  - 3G beyond, Wimax, LTE, Fixed Broadband, etc.
- Sometimes also beta test user communities
- Sometimes mixture of all above domains



Related FOKUS Testbeds for Research and Development

NGN2FI
NGN to Future Internet Evolution

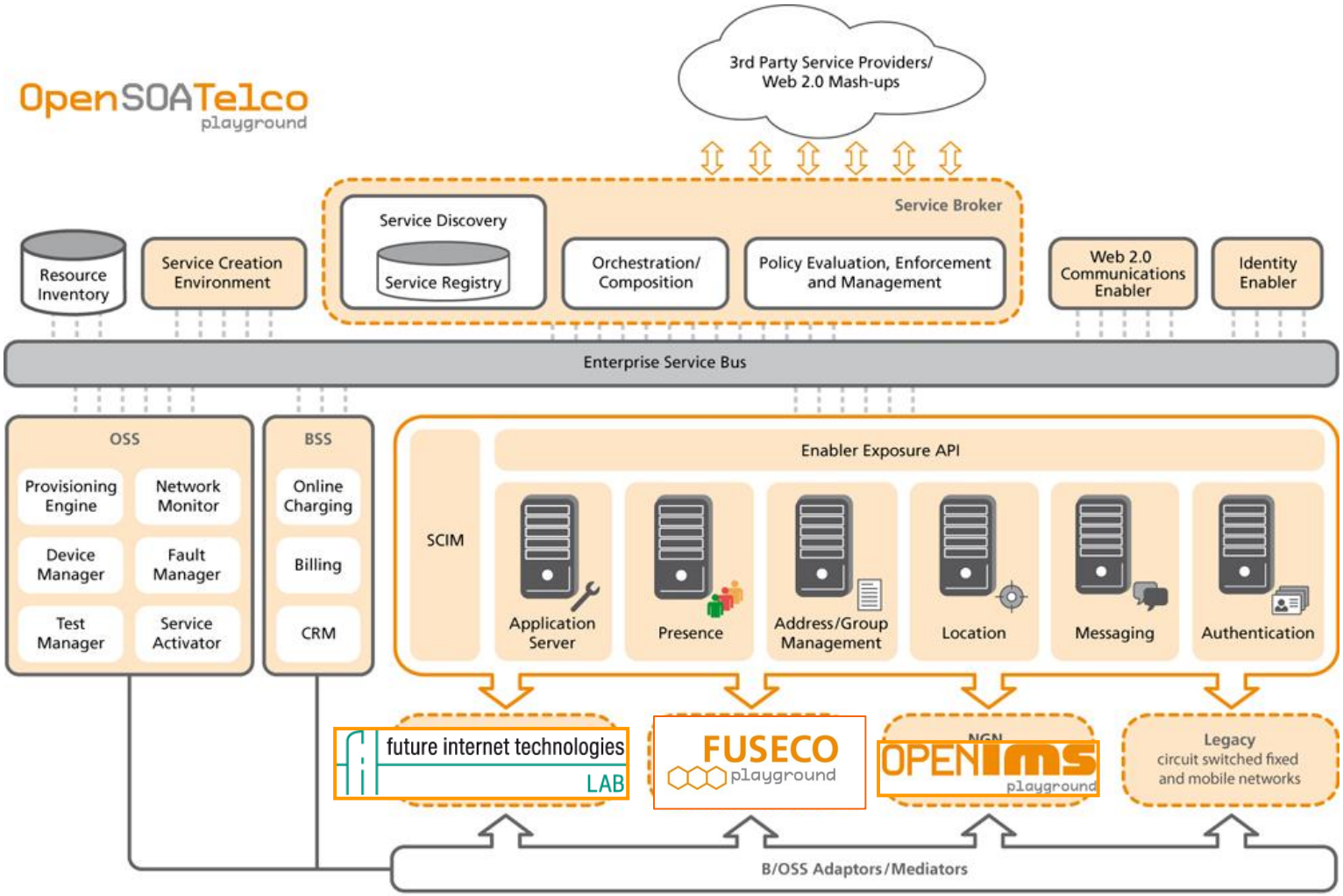


FUSECO playground

future internet technologies LAB

Exploring Services Composition - Open SOA Telco Playground

Enabling seamless Services across different Networks and Service Domains

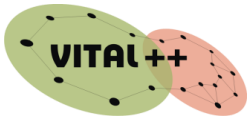


Example: FOKUS Future Internet Lab

Major Activities

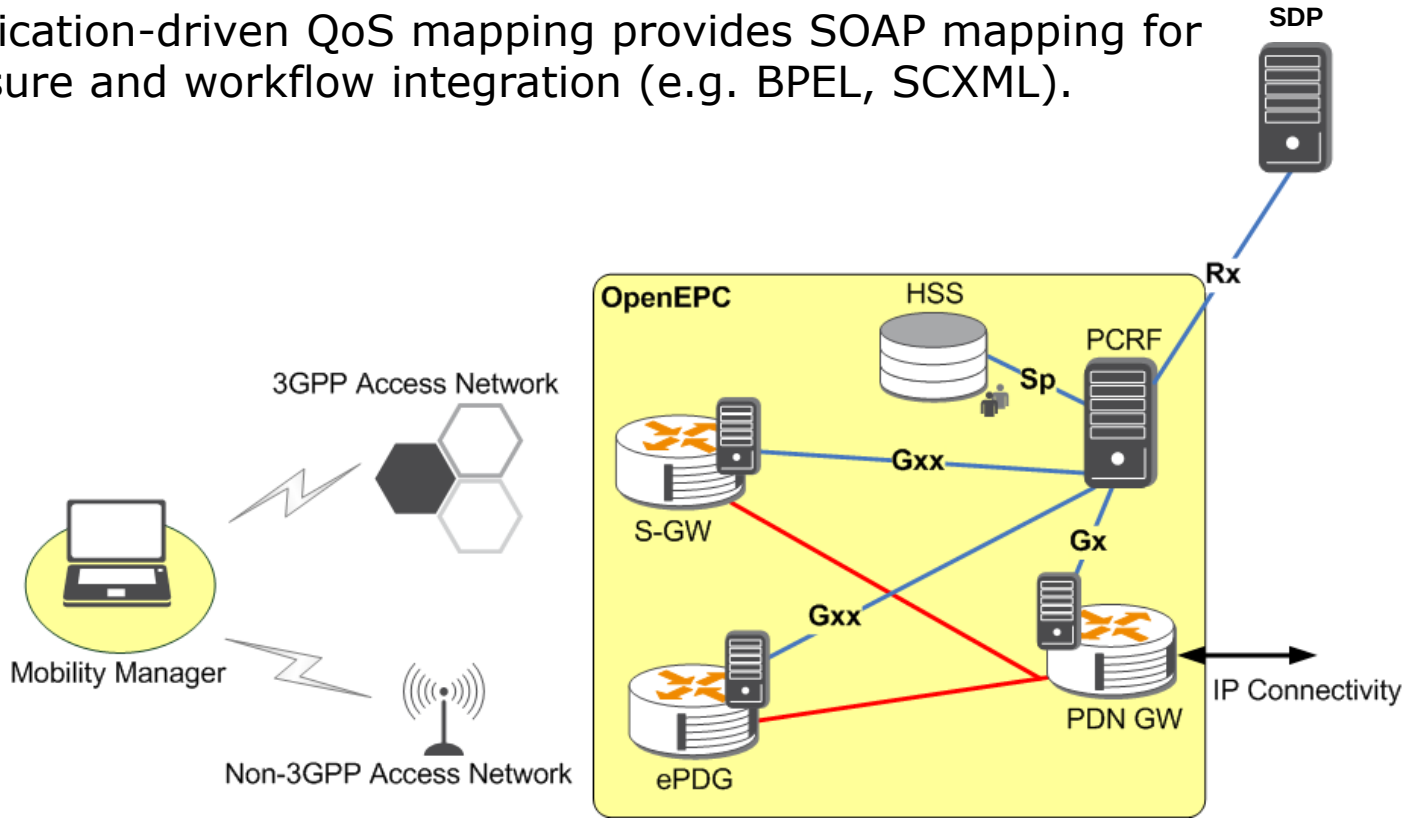
- Participation in major BMBF and EU FI projects
  - EU FIRE ONELAB2, Panlab2, EU Vital++, BonFIRE, and TEFIS
  - BMBF G-Lab Deep

- Focal points of research
  - Evolution from fixed and mobile NGN toward Future Internet
  - Cross-domain/-layer monitoring and testing based on policy-based control loops
  - Service composition and brokering on top of Future Internet Infrastructures
  - Future Internet resource and testbed federation (→ Teagle)
  - Evolved packet core introduction and evolution
  - Cloud federation and Everything as a Service (XaaS)



Network Control from the Service Layer
QoS Control through Rx interface

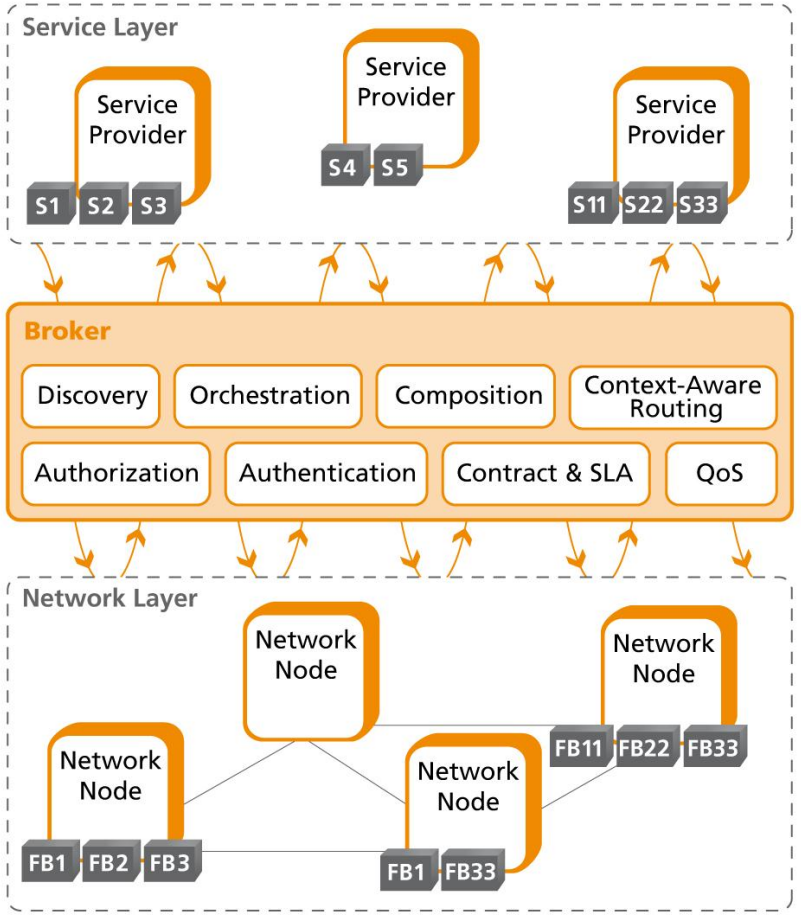
- Diameter-based Rx interface allows the integration of QoS control into the service layer.
- Parlay X Application-driven QoS mapping provides SOAP mapping for service exposure and workflow integration (e.g. BPEL, SCXML).



Network-aware Service Broker

Enabling cross-layer composition between Network & Service Layer

- Service-Oriented Architecture Concepts can be applied to all layers of the network architecture and will finally replace the layer-oriented Internet with a service-oriented end-to-end architecture.
- A converged NGN/FI Service Broker provides a link between application and network layer capabilities:
  - Cross-layer composition of service and network resources.
  - Security mechanisms,
  - Efficient request routing, and Quality of Service (QoS) parameter settings.
- The NGN/FI Broker address application-aware networking from the perspective of the Service Layer



Join us at the 2nd FOKUS Future Seamless Communication Forum (FFF)

Berlin, Germany, November 17-18, 2011

- Theme: "From FMC towards total Convergence: *New Applications and Platforms for Converging Mobile and Fixed Next Generation Networks and the emerging Future Internet"*
- Visit our Website: www.fuseco-forum.org
- FFF will feature vendor exhibitions, and operator only talks
  - FFF is the successor of the famous FOKUS IMS Workshop series
  - FFF 2010 attracted 150 experts from 21 nations
  - See www.fuseco-forum.org/minutes for details and free download of presentations

FUSECO playground

Agenda

- Introduction
- IP Multimedia System (IMS) as Uniform All-IP Operator Service Platform
- Evolved Packet Core (EPC) Overview
- Future Internet (FI)
- Summary - Relating EPC, IMS, SDPs, and FI
- Q&A

Agenda

1. Introduction

- All-IP Network Convergence Pushing for Smart Bit pipes and Seamless Services
- The Data Highways: fixed and mobile Next Generation Networks (NGNs) for what?
- Future Operator Telco Services vs. domain specific Over the Top Applications vs. Service Enablement
- Back to the Future: IN vs. Service Enablement in NGNs and the emerging Future Internet (FI)
- How Smart will the Smart Bit pipe be? Best Effort vs. Connectivity plus PCC vs. IMS vs. Open APIs
- Implementing Open APIs (BONDI, GSM ONE, WAC) on top of which platforms?
- NGN2FI Evolution: The role of open toolkits and testbeds for open innovation

2. IP Multimedia System (IMS) as Uniform All-IP Operator Service Platform

- IMS Standards review
- IMS Key Capabilities and Services (VoIP, RCS, IPTV, and ?)
- IMS Challenges – IMS vs. SDPs, vs. Web 2.0
- IMS Limits: SIP vs. HTTP Services and Enablement
- Lessons learned from the FOKUS IMS and Open SOA Telco Playgrounds

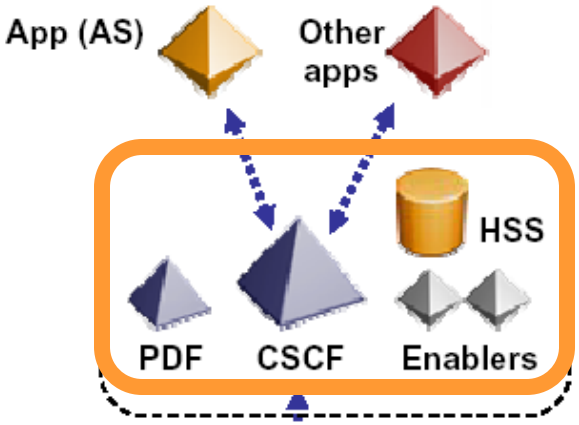
NGN Over the Top (OTT) vs. Standardised IMS Service Platform

Proprietary Service Platform

Fixed or mobile NGN IP Pipe

Standalone Solution

Fast one-off deployment
Optimised one-off CAPEX (but repeated)
OPEX for each standalone solution
Fragmented end-user experience



SDP + IMS Overlay Platform

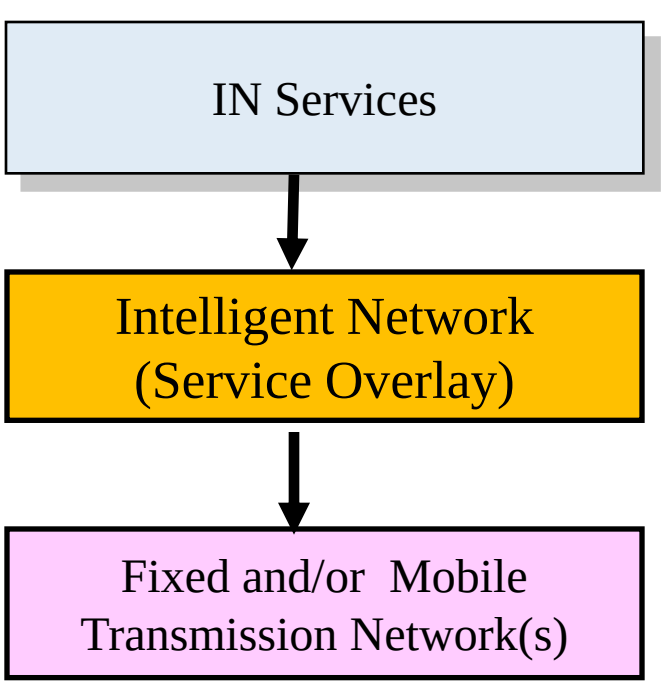
Fixed or mobile NGN IP Pipe

IMS based Solution

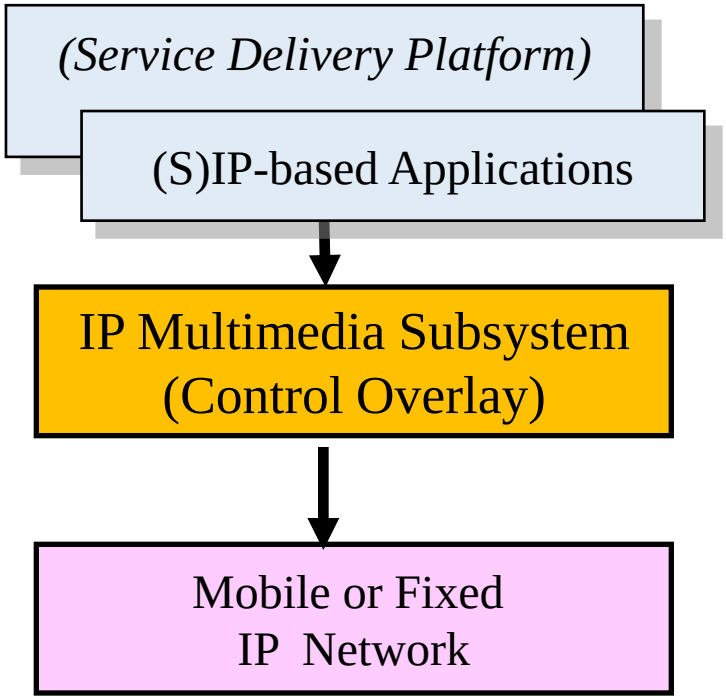
Faster integration of subsequent apps
Re-use deployed infrastructure
OPEX shared across whole solution
Integrated end-user experience

IN Concept Evolution toward IMS

Main Idea: Service Overlay Architecture abstracts from underlying network technology and provides common platform capabilities for Applications / Services



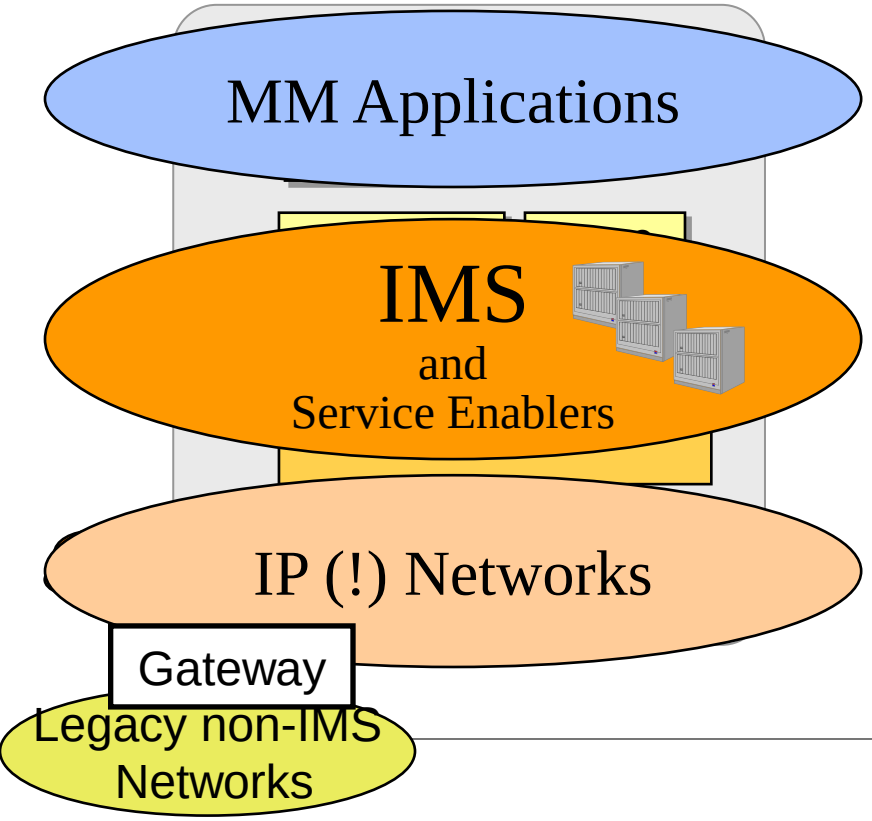
Circuit Switched Telco Domain



Packet Switched Telco Domain (NGN)

IP Multimediasystem (IMS) = Common Control Platform in NGNs

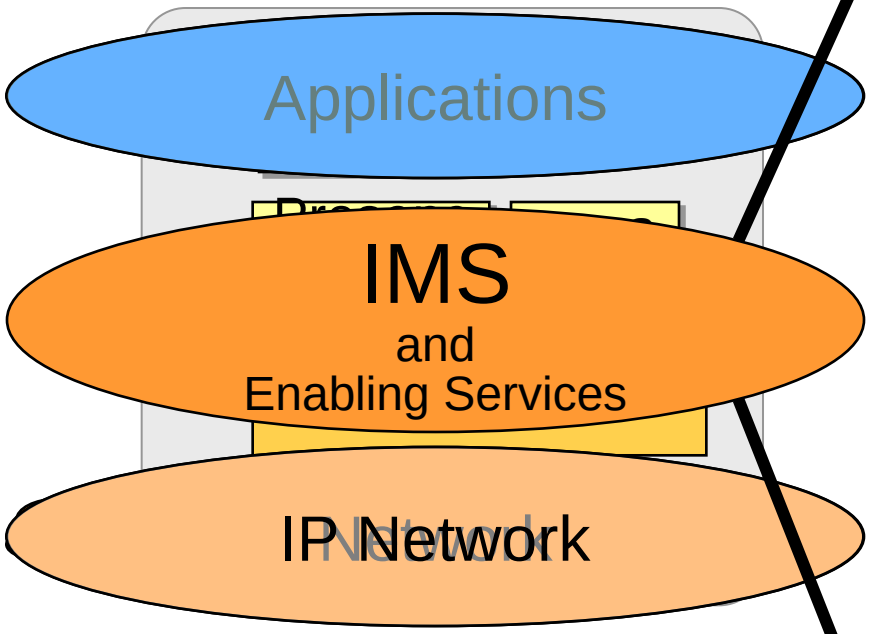
- based on SIP and Diameter, IMS provides a control platform for IP nets
- supports inherently multimedia services: VoIP, Video, IM, presence
- is an overlay and works on fixed and mobile IP networks (FMC)
- IMS applications are provided in SIP Application Servers



- Horizontal Architecture defining a "docking station" for applications
- Defines service enabler capabilities
- Build on existing IETF and telco SDP standards
- Provides compared to standard internet
- Better security, Service based QoS, flexible charging and single sign on

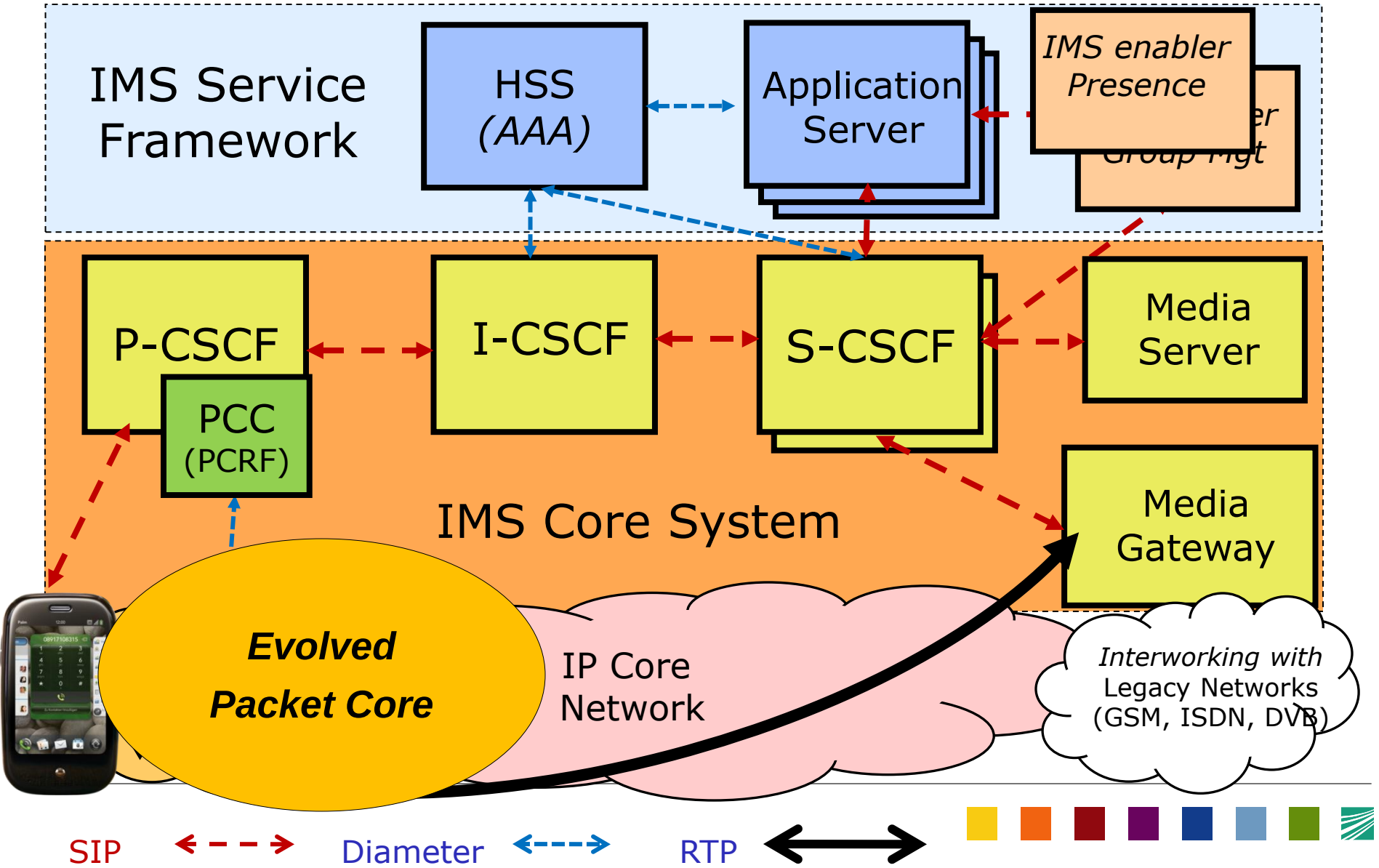
IMS provides common Control Capabilities

IMS Applications are provided by Application Server



- Multiparty / Multimedia Session handling based on SIP Control
- Multimedia Content Pull & Push
- Messaging Support
- Conferencing and Group Com. Support
- Fixed Mobile Convergence / 3P
- Single-Sign-On User-Authentication
- High Secure Service Access and Provision
- Service based Bearer QoS
- Flexible Charging
- Legacy Network Interworking Support
- *Docking Station for Service Enablers*
- *Docking Station for Applications*

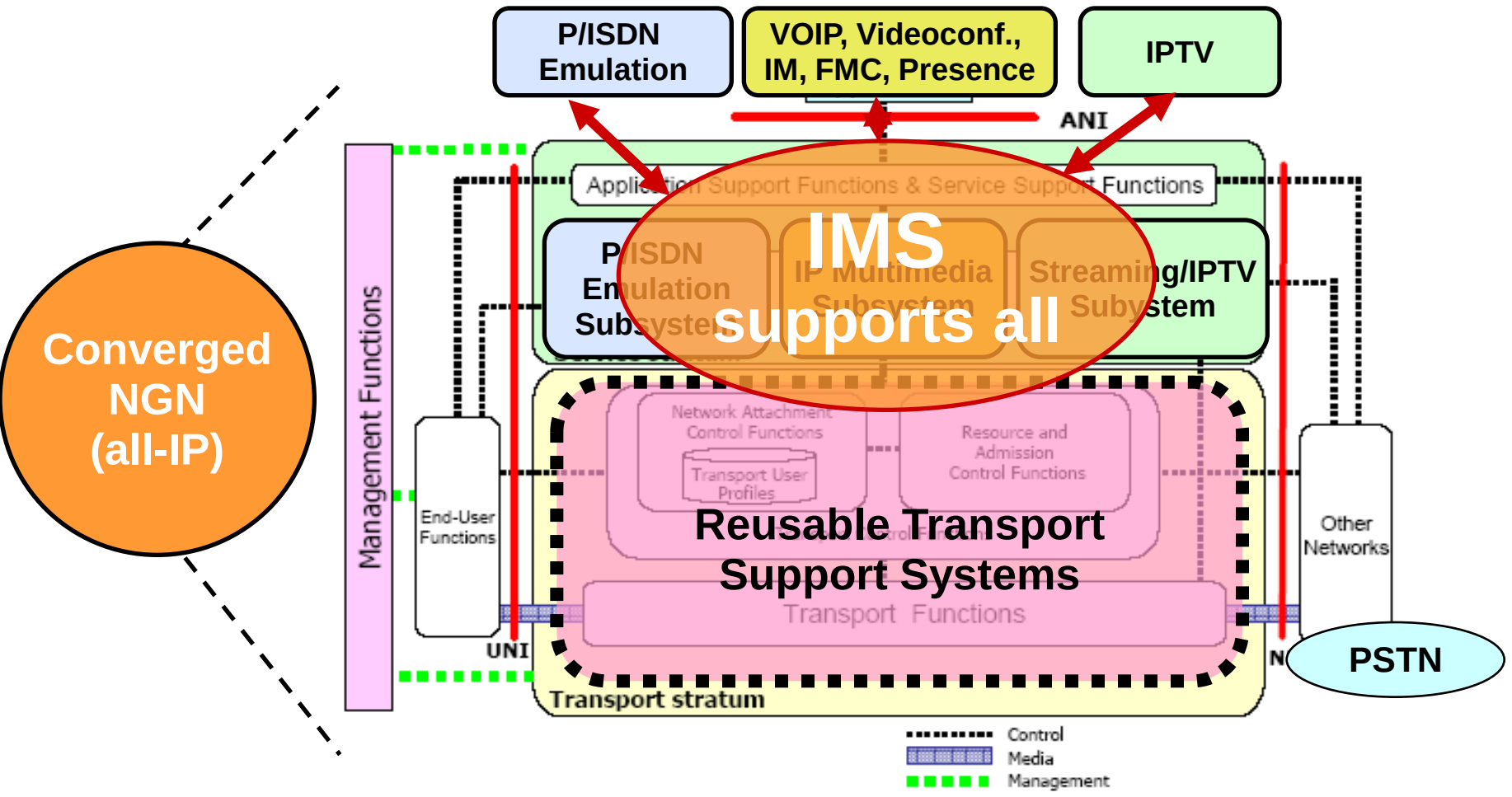
3GPP IMS Architecture: IMS Core and Application Layer



IMS Major Components

- The IMS is an Overlay Session/Service Control Architecture on top of the Packet domain based on IP technologies and protocols:
  - IMS Core
    - S-CSCF (Serving Call Session Control Function) the IMS anchor point in the home network
    - I-CSCF (Interrogating Call Session Control Function) provides topology hiding
    - P-CSCF (Proxy Call Session Control Function) entry point into IMS world
    - MRF (Media Resource Function) – Media Server hosting special resources
    - MGCF (Media Gateway Control Function) for interworking with legacy networks
    - PCC (Policy Charging & Control) for integrated QoS Control and Charging
  - IMS Application Layer
    - HSS (Home Subscriber System) for maintaining subscriber and AS profiles
    - AS (Application Server Function) for specific applications or enabling services
- The main new protocols used are (IETF's) SIP and DIAMETER (but 3GPP MAP and CAP are also important).
- *Note that all Online and Offline Charging components and interfaces (Ro, Rf) are not shown in the previous slide!*

IMS is the common control platform within the NGN for many Application Domains



IPTV plus Telephony & Chatting

- VoIP enabled IPTV client offers telephone service
- interaction between TV and communication services
  - on incoming call displaying caller id
  - if call is connected:
    - VoD: pause video
    - LiveTV: mute

Rich Communications Services (RCS) Features

- Enhanced Phonebook
  - with service capabilities and presence enhanced contacts information
- Enhanced Messaging
  - which enables a large variety of messaging options including chat and messaging history
- Enriched Call
  - which enables multimedia content sharing during a circuit switched voice call
- Standardized services:
  - Presence
  - Voice Call
  - IM
  - Video Share
  - Image Share
  - SMS
  - MMS

IMS Standards

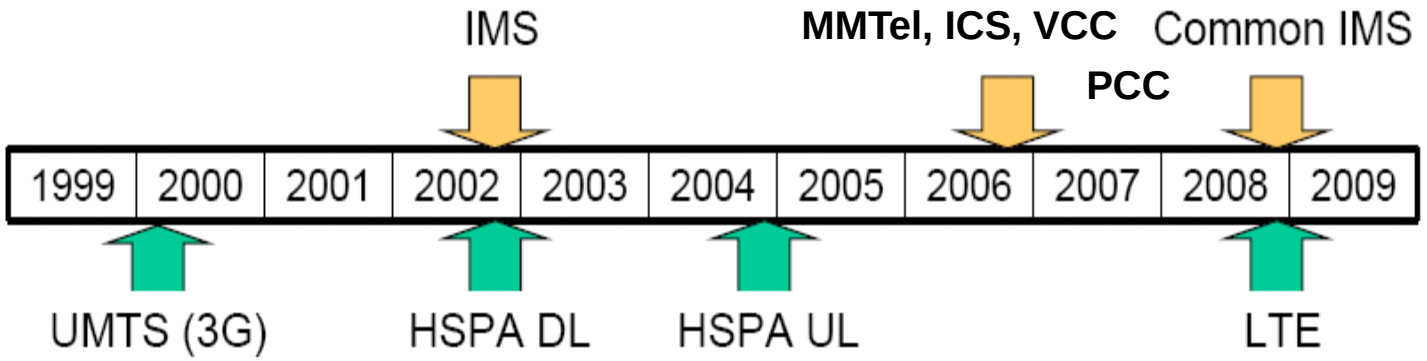
- 3GPP Release 7 provides major extensions for Voice Services and Multiple Accesss Network support:
  - Voice service enabled IMS (CSI, MMTel, Emergency, call performance improvements, VCC)
  - Support for IMS based emergency calls
  - Support for multi-service environment and mass-market reachability →IMS Communication Service
  - Policy & Charging Control (PCC)
  - Enabling fixed (e.g. DSL, Cable) access to IMS
  - Parlay-X / Webservices (SOA) enabling value add services (”northbound interface”)

IMS Standards (cont.)

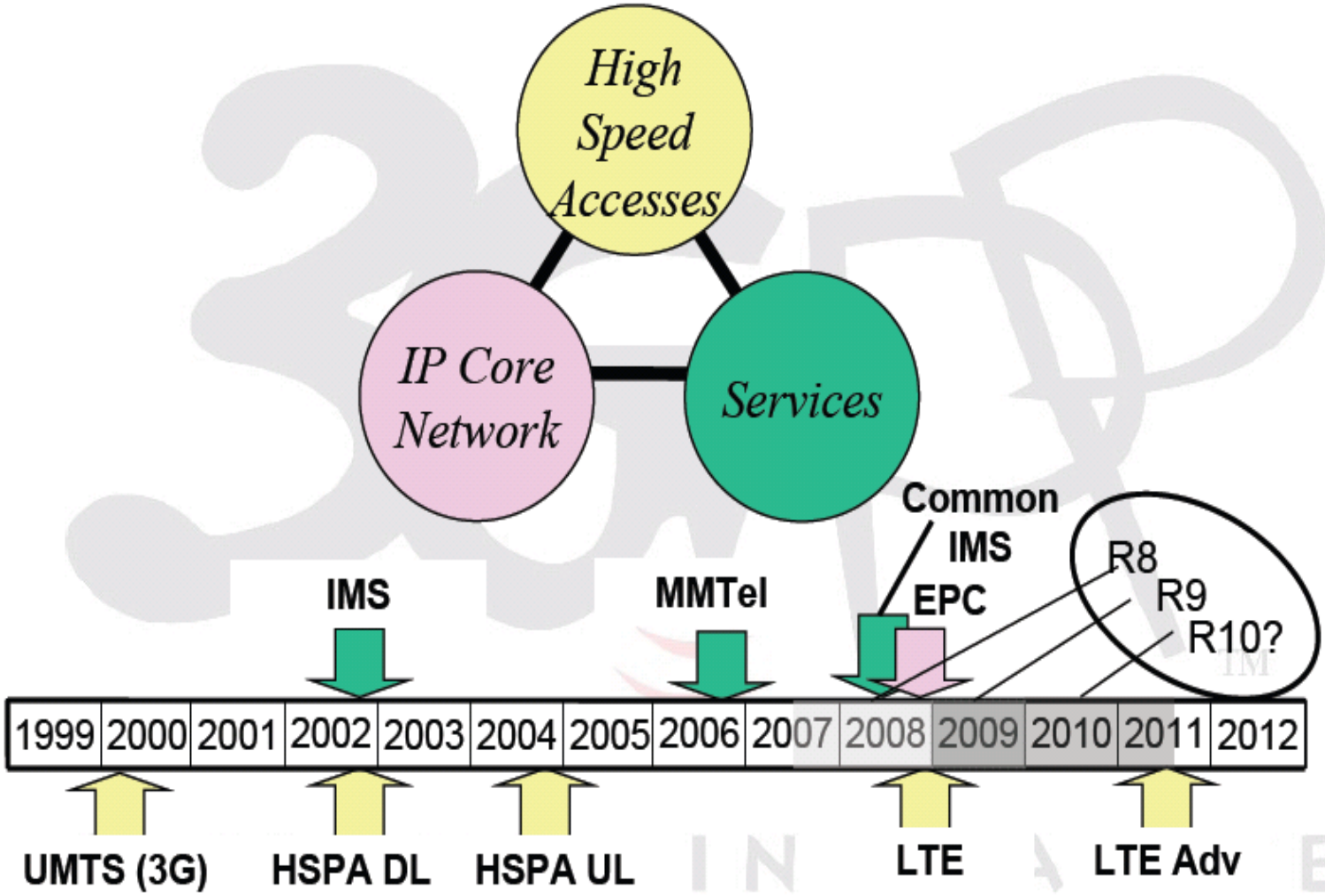
- 3GPP Release 8 extends Session Mobility / Handover Capabilities
- Common IMS aligning TISPAN, 3GPP2 and PacketCable requirements into 3GPP
  - IMS Centralised Services (ICS) and session / service continuity (extension to and replacement of VCC), SR-VCC
  - IMS NNI interconnect profile
  - ISC/iFC enhancements (increased flexibility)
  - Recovery Procedures
  - Local Breakout for IMS
  - IMS based Mobile TV

IMS Standards Evolution in regard to Access Network Evolution

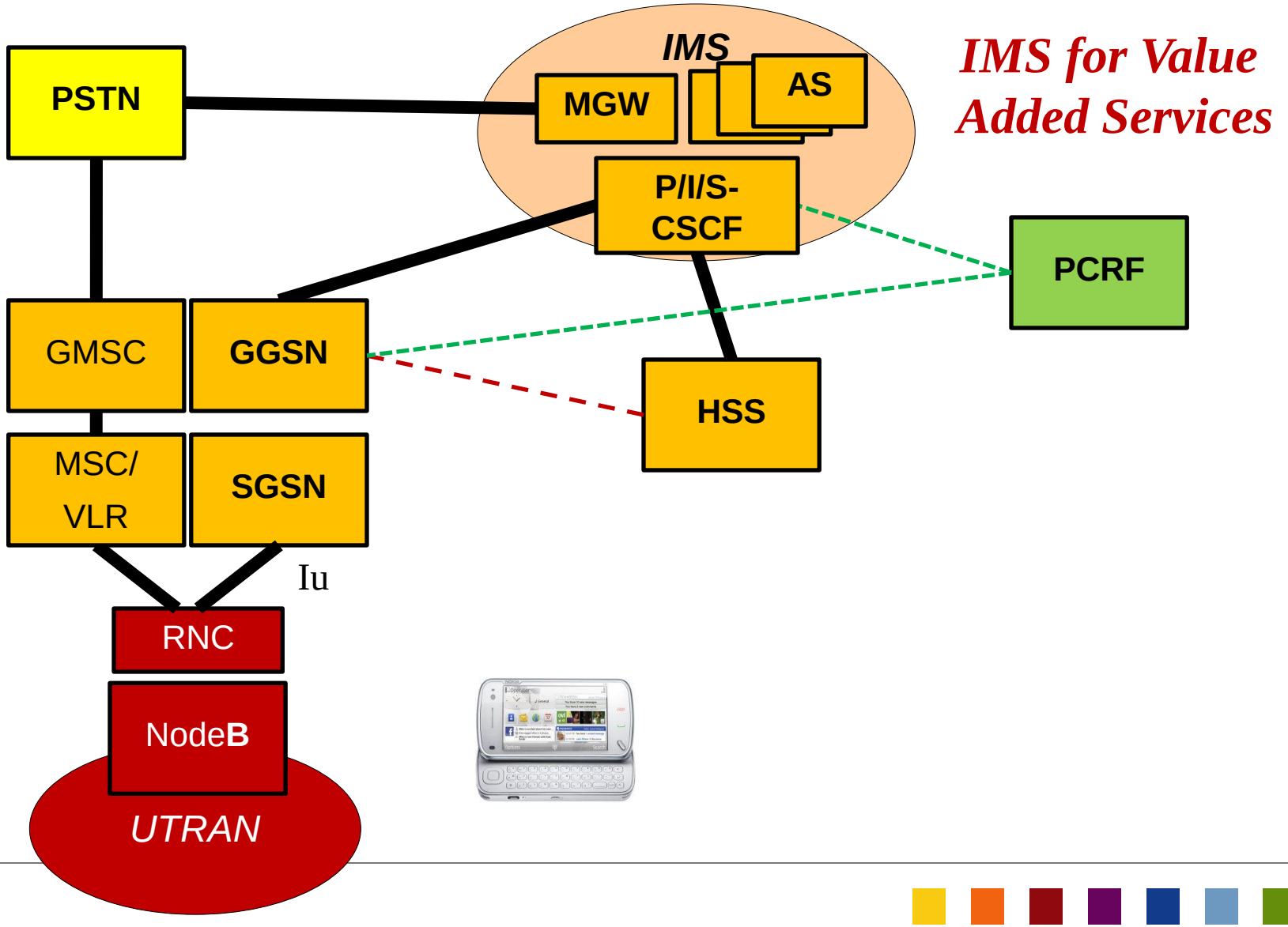
- IMS developed as part of 3GPP Release 5 as an application development environment based on IN/CAMEL and VoIP (IETF) concepts and protocols
  - Encourage new applications on top of 3G networks
  - Greater operator policing than native SIP/SDP
  - Home control allowing service customization
- IMS retargeted in Release 7 for telephony replacement
  - Standardized multimedia suite developed (ICS, MMTel, VCC)
  - Optimizations for QoS and Charging (PCC)
  - Access independence
- Common IMS specified in Release 8
  - Extension of Session Mobility support
  - Integration of IMS variants and requirements from 3GPP2, TISPAN, and Cablelabs



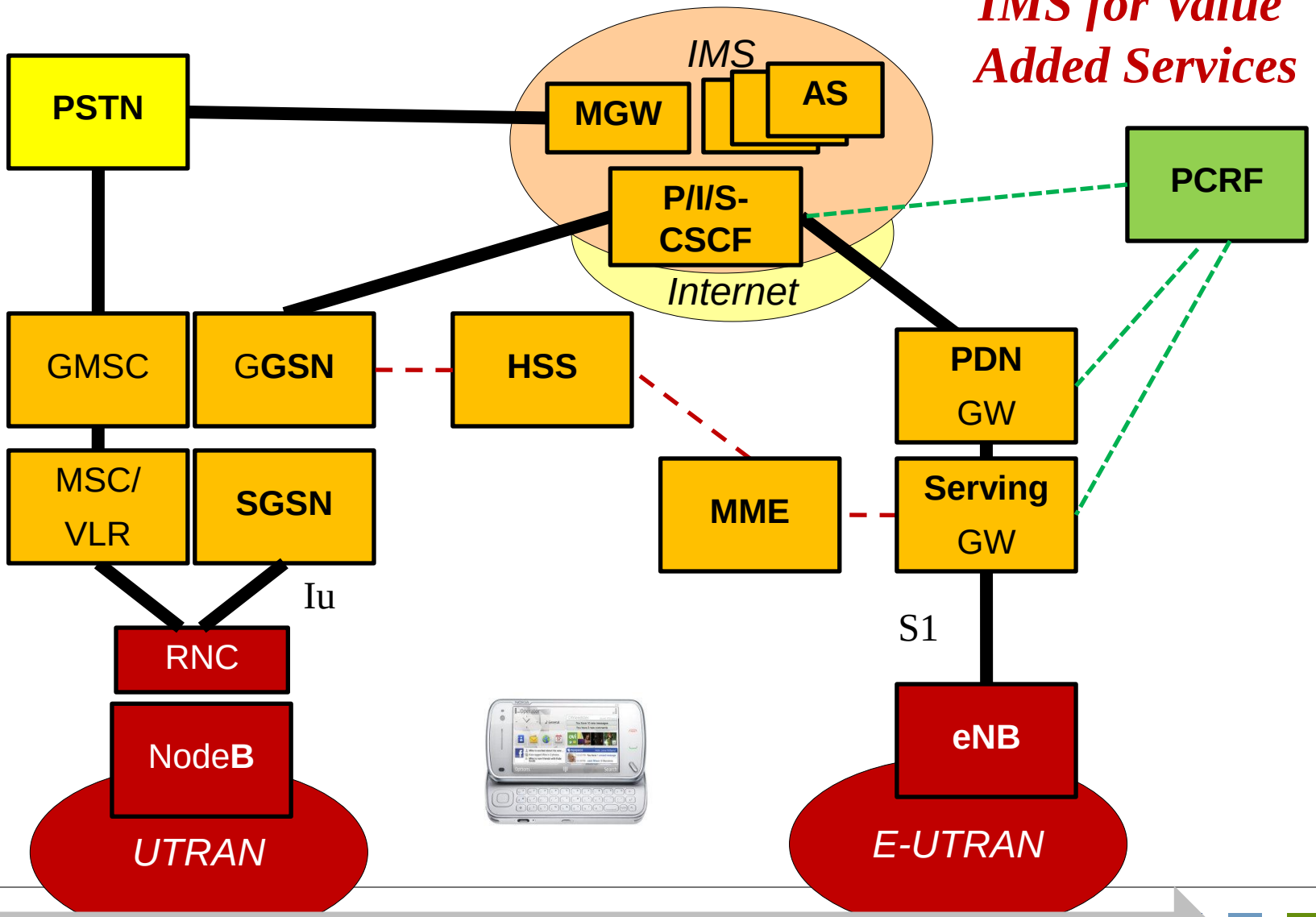
IMS Services Evolution related to LTE/EPC



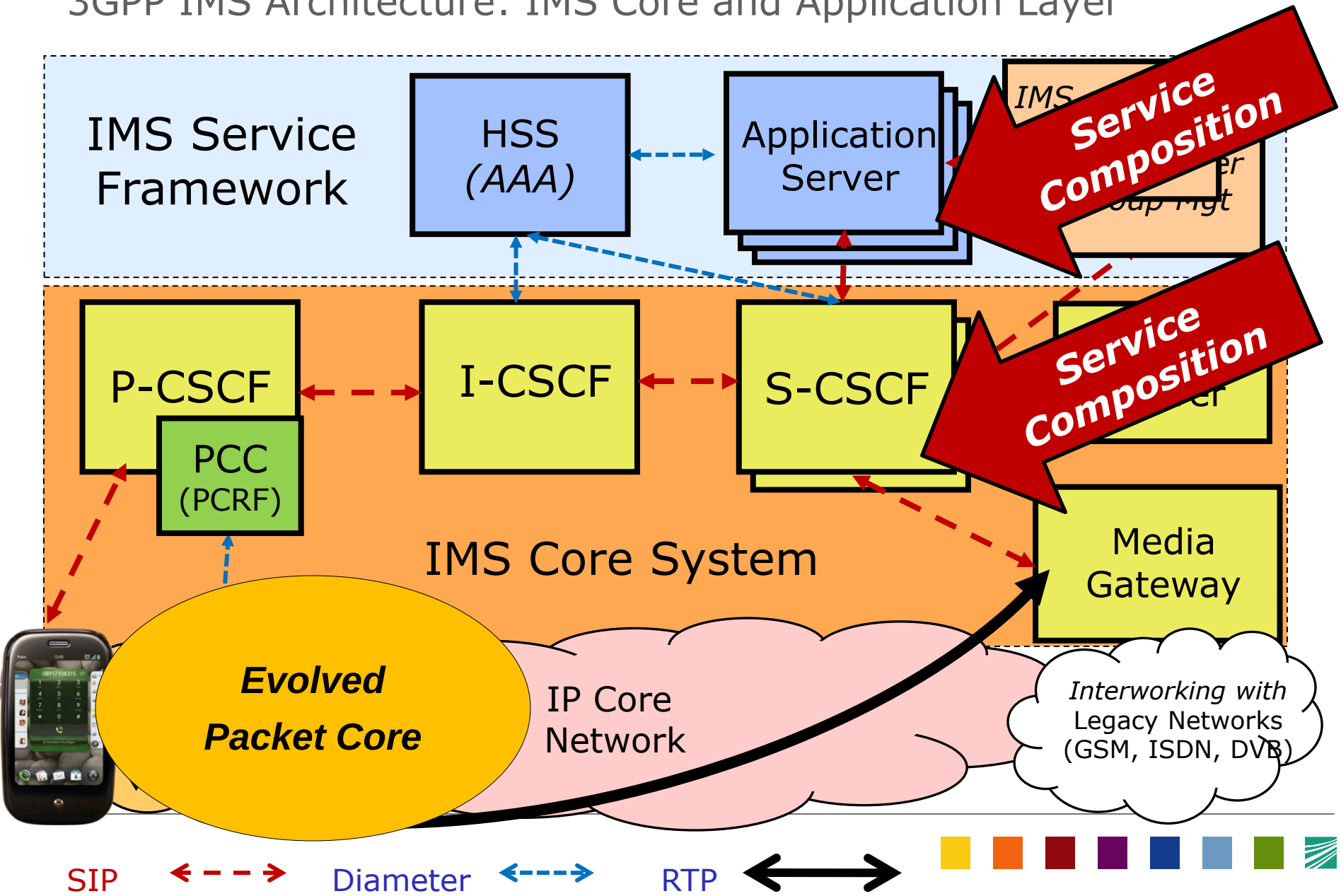
IMS over GPRS/UMTS plus Policy Control and Charging (PCC)



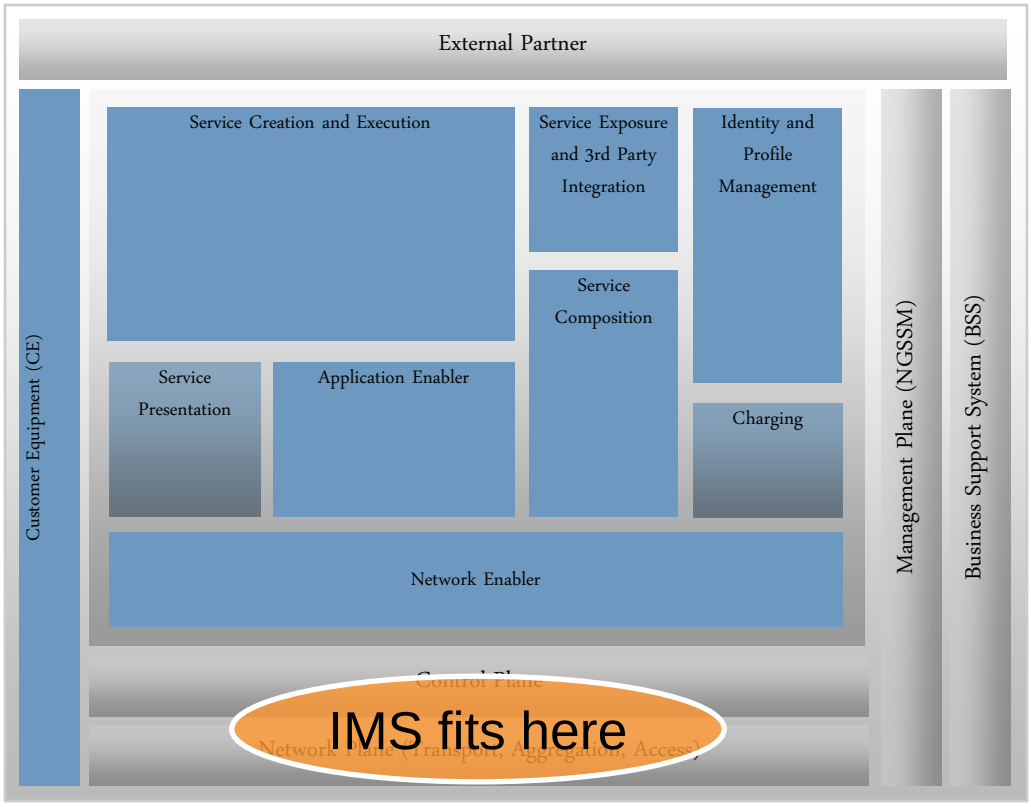
IMS over GPRS/UMTS plus EPC Architecture



3GPP IMS Architecture: IMS Core and Application Layer



Service Architectures Evolution: Network abstraction
Focus shift from Network to Application Plane

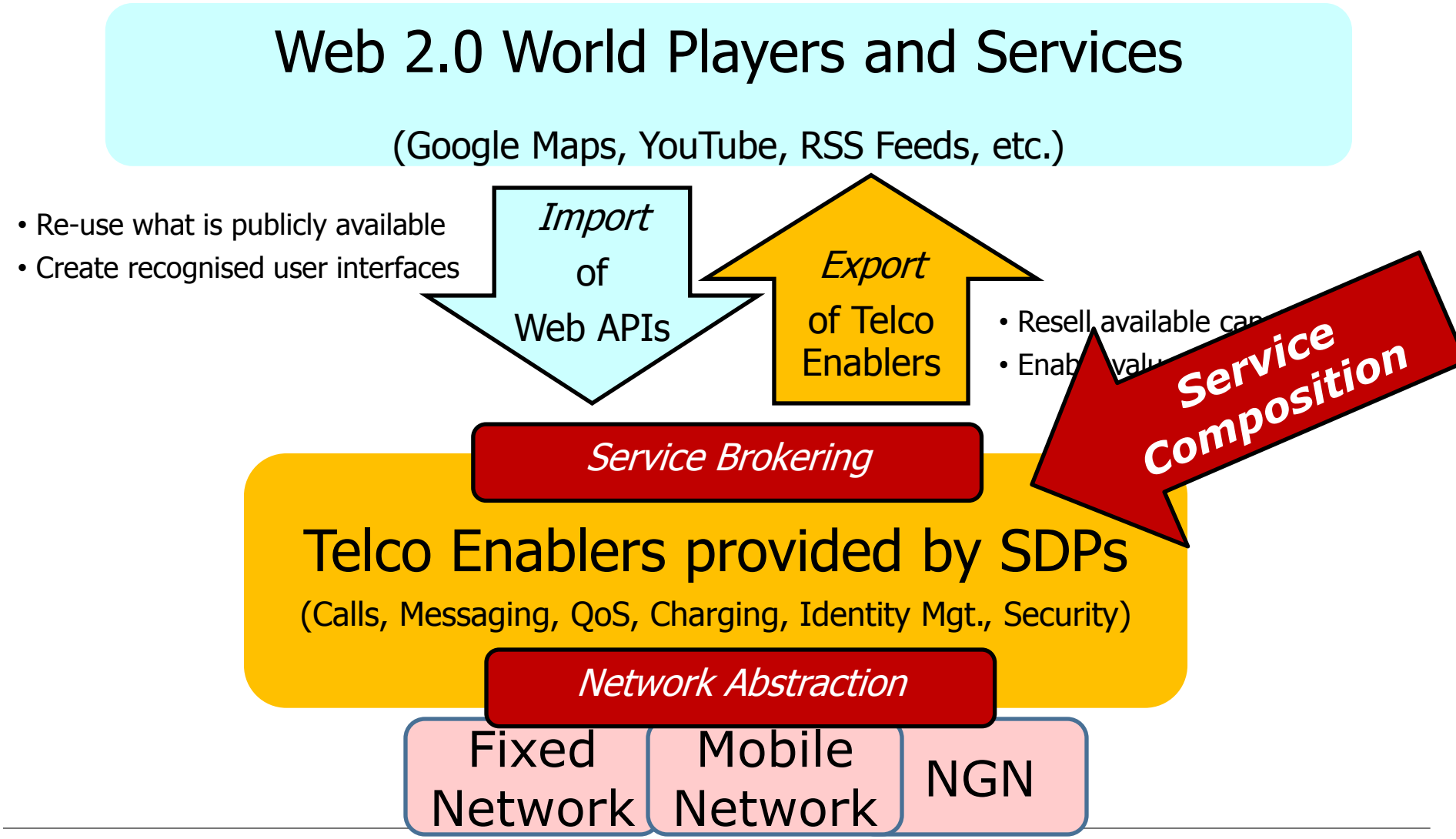


The service architecture of the application plane is the focal point of current operator investigations

In particular, architectural consideration is on:

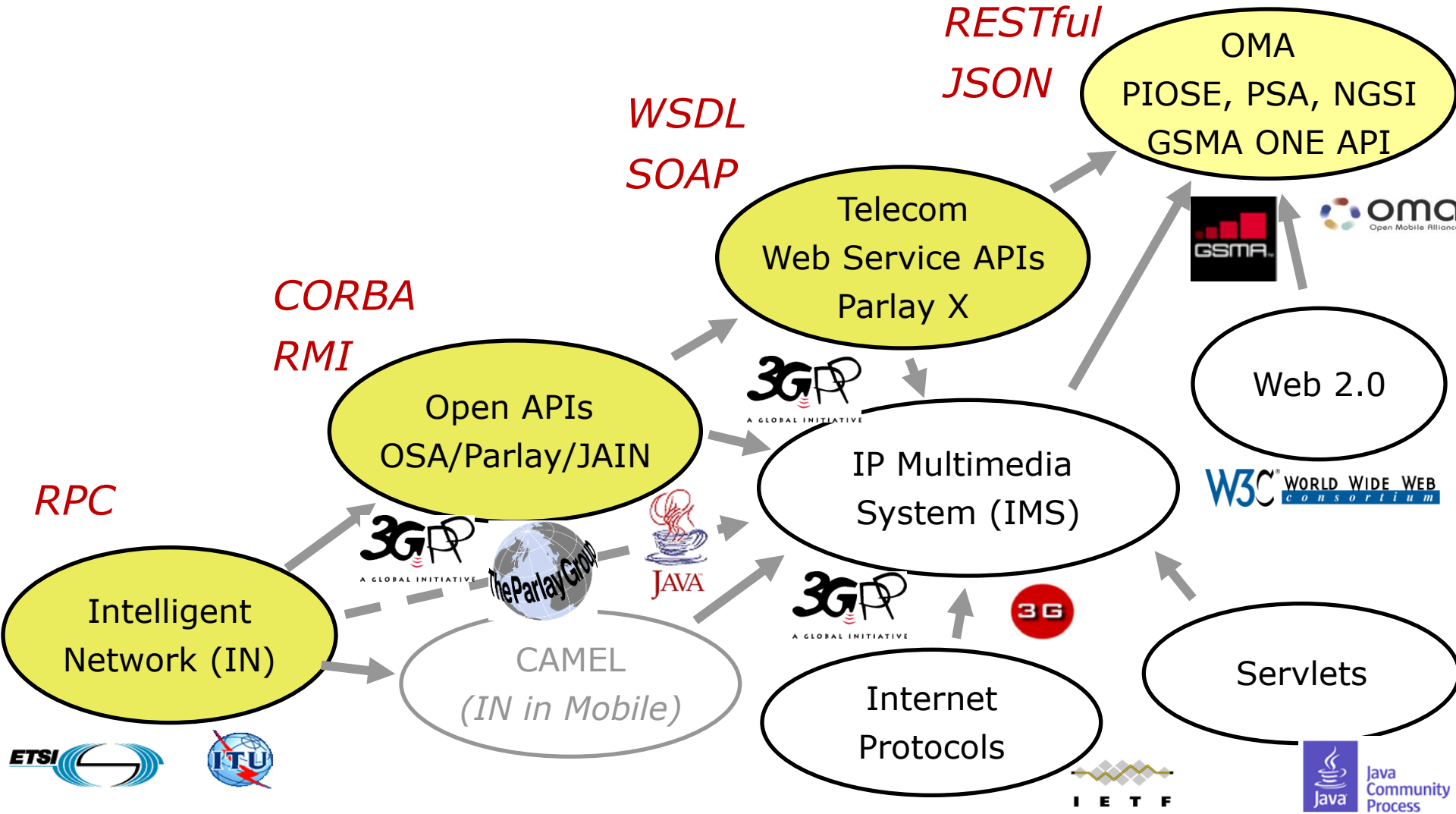
- Enabling bidirectional services to and from 3rd parties.
- shaping the enabling services portfolio.
- supporting user centricity and leveraging customer equipment for service deployment and visibility.

Open Network APIs: Import and Export of „Services Enablers“



SDP = Service Delivery Platform

Evolution of Network API Concepts in Telecommunications



Service APIs

GSMA One API (network API)	OMTP BONDI (device API)	JSR 281 (device API)	JSR 325	OMA PSA
Service APIs				
- Messaging - Location - Charging - Connection - Presence - Call & Conference - Subscriber Info - User Data (Profile, Contacts, etc)	APIs to native apps for - Messaging (SMS, MMS) - Call - Gallery - Camera - Location (GPS) - PIM - Personal Data Storage - Application settings - user interaction - Phone status - Application invoke - Communication Logs	IMS client core framework for • Capabilities • Messaging (pager-mode) • Publication • Subscription • Session (chat, call, video)	IMS communication enabler: • Chat • Conference Chat • Pager-mode / Large message mode • File Transfer • Communication Log • Presence Information Mgt. with Location • Group List Mgt • XDM client	Parlay X Services: - Messaging (in/out) - Call (in/out) - Location (out) - Presence (in/out) - Address list mgt. - Multimedia Multicast Session - Payment - ...
Interface Technology				
RESTful and Web Service APIs	JavaScript API	Java Interfaces API	Java Interfaces API	Web Service and diverse other API's

Service API Matrix

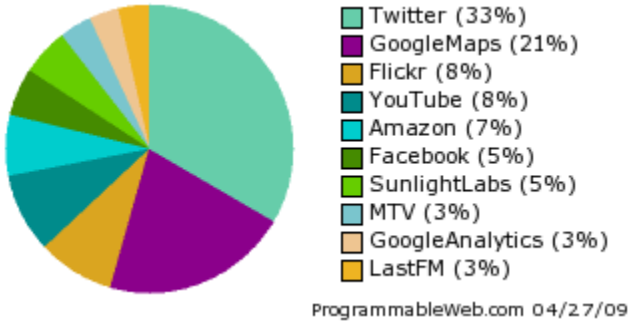
	GSMA One API	OMTP BONDI	JSR 281 & JSR 325	OMA PSA	Ribbit
Messaging	X	X	X	X	X
Call & Conference	X	X	X	X	X
Presence	X	-	X	X	X
Event Subscription	X	-	X	X	X
User Data (Profile, Contact list)	X	X	X	X	X
Charging	X	-	-	X	X
Location	X	X	-	X	-
Communication Logs	X	X	X	X	X
Multimedia multicast	-	-	-	X	-
Security	X	-	-	X	X
PIM (Calendar, tasks, notes, device contacts)	-	X	-	-	-

Open API Comparison

	GSMA One API	OMTP BONDI	JSR 281	JSR 325	Ribbit	OMA PSA
Reference Impl	YES	YES	YES	Not Yet	YES	NO
Interfaces	RESTful and Web Service APIs	JavaScript	Java Interfaces	Java Interfaces	REST / Flash API	API / Web Service
Level of abstraction	HIGH	HIGH	LOW	HIGH	HIGH	LOW
Domain Integration	Network	Device	Device	Device	Device / Network	Network
Developers	Web and mobile web developers	Web and mobile web developers	Native application enabler developers	Native protocol developers	Web, moblie	Web applications
Openess	Closed	Closed	Open	Open	open	closed
Standard Integration	Interworking with OMTP BONDI		Mobile service architecture (JSR 249)	Mobile service architecture (JSR 249)		Interworking with Parlay X

API Trends in the Internet

- New trend in the WWW to develop distributed services (so called mash-ups) with high-level APIs
- Open Telecommunicaitons APIs may provide communications channel to those services
- Problem: Business concepts are currently uncertain.



	Google	amazon.com	Microsoft	ebay	YAHOO!	AOL	Other APIs
Advertising	21		0				
Answers							
Blogs	18		4				
Bookmarks							
Chat	8		19	23	3	10	
Classifieds	39		5				
Database		5					
Desktop	12		3		12		
Events	31				33		
Hosting		42					
Identity	3		0		3	3	
Mapping	1674		168		128	5	
Music					2		
Office	9						
Payments	6	2		15			
Photo	18		1		436	1	
Presence						0	
Search	75	6	29		120		
Shopping		288		167			
Social	3					4	
Storage		46				0	
Video	368				20	23	
Voice	8			23	3	1	
Widgets	85		4		12		
All	50/2300	16/377	24/219	6/224	34/845	14/49	1278/3916

AOL Instant Messenger
10 mashups listed here
Click the cell for details.

Proprietary APIs in the Market

	BT / Ribbit	Orange	DTAG	Telefonica	SIPGate
Web Services		X	X		
REST	X				
Flash / Flex	X				
JAVA /PHP/ SDK			X	X	
XML-RPC		X			X

	SMS	MMS	Conferencing	Call Control	IM	Address Book	Calendar	Authentication	Localization	Fax
BT / Ribbit				X	X	X				
Orange	X		X	X		X	X	X	X	
DTAG	X			X						
Telefonica	X	X		X (WIMS)					X	
SIPGate	X			X						X

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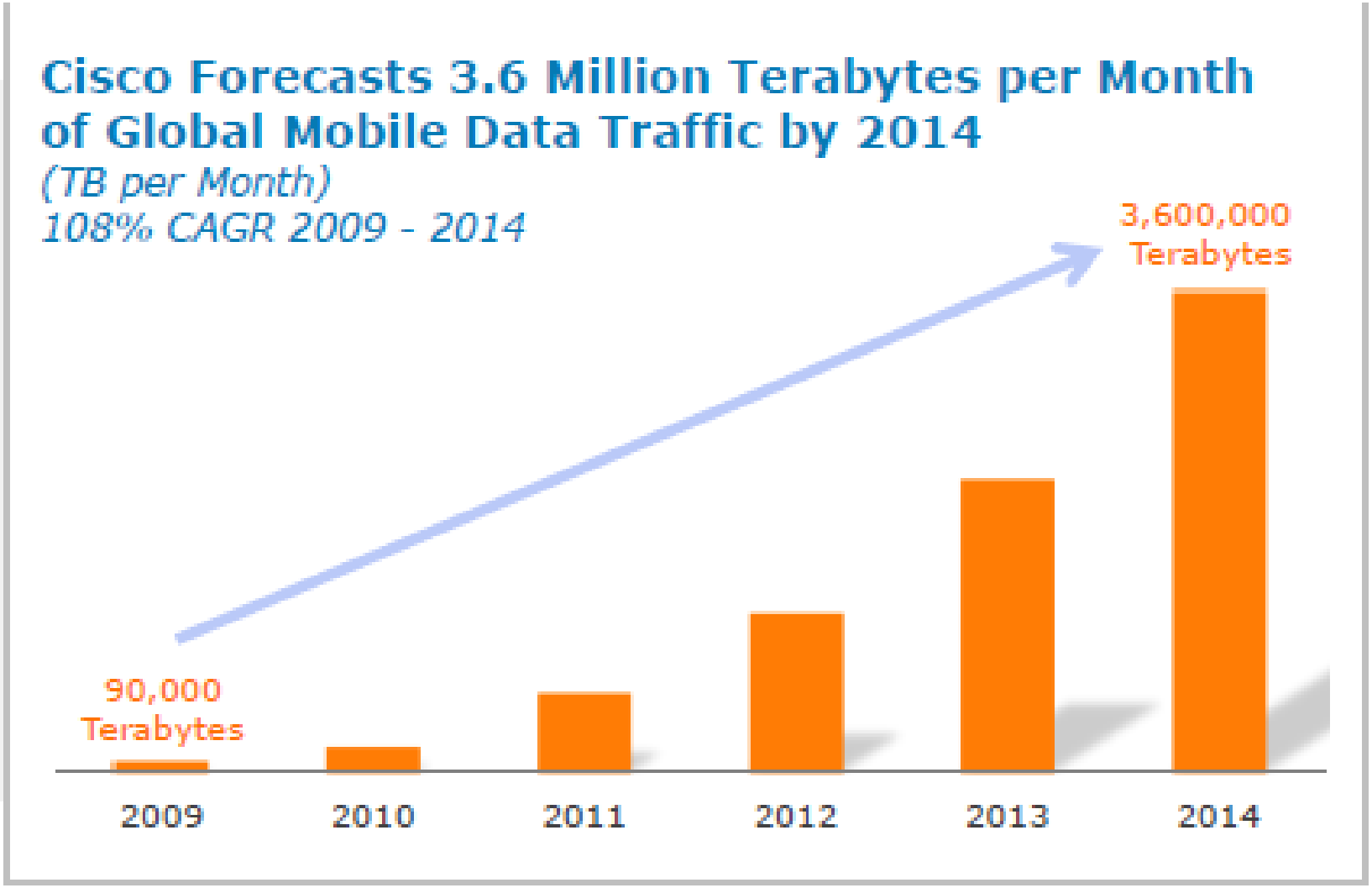
3. Evolved Packet Core (EPC) Overview

- Mobile Broadband Drivers and Challenges
- 3GPP Evolved Packet System (EPS)
- Long term Evolution (LTE) vs. Evolved Packet Core (EPC)
- EPC Standards and Capabilities
- Services above EPC – Operator Services (VoIP, RCS, IPTV, WAC) vs. ABC OTT
- EPC Challenge: Voice Options (CSFB, VoLGA, VoLTE)
- Relating EPC and IMS and SDPs/Open APIs
- Towards EPC as universal all-IP service control platform
- Lessons learned from the Future Seamless Communications (FUSECO) Playground

The World goes Mobile

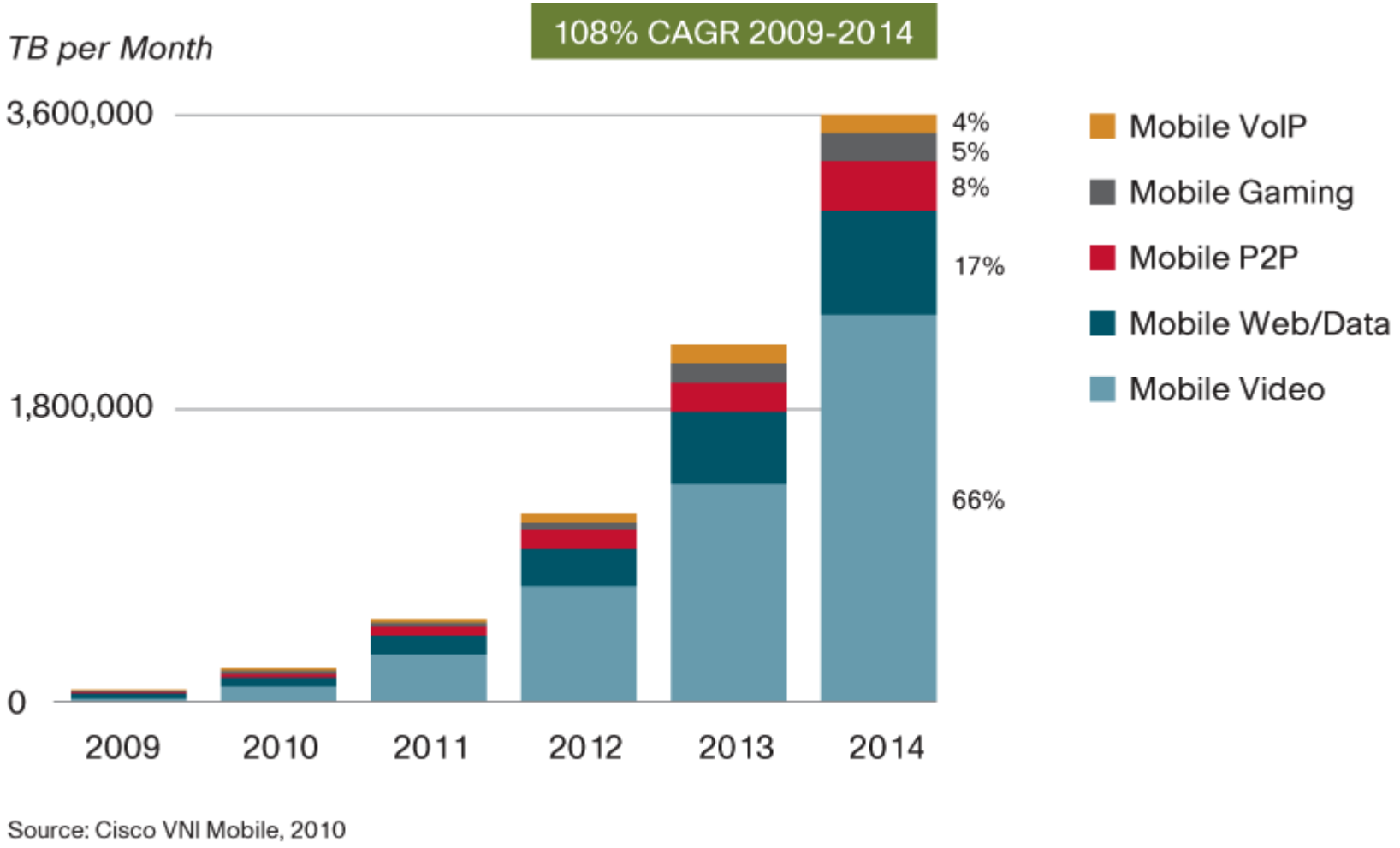
- Dramatical increase of mobile internet devices (smartphones, netbooks, tablets, cameras, ebook readers) demands much more bandwidth
- Machine 2 Machine communications will be likely the next „killer application"
- Wireless Sensors generate an giant data cloud
- The challenges will be to provide the required bandwidth
- 4G Networks, i.e. Longterm Evolution (LTE), are designed to solve the upcoming bandwidth demand in an efficient way
- Global 4G coverage will take 10 years, thus interworking is needed with existing mobile networks, such as WLAN Hotspots, 2/3G, HSPA, etc.
- New control platform provides seamless mobility: *Evolved Packet Core*

Mobile Data Traffic Volume Forecast



Source: Cisco, VNI Mobile, 2010

Mobile Traffic Forecast



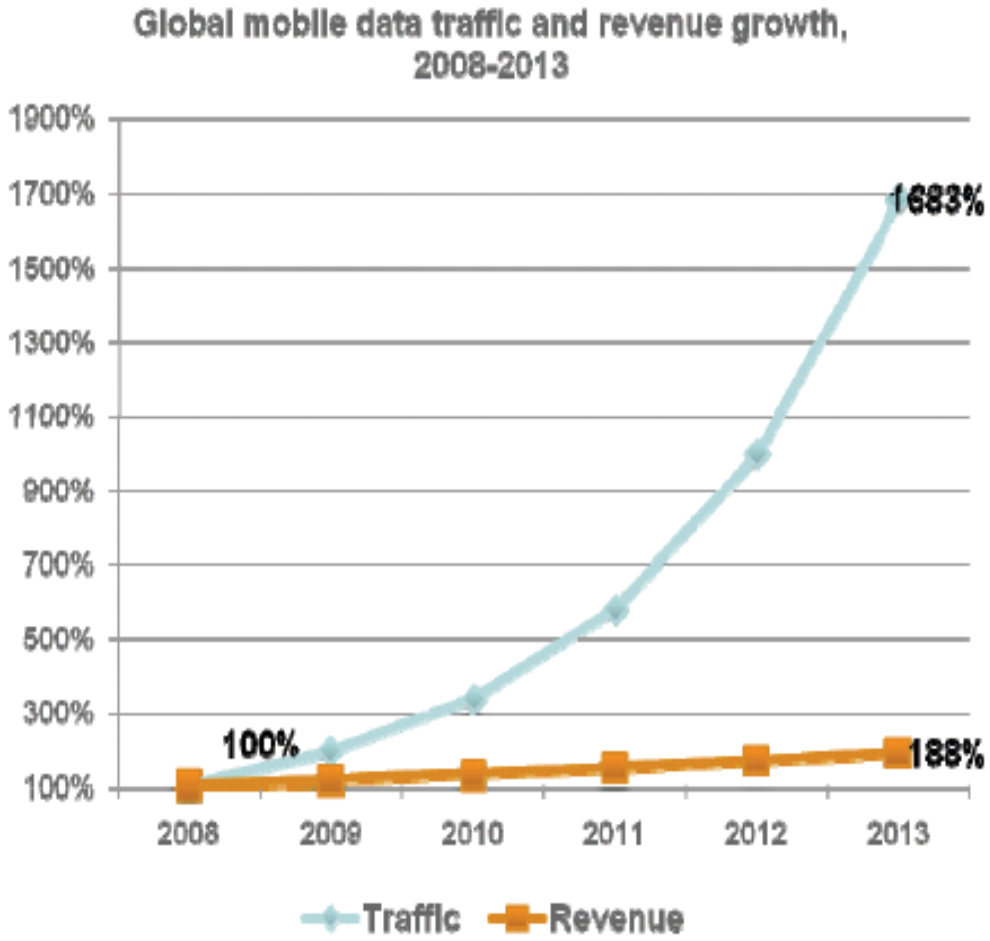
Source: Cisco VNI Mobile, 2010

Expected Mobile Broadband Services (Just Examples ….)

- VoIP alternatives to expensive tariffs
  - e.g., avoiding international roaming charges
- Video/Music on demand while mobile
- Multicast and broadcast service offerings
- Life IPTV (in HD)
- Interactive gaming (graphics, twitch games)
- Downloaded applications
- Larger, multi-media, graphically intensive ones
- High quality/definition audio/video services
- Superior encoding options
- Cloud computing functions and features (all user data is in the cloud)

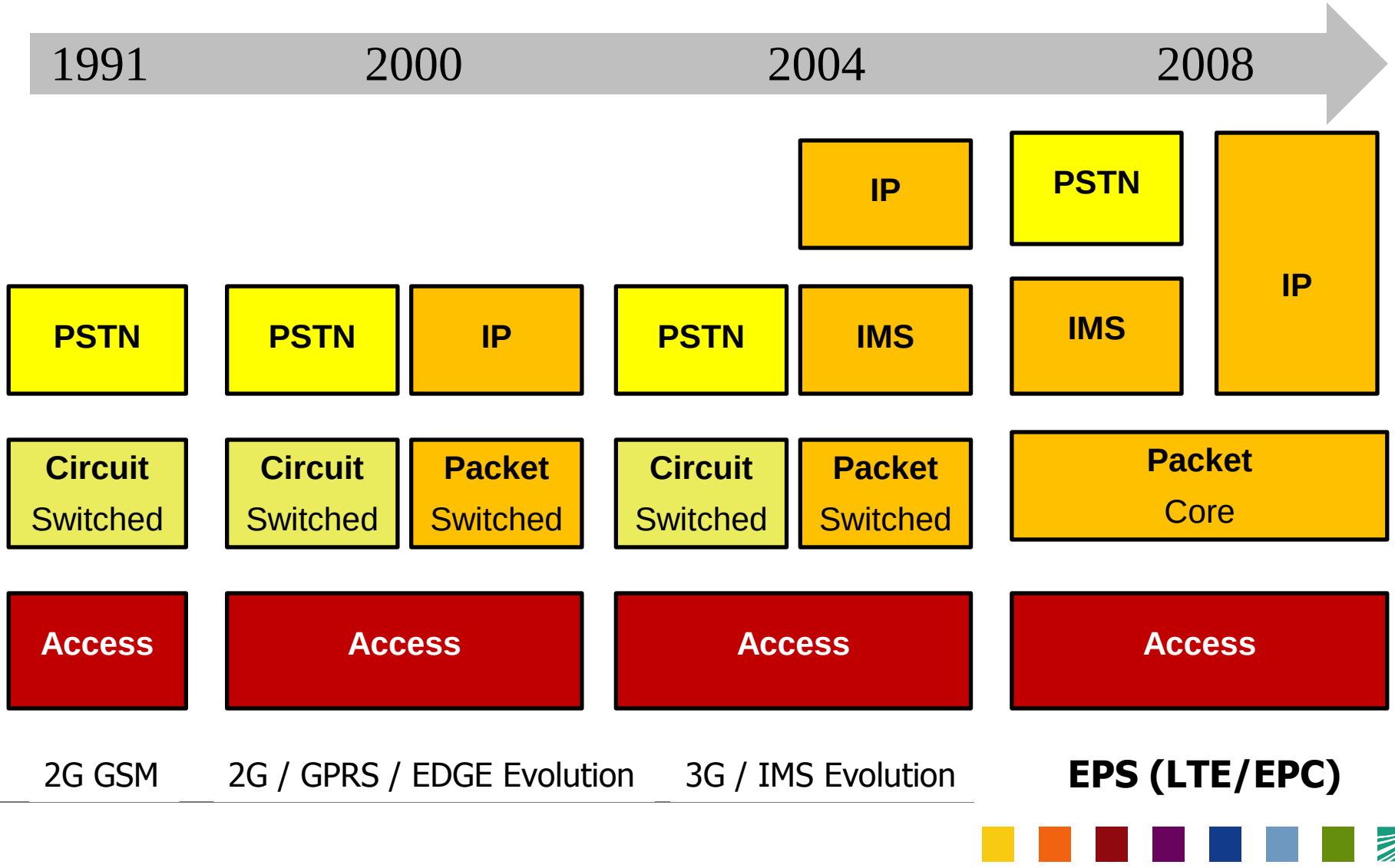
Traffic vs. Revenues Forecast

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



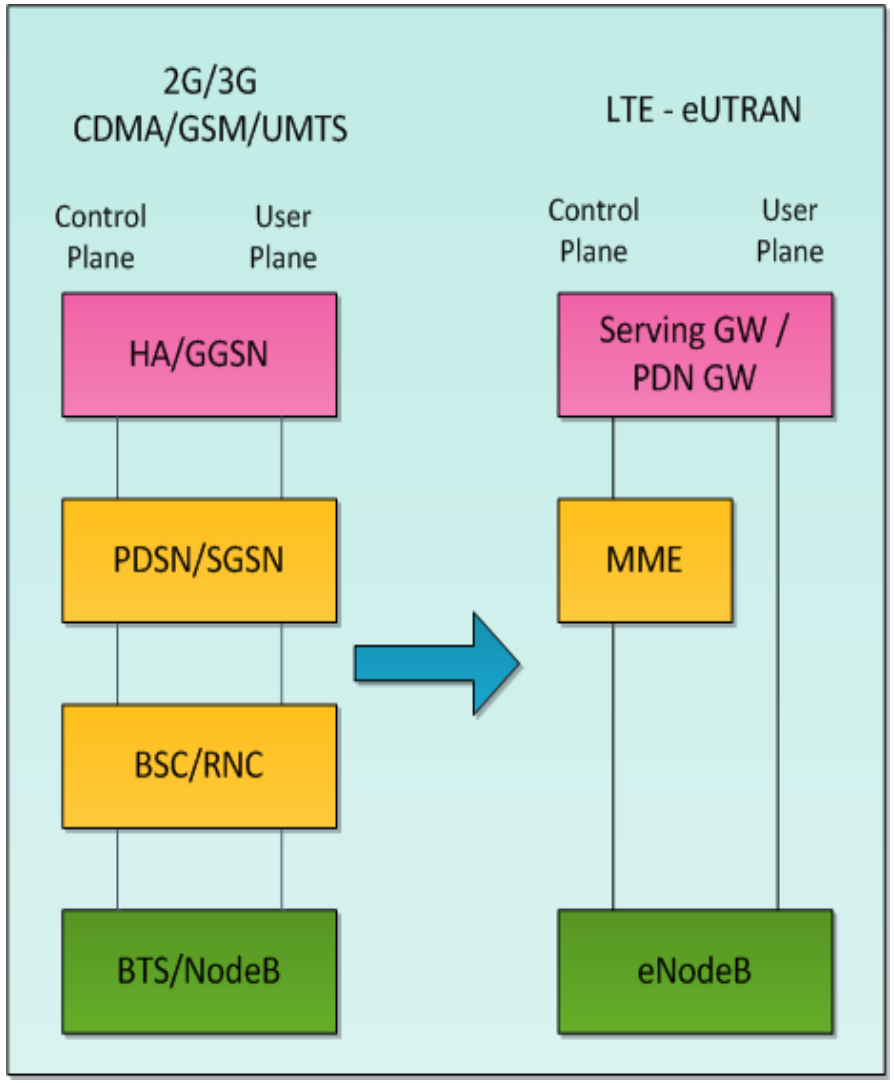
Source: Informa's Global Content & Services Traffic Forecast, 2009

Mobile Network Architecture Evolution



LTE/SAE/EPC – Towards a flat architecture

- System Architecture Evolution (SAE) is the core network architecture of 3GPP's future LTE wireless communication standard.
- SAE / EPC is the evolution of the GPRS Core Network, with some differences:
  - simplified architecture
  - all IP Network only
  - support for higher throughput and lower latency radio access networks (RANs)
  - support for multiple, heterogeneous RANs, including legacy systems as GPRS, but also non-3GPP systems (e.g. WiMAX)
  - mobility between heterogeneous RANs, including legacy systems as GPRS, but also non-3GPP systems (e.g. WiMAX)



Evolved Packet System (EPS)

- 3GPP required a network architecture able to support the characteristics of E-UTRAN
- The study point to generate such network architecture was called the "System Architecture Evolution" (SAE)
- *SAE objective was:*

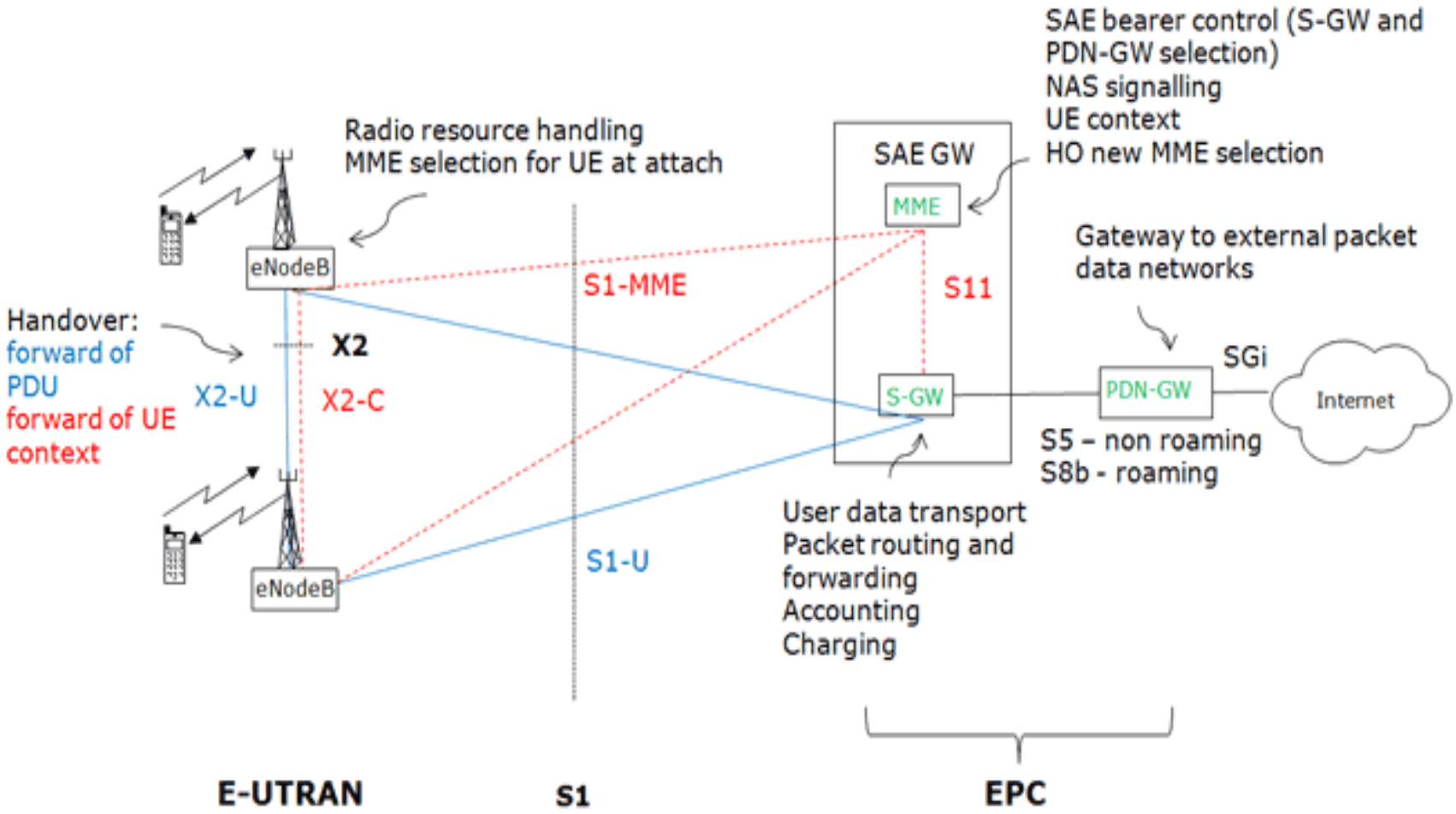
  "to develop a framework for an evolution or migration of the 3GPP system to a higher-data-rate, lower-latency, packet-optimized system that supports, multiple RATs. The focus of this work is on the PS domain with the assumption that voice services are supported in this domain"
- The result of that study is a new simplified All-IP architecture which fulfills the requirements of NGMN Alliance the "Evolved Packet Core" (EPC)
- The Evolved Packet System (EPS) is the term used to refer to the combination of EPC + E-UTRAN
- The EPS is an IP network and uses the standard routing and transport mechanisms of the underlying IP network.

EPS Functional Split between E-UTRAN and EPC

- Target was the enhancement of Packet Switched technology to cope with higher data rates, lower latency, packet optimized system with support for multiple Radio Access Technologies
- This lead to a simplified IP-based overlay architecture with distributed control
- Functionality is divided between E-UTRAN (LTE radio access) and EPC (NAS and IP functionality)

<table>
<tr><th colspan="3">Evolved Packet System</th></tr>
<tr><th>Evolved UTRAN (E-UTRAN)</th><th colspan="2">Evolved Packet Core (EPC)</th></tr>
<tr><td rowspan="2"><u>eNodeB (eNB)</u>
Inter Cell Radio Resource Management, Radio Bearer Control, Connection Mobility Continuity, Radio Admission Control, Dynamic Resource Allocation</td><td colspan="2"><u>Mobility Management Entity (MME)</u>
NAS, Idle State control, Security, EPS Bearer Control</td></tr>
<tr><td><u>S-Gw</u>
Mobility Anchoring for intra-3GPP</td><td><u>PDN-Gw</u>
IP address allocation, Packet Filtering, inter 3GPP mobility anchoring</td></tr>
</table>

3GPP Evolved Packet System (EPS) = E-UTRAN (LTE) + Evolved Packet Core (EPC)



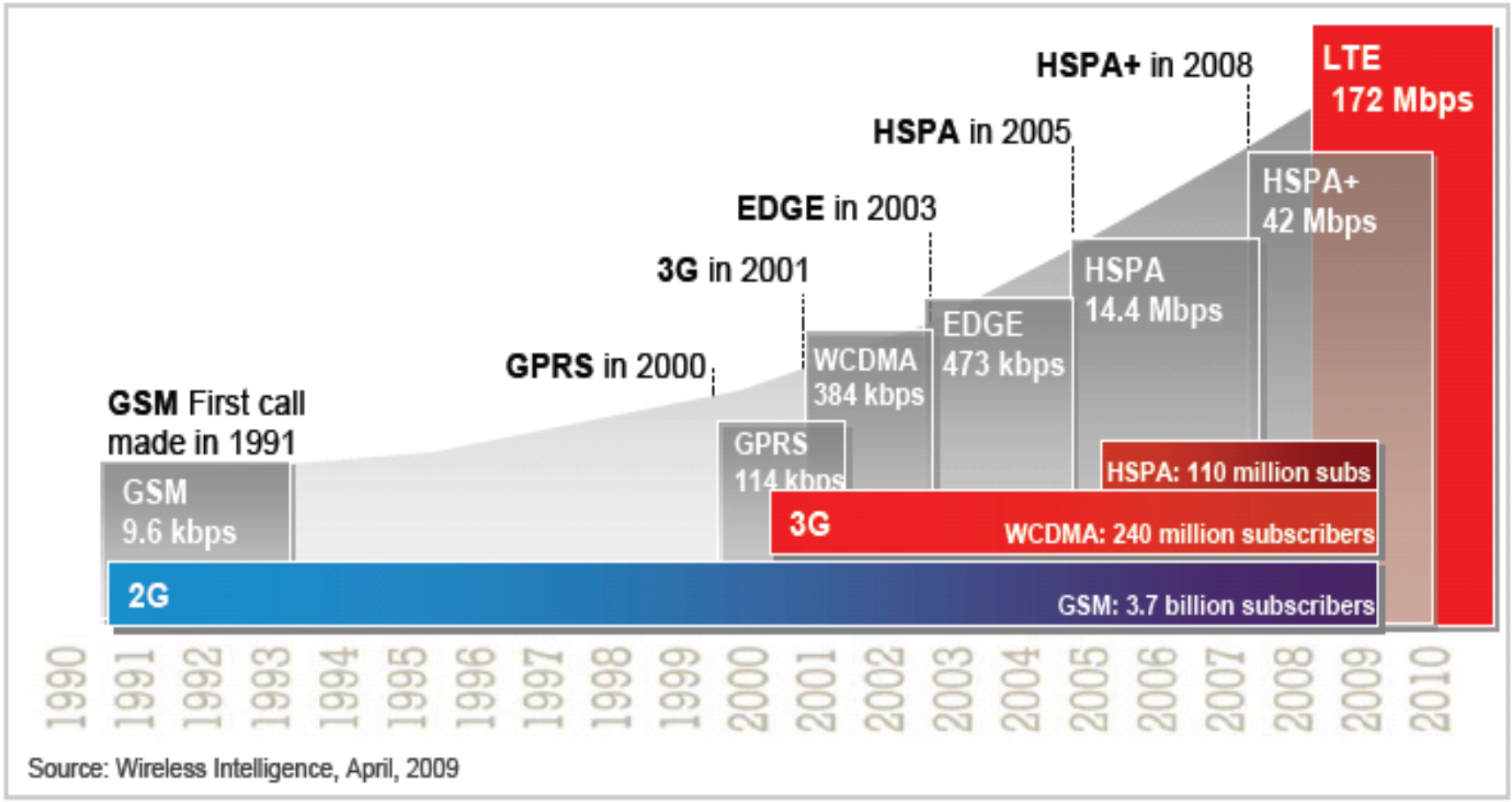
Long Term Evolution (LTE)

- LTE is a mobile communications technology
- LTE brings some major changes to the existing UMTS protocol concepts!
- LTE is focusing on optimum support of Packet Switched (PS) services
- LTE is the successor of UMTS (HSDPA) and is referred to as the **3.9th Generation** of Mobile Networks
- The successor of LTE - *LTE Advanced* - is referred to as 4th Generation
- Concepts for UMTS Long Term Evolution (LTE) have been introduced in 3GPP Release 8 in order to ensure the competitiveness of UMTS for the next 10 years and beyond
- Objective is a high-data-rate, low-latency and packet-optimized radio access technology
- LTE is also referred to as
  - EUTRA (Evolved UMTS Terrestrial Radio Access) or
  - E-UTRAN (Evolved UMTS Terrestrial Radio Access Network)

LTE Main Technical Characteristis

- In contrast to to UMTS (3G) and HSPA/HSPA+ (High Speed Packet Access, 3.5 G) supports LTE much higher data rates:
  - Max. **Downlink-Rates** will be up to **100 Mbit/s** (within a 20 MHz band)
  - Max. **Uplink-Rates** will be up to **50 Mbit/s** (within a 20 MHz band)
- These rates could be increased by the use of high performance modulation techniques (64 QAM) und multi antenna systems (4x4 MIMO) downlink rates of up to **326 Mbit/s** and Uplink rates up to **86 Mbit/s** may be possible.
- In addition, LTE has much lower **latency** of around **10ms round trip delay**.
- LTE uses new multiple access schemes on the air interface:
  - OFDMA (Orthogonal Frequency Division Multiple Access) in downlink and
  - SC-FDMA (Single Carrier Frequency Division Multiple Access) in uplink
- Main requirements for the design of an LTE system were identified in the beginning of the standardization work on LTE and have been captured in 3GPP TR 25.913

Evolution Path of 2G and 3G Technologies



HSPA+ peak theoretical data rate reaches up to 42 Mbps when using single carrier with QAM 64 and 2x2MIMO
LTE peak theoretical data rates reaches up to 172Mbps when using 20MHz channel and 2x2 MIMO

3G vs. LTE

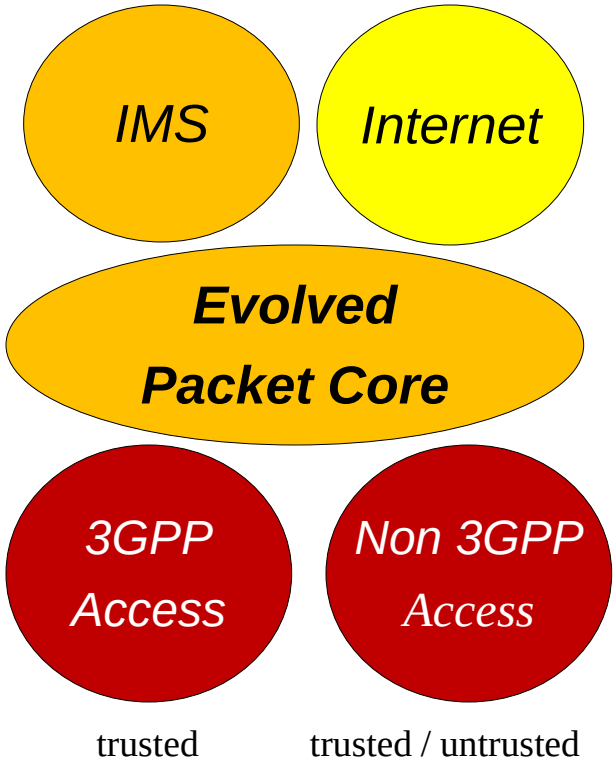
	Existing paradigm (3G)	LTE
Voice	Circuit switched	No Circuit Switched core, all voice is VoIP
Broadband services	Today: Best effort, Limited expensive "broadband"	Real-time, interactive, low latency, true broadband QoS
Multisession data	"Wait until you finish with mini-web browsing or the long conference call, so you can get your push-emails"	All about bearers, sessions, flows: - user-initiated sessions - network-initiated sessions
QoS	No e2e guarantees, only CoS! In theory: up to 8 CoS Practice: 2 - 4 (voice/control, best effort data)	9 QoS, strictly defined parameters, e2e QCI, SDF, bearers (3GPP TS 23.207)
Policy Management	Theory: PCRF introduced in 3GPP R7 Not widely adopted	True network-wide policy control and management (PCRF and PCEF)
Mobility Management	Has always been part of RAN; Mobility has been hidden from core network	- no RNCs (radio mgt. by eNB) - mobility visible and moved to core

Evolved Packet Core (EPC)

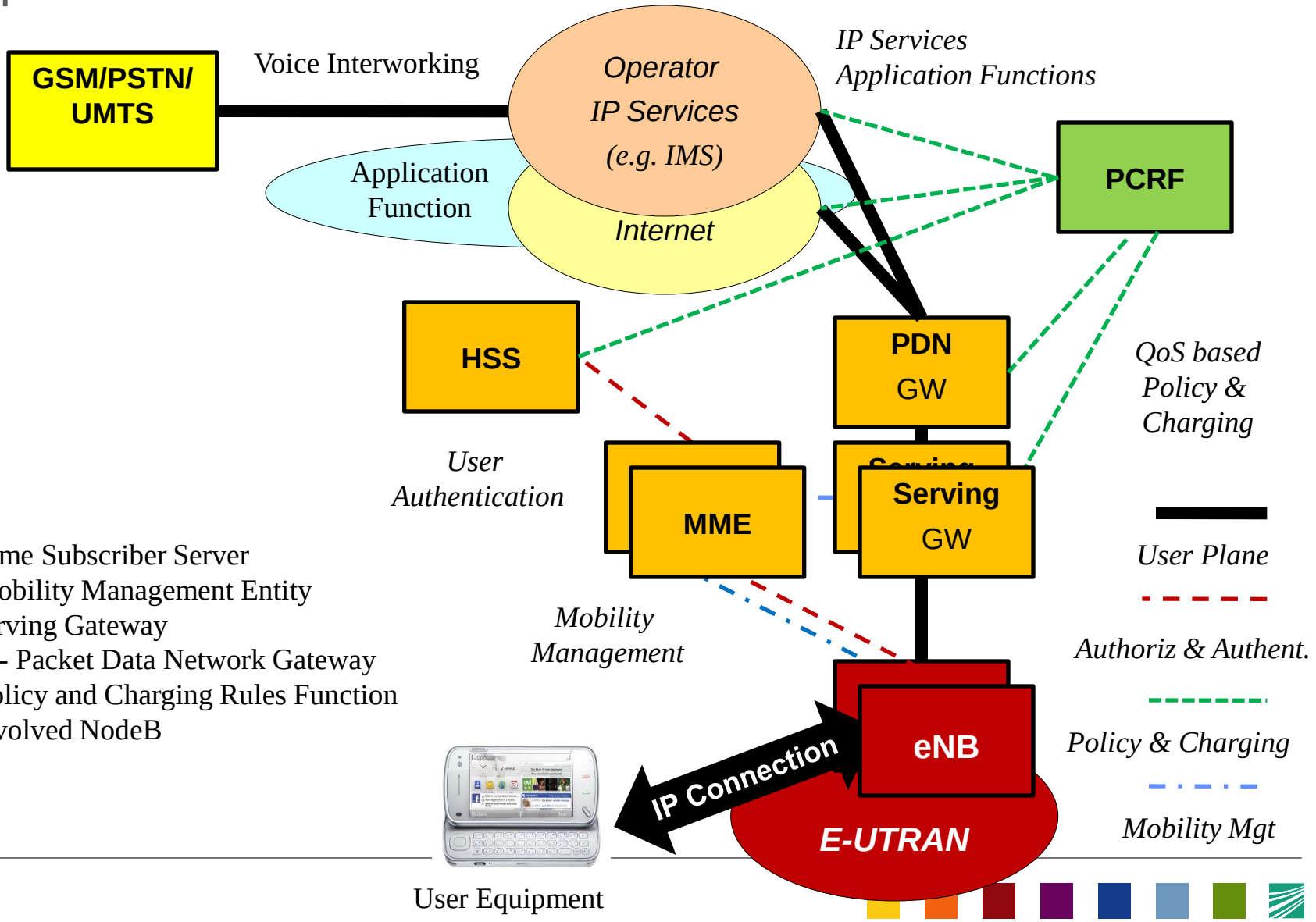
- is an evolution of the legacy GPRS architecture to improve performance and reducing costs
- is the new, all-IP only, mobile core network introduced with LTE in 3GPP release 8
- EPC is motivated by the fact that LTE is just one access network technology, and mobile applications have to interoperate with various access network technologies
- LTE access and EPC overlay form together the **Evolved Packet System (EPS),** formerly known as System *Architecture Evolution (SAE)*
- EPC is based on end-to-end IP only connectivity (no circuit switched connections!)
  - Clear delineation of control plane and data plane
  - Simplified architecture: flat IP architecture with a single core network
  - EPC is based entirely on IETF protocols
- EPC allows the operator to realize a truly converged packet core supporting different wireless access technologies (3GPP and non-3GPP)
- EPC maintains seamless mobility, QoS and unified charging and thus provides the foundation for seamless, consistent and optimized services provision independent of the access network type

Evolved Packet Core (EPC)

- The EPC is a multi-access core network based on the Internet Protocol (IP) one common packet core network for both
  - trusted networks including
    - 3GPP Access (LTE-E-UTRAN, UMTS-UTRAN, GPRS-GERAN)
    - Non 3GPP Access (WIMAX, CDMA2000/HRPD)
  - and untrusted networks including
    - Non-3GPP Access (WLAN)
- EPC provides connection to IP service domains
  - IMS
  - Internet (or others, e.g. P2P etc.)
- Important EPC functions include:
  - NAS and security (AAA)
  - mobility and connectivity management
  - policy QoS control and charging (PCC)



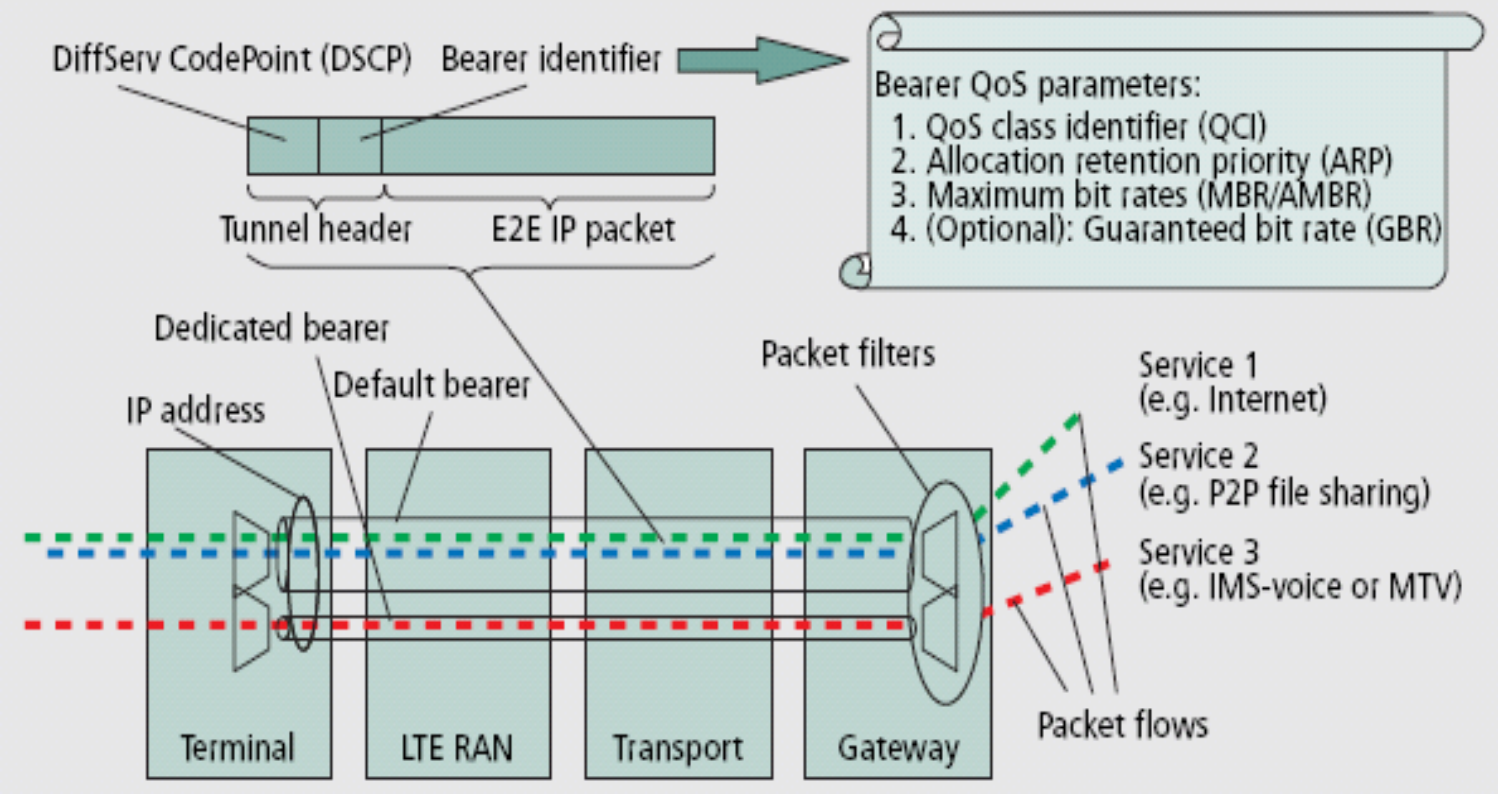
Simplified EPC Architecture



HSS - Home Subscriber Server
MME - Mobility Management Entity
SGW - Serving Gateway
PDN GW - Packet Data Network Gateway
PCRF - Policy and Charging Rules Function
eNB – Evolved NodeB

EPC QoS -Default vs. Dedicated EPS Bearers

- To provide different QoS in the network to two different packet flows for the same IP address of a terminal, one or more *dedicated bearers* are required
- The operator can control which packet flows are mapped onto the dedicated bearer, as well as the QoS level of the dedicated bearer through policies that are provisioned into the network PCRF

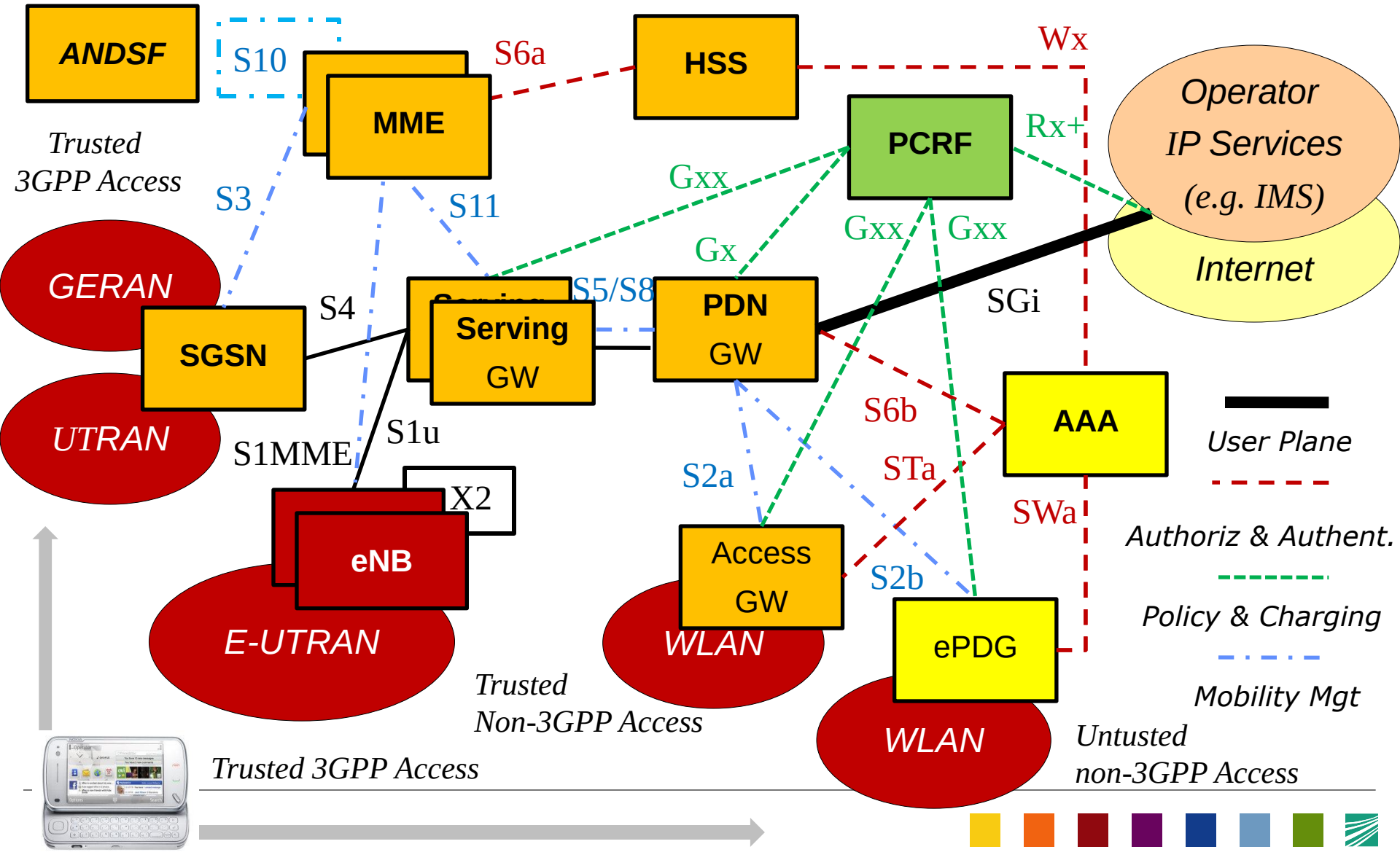


Source: IEEE

EPC Key Elements

- Home Subscriber Server (HSS)
- Mobility Management Entity (MME)
- Serving Gateway (Serving GW)
- Packet Data Network Gateway (PDN GW)
- Policy and Charging Rules Function (PCRF)
- *Application Function (AF)*
- *User Equipment (UE)*
- Additional EPC Components (see later slides):
  - 3GPP AAA Server (for non-3GPP access networks)
  - evolved Packet Data Gateway (ePGW) for untrusted access networks (WLAN)
  - Trusted non-3GPP accesses (Access GW) for WiMax, etc.

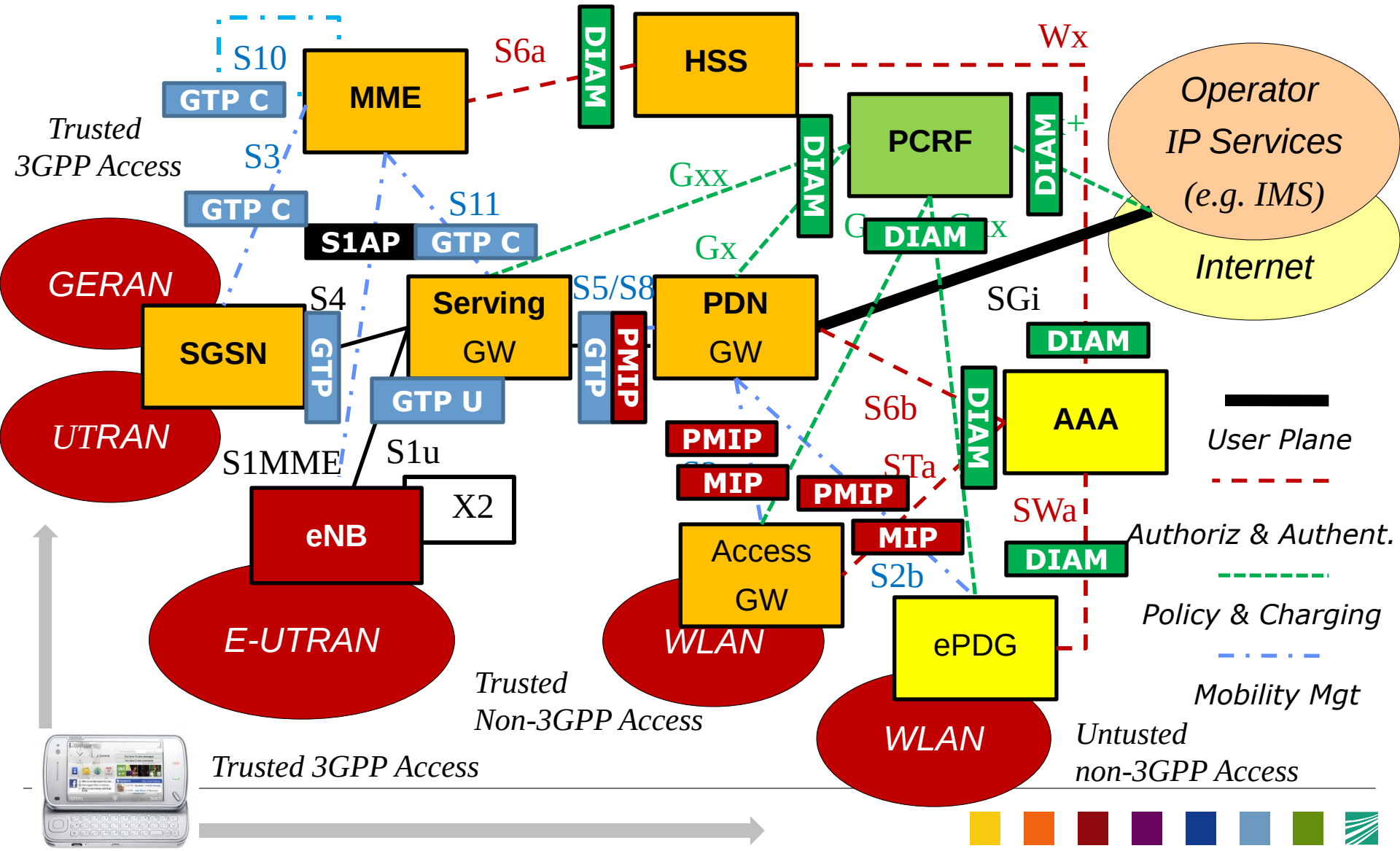
Full EPC Architecture Reference Points



EPC Components

- A number of diverse access networks can be connected to the EPC based on IP technology through different interfaces.
- All 3GPP-specific access technologies are connected through the serving gateway (Serving GW / S-GW), while all non-3GPP specific access technologies are typically connected through the packet data network gateway (P-GW) or evolved packet data gateway (ePDG), which provides extra security functionality for untrusted access technologies (e.g., legacy WLANs with no strong built-in security features).
- The S-GW acts as a mobility anchor for mobility within 3GPP-specific access technologies, and also relays traffic between the legacy serving GPRS support node (SGSN) accesses and the P-GW. For E-UTRAN, the S-GW is directly connected to it through the S1 interface, while the SGSN is the intermediate node when GERAN/UTRAN is used. It is important to mention that a mobility management entity (MME) is also incorporated in the architecture for handling control functions such as authentication, security, and mobility in idle mode.
- For access to EPC through WLAN, CDMA2000 HRPD, or WiMAX, different data paths are used.
  - HRPD and WiMAX are considered trusted non-3GPP accesses and are directly connected to a P-GW through the S2a interface, which is used particularly for *trusted* non-3GPP accesses.
  - On the other hand, a WLAN considered as untrusted access (e.g., because it may not deploy any strong security measures) connects to the ePDG and then to a P-GW through the S2b interface. In this case the ePDG serves as a virtual private network (VPN) gateway and provides extra security mechanisms for EPC access.
- All data paths from the access networks are combined at the P-GW, which incorporates functionality such as packet filtering, QoS policing, interception, charging, and IP address allocation, and routes traffic over SGi to an external packet data network (e.g., for Internet access) or the operator's internal IP network for accessing packet services provided by the operator.
- Apart from the network entities handling data traffic, EPC also contains network control entities for keeping user subscription information (home subscriber server [HSS]), determining the identity and privileges of a user and tracking his/her activities (access, authorization, and accounting [AAA] server), and enforcing charging and QoS policies through a policy and charging rules function (PCRF).

Full EPC Architecture Reference Points & Protocols



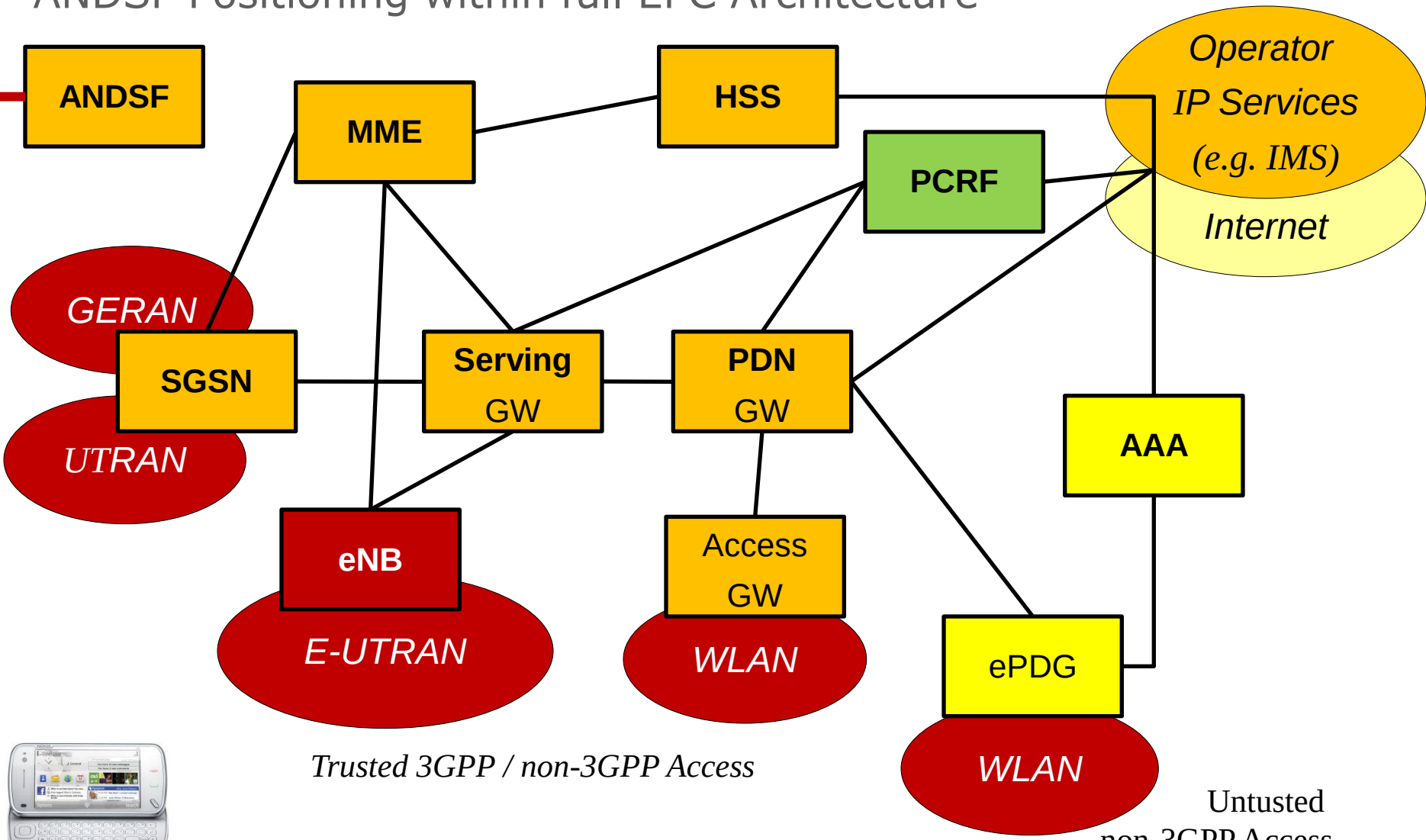
EPC Reference Points

- S1-MME Reference point for the control plane protocol between EUTRAN and MME. The protocol over this reference point is eRANAP/S1-AP and it uses the Stream Control Transmission Protocol (SCTP) as the transport protocol.
- S1-U Reference point between EUTRAN and SGW for the per-bearer user plane tunneling and inter-eNB path switching during handover. The transport protocol over this interface is the GPRS Tunneling Protocol-User plane (GTP-U) over UDP.
- S2a provides the user plane with related control and mobility support between trusted non-3GPP IP access and the Gateway. S2a is based on Proxy Mobile IP. To enable access via trusted non-3GPP IP accesses that do not support Proxy Mobile IP (PMIP), S2a also supports Client Mobile IPv4 FA (MIP).
- S2b provides the user plane with related control and mobility support between evolved Packet Data Gateway (ePDG) and the PDN GW. It is based on Proxy Mobile IP.
- S2c provides the user plane with related control and mobility support between UE and the PDN GW. This reference point is implemented over trusted and/or untrusted non-3GPP Access and/or 3GPP access. This protocol is based on Client Mobile IP (MIP) co-located mode.
- S3 is the interface between SGSN and MME and it enables user and bearer information exchange for inter 3GPP access network mobility in idle and/or active state. It is based on Gn reference point as defined between SGSNs. Is based on GTP-C.
- S4 provides the user plane with related control and mobility support between SGSN and the SGW and is based on Gn reference point as defined between SGSN and GGSN. Is based on GTP-C/-U.

EPC Reference Points (cont.)

- S5/S8 provides user plane tunneling and tunnel management between SGW and PDN GW. It is used for SGW relocation due to UE mobility and if the SGW needs to connect to a non-collocated PDN GW for the required PDN connectivity. Two variants of this interface are being standardized, namely GTP-C/-U and (PMIP) solution. S8 is the inter PLMN variant of S5.
- S6a enables transfer of subscription and authentication data for authenticating/authorizing user access to the evolved system (AAA interface) between MME and HSS. Is Diameter over SCTP
- Gx provides transfer of (QoS) policy and charging rules from Policy and Charging Rules Function (PCRF) to Policy and Charging Enforcement Function (PCEF) in the PDN GW. Is based on Diameter.
- S10 Reference point between MMEs for MME relocation and MME to MME information transfer. Is based on GTP-C
- S11 Reference point between MME and SGW based on GTP-C over UDP
- SGi is the reference point between the PDN GW and the packet data network. Packet data network may be an operator-external public or private packet data network or an intra-operator packet data network, e.g. for provision of IMS services. This reference point corresponds to Gi for 2G/3G accesses
- Rx+ The Rx reference point resides between the Application Function and the PCRF in the 3GPP TS 23.203 and is based on Diameter
- SWa This is the reference point between the Untrusted Non-3GPP IP Access and the ePDG. Traffic on this interface for a UE initiated tunnel has to be forced towards ePDG.

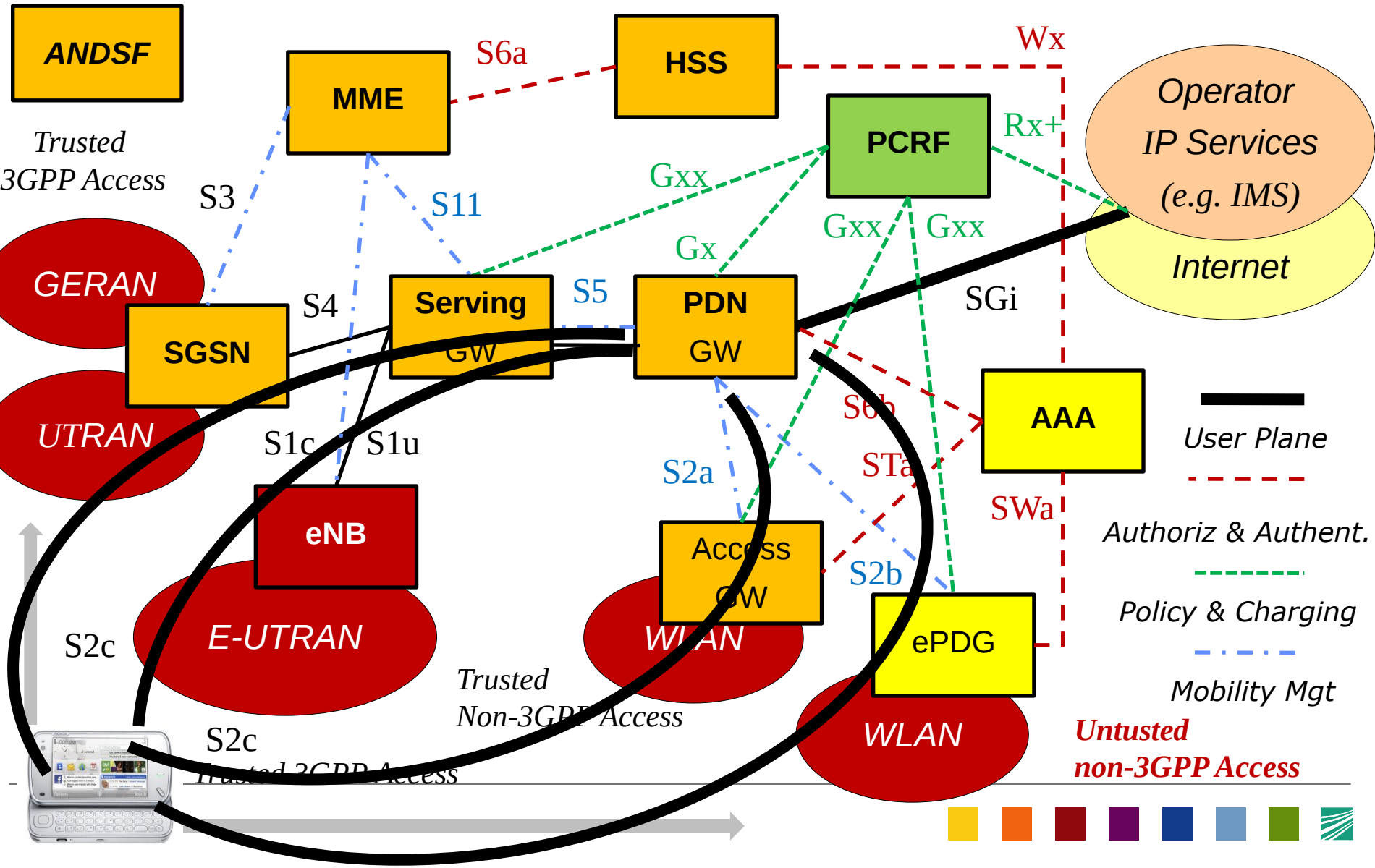
ANDSF Positioning within full EPC Architecture



Access Network Discovery and Selection Function

- The ***Access Network Discovery and Selection Function (ANDSF)*** is a new EPC element in Release 8, which performs data management and control functionality to assist the UE on the selection of the optimal access network in an heterogeneous scenario
- The ANDSF exchanges discovery information and Inter-System mobility policies with the UE
- The specific functionality of this component and its interfaces is being standardized currently in Release 9
- The ANDSF has (for now) interfaces to:
  - S14 to UE *(OMA Device Management over HTTP over TLS over TCP)*

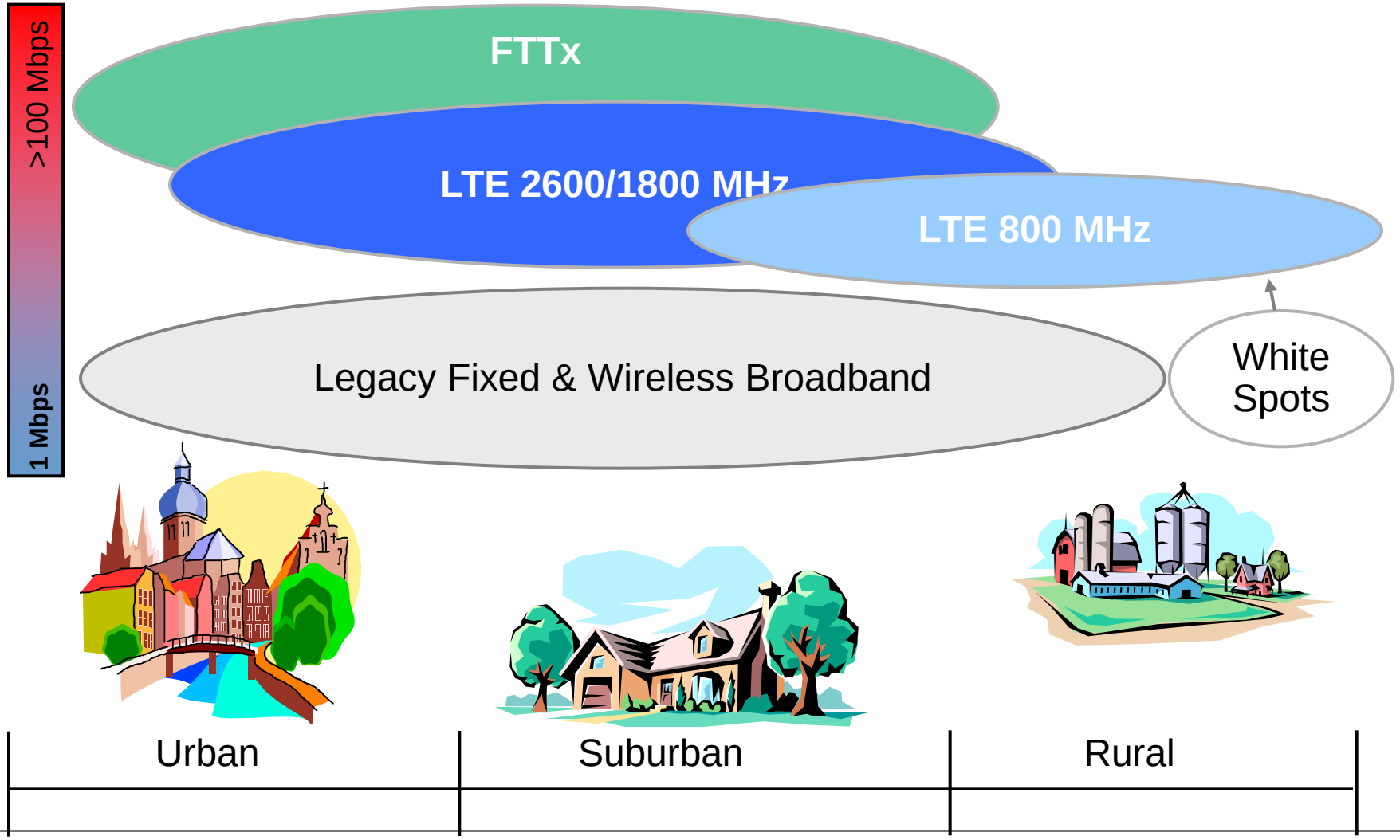
EPC Architecture User Planes



LTE/EPC Applications

- LTE similar to previous mobile data networks, but is **only an all – IP network**!
- Thus no Circuit Switched (CS) voice will be supported! ➔ **VoIP**
- First devices will be USB dongles and chips for notebooks/netbooks
- Due to its high bandwidth and low latency it ideal for ***mobile high quality real time applications***, such as
  - high definition television / video transmission,
  - multi party video conferencing
  - multi party games, etc.
- Its first application will be the provision of DSL access in rural areas within the digital dividend band
- However, its primary goal is cost reduction and efficiency and thus it will primarily support the increasing bandwidth demand from a strongly increasing number of high resolution smartphones and tablet PCs (Ipad & co.)
- Traget application domain will be cloud-based applications

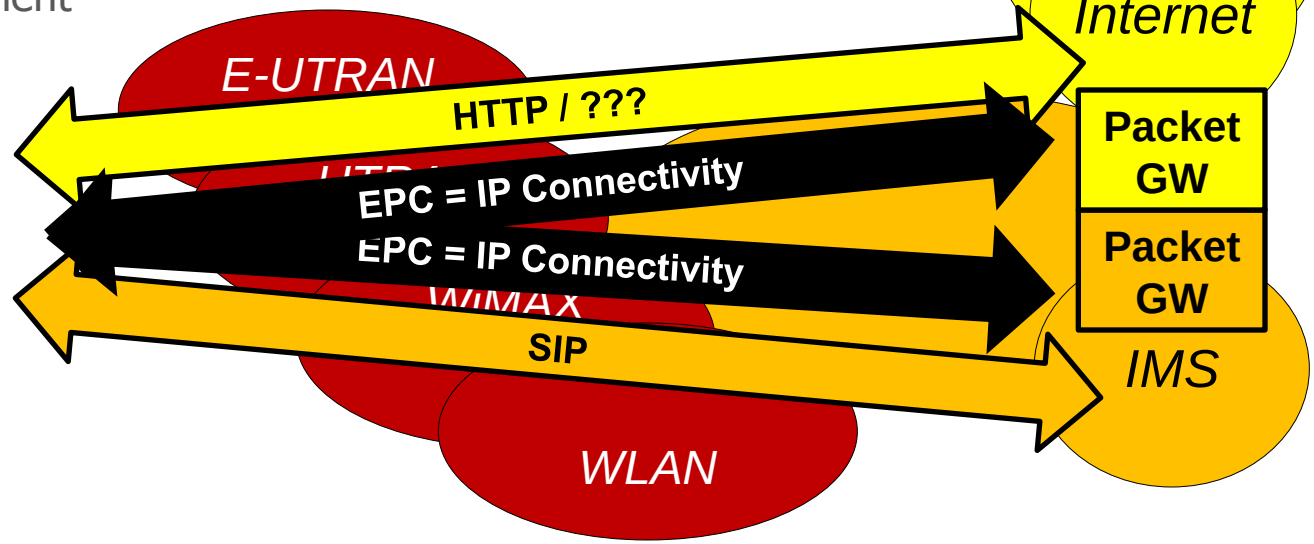
Deployments for Broadband Access



EPC Capabilities = Seamless IP Connectivity (= ABC)

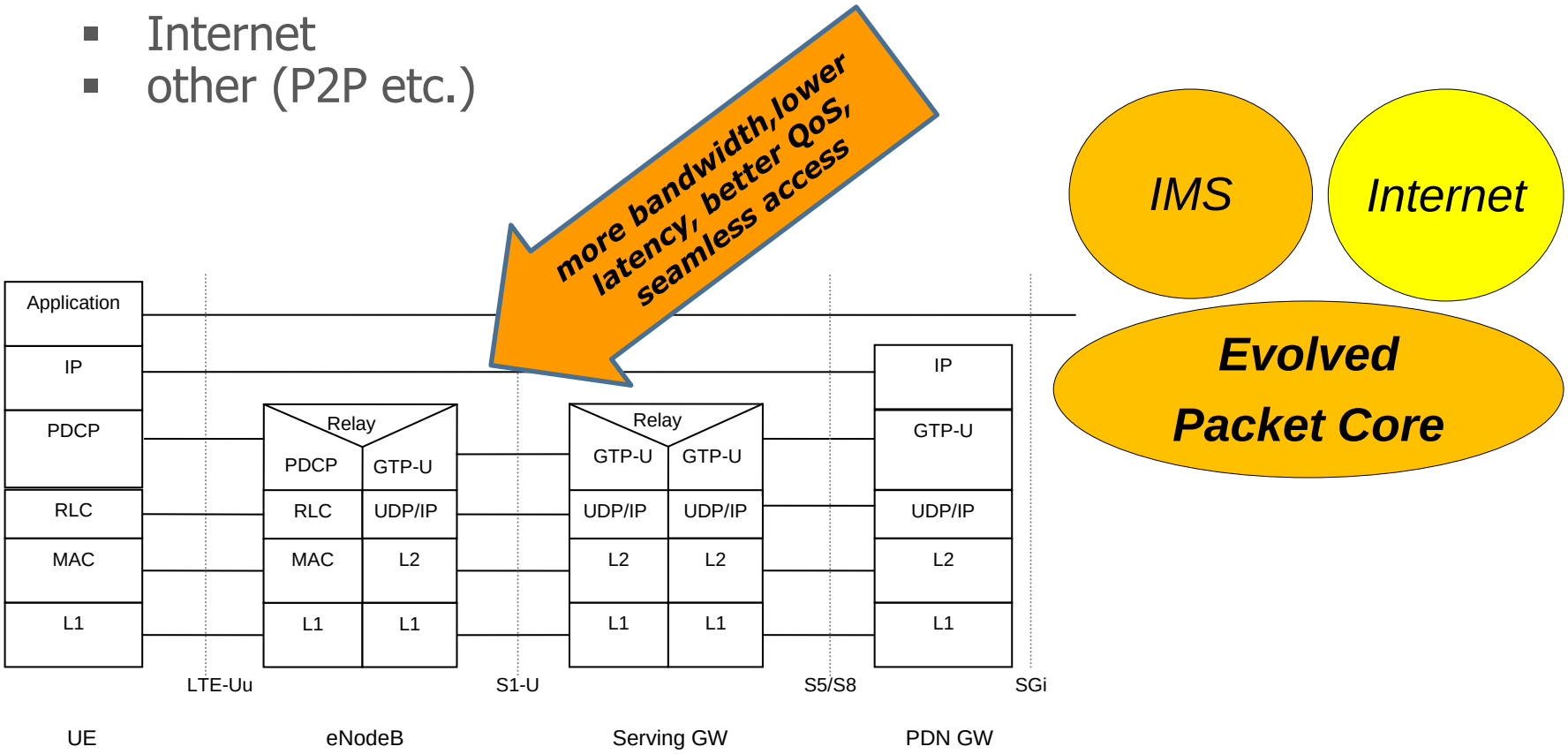
- The EPC allows multiple access networks to be connected in a controlled way (secure, QoS, seamless) to either
  - the operator IP cloud (e.g. IMS or any intranet)
  - the internet or others
- Note that the EPC provides controlled IP connectivity, in regard to
  - User authentication and authorization
  - Quality of Service and related Charging
  - Mobility Management

User Equipment
may be connected to several IP service domains in parallel



EPC connects to IP Service Domains

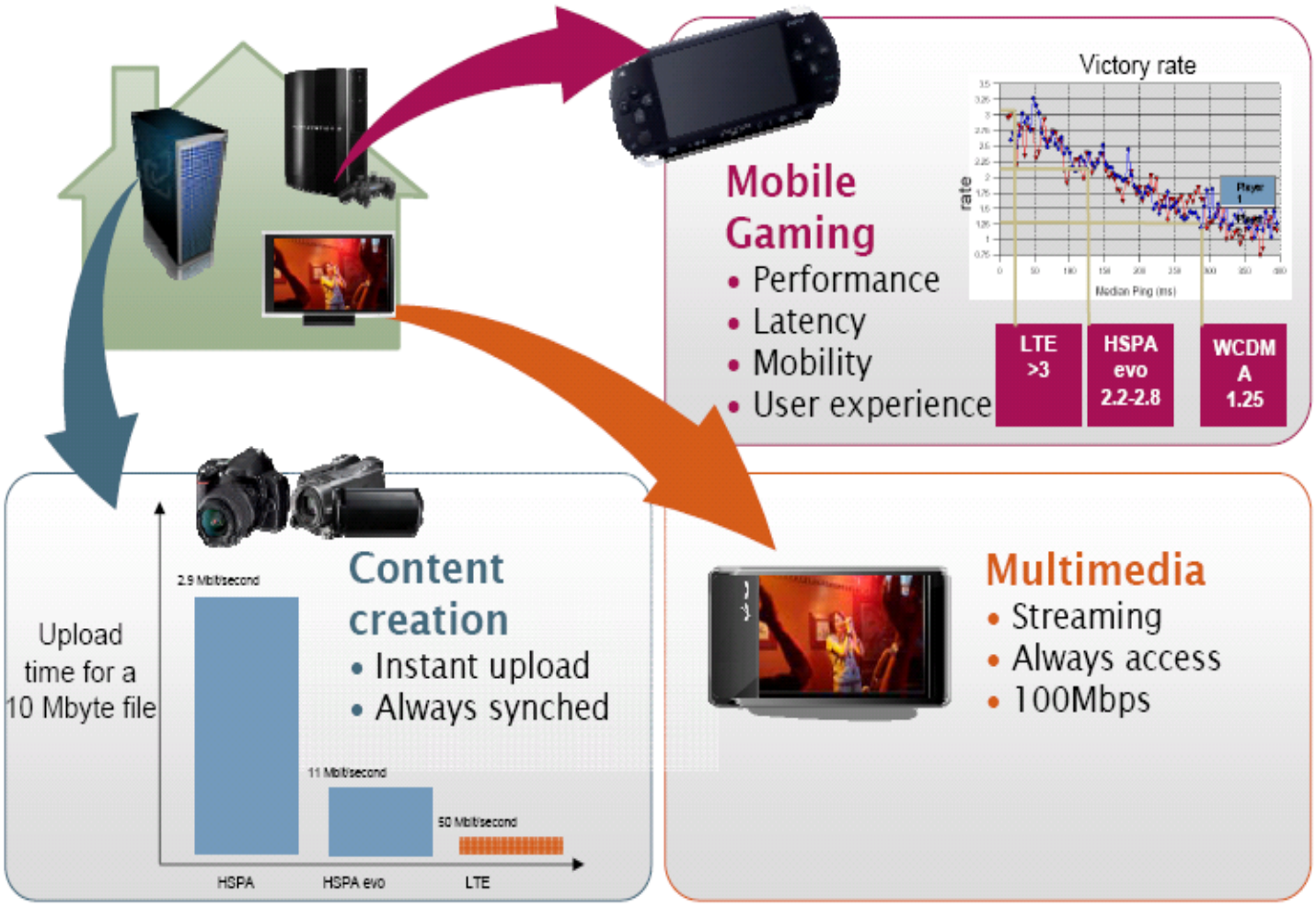
- The EPC provides connection to IP Service Domains
  - IMS
  - Internet
  - other (P2P etc.)



Wireless Broadband enables new services

Source: Alcatel-Lucent

Coming up soon: The Digital Home on the Move



Source: DTAG

Expected Mobile Broadband Services (Just Examples ….)

- VoIP alternatives to expensive tariffs
  - e.g., avoiding international roaming charges
- Video/Music on demand while mobile
- Multicast and broadcast service offerings
- Life IPTV (in HD)
- Interactive gaming (graphics, twitch games)
- Downloaded applications
- Larger, multi-media, graphically intensive ones
- High quality/definition audio/video services
- Cloud computing functions and features (all user data and services is in the cloud)
- Fixed Mobile Convergence (FMC)
- Machine 2 Machine (M2M)

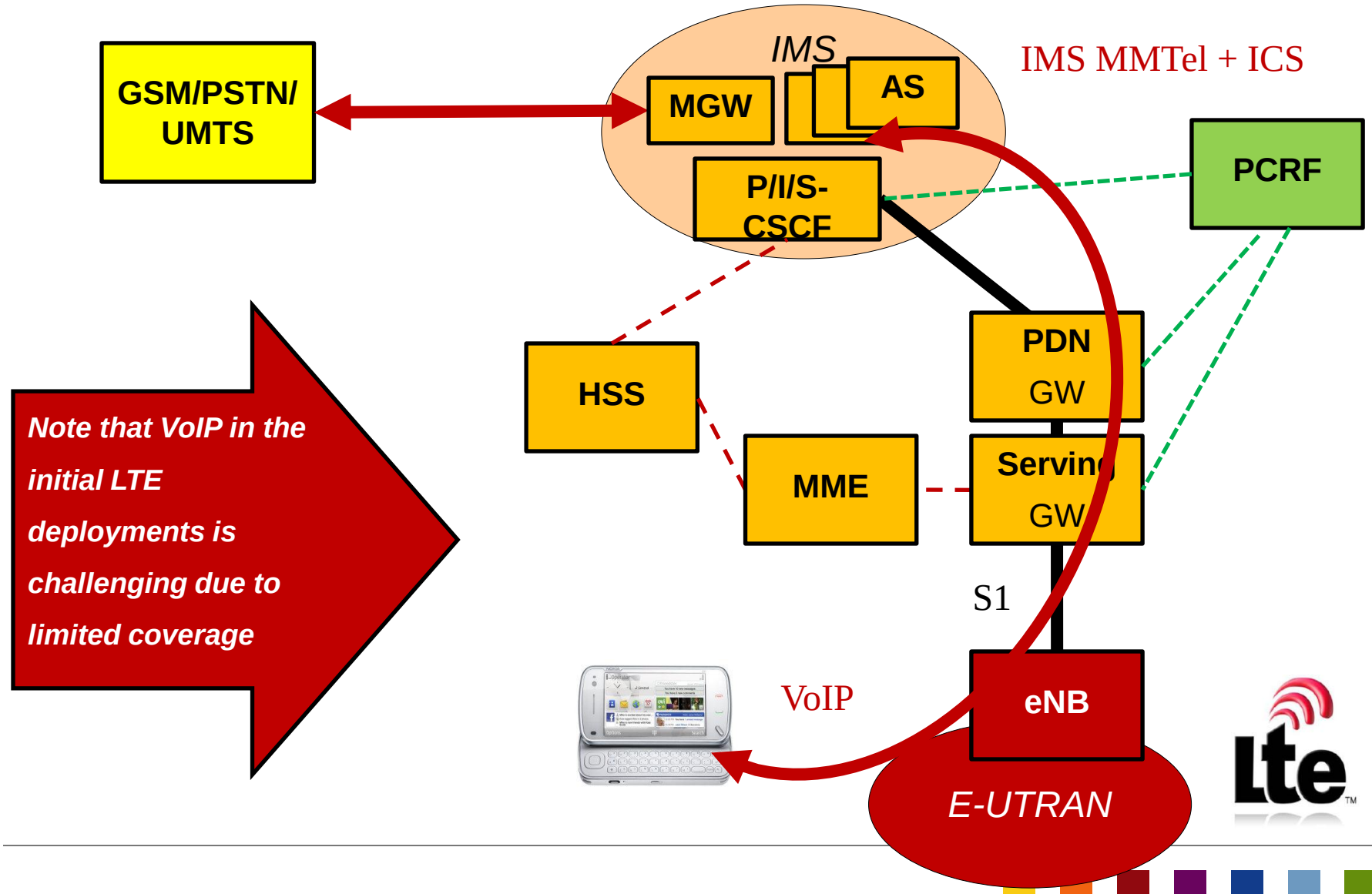
Service Challenges & Opportunities

- LTE technologies will enable new service types and affect previous wireless client/server design tradeoffs
  - iPhone and Co., Netbooks, Full browsers in mobiles, 4G Cameras, Rich Internet Applications, Clouds, Youtube on the road, etc.
- Device evolution and availability and pricing are critical to success of the new models and services
- Latency improvements will result in usable IP options for many circuit switched services (e.g., VoIP/PTT) – but voice will not be offered until 2012!
- Will LTE pave the way for Skype everywhere?
- Business model changes will be as important as service architectures in meeting the potential of LTE
- Smart Bit Pipe Services (QoS and service differentiation) could be an interesting service option
- But network neutrality may be a big challenge!
- Will LTE become eventually only a large highway to Google / Android Apps?

The Challenge: Voice over LTE

- LTE being packet only does not include a solution for how to provide voice calls over the new network
- Such a solution must include also handover to UTRAN/GERAN, as LTE will in the first years only be provided in "islands"
- Thus a pure VoIP solution may not be sufficient in case of UTRAN/GERAN usage
- Several solutions have been proposed but no final agreement has been reached so far
- ***This is the biggest threat for LTE introduction, as LTE may be establish without proper voice offering as a mobile DSL access with associated flat rate pricing!***

IMS VoIP in EPC Architecture



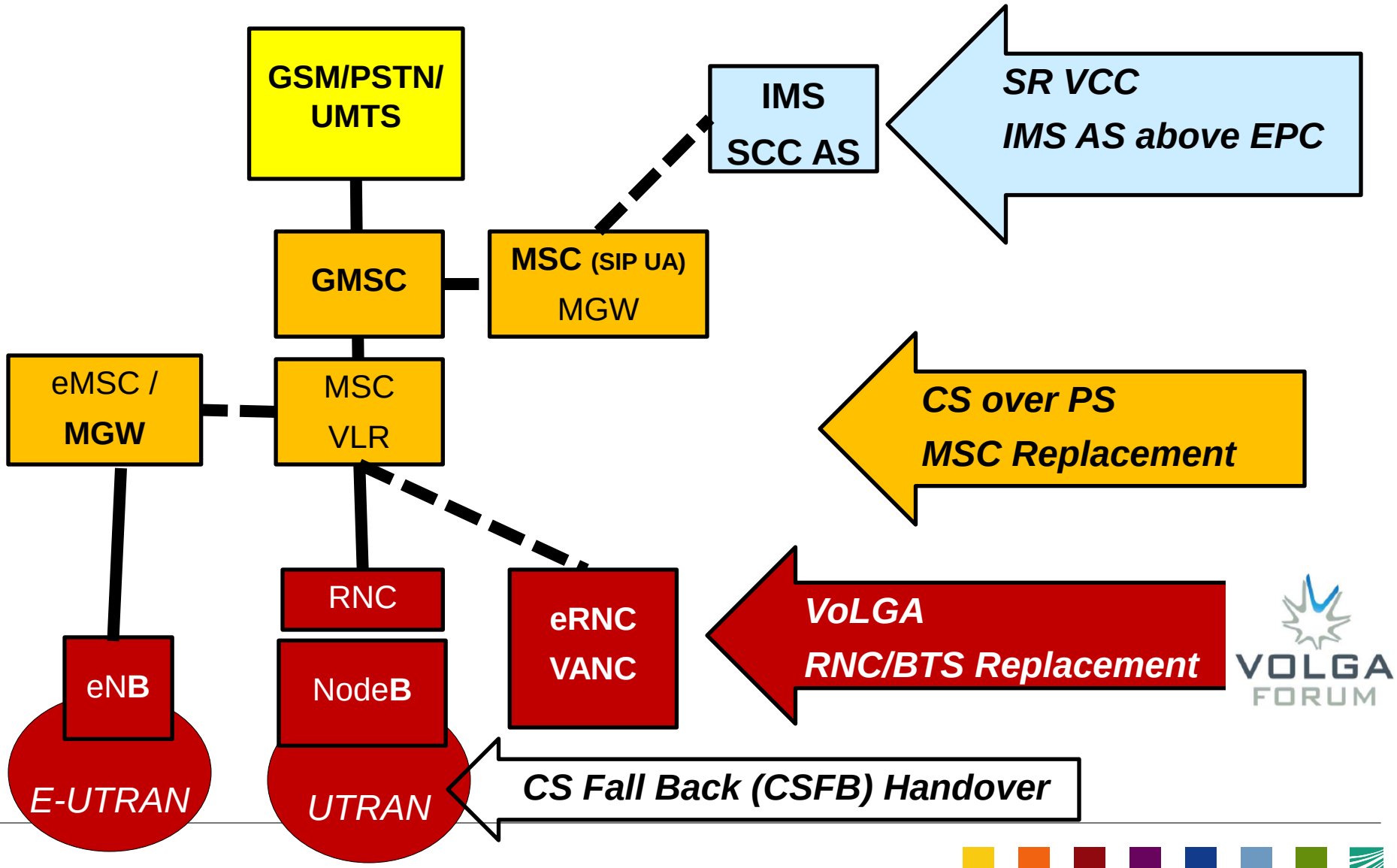
Voice in LTE Options

- LTE being packet only does not include a final solution for providing voice calls over the new network in the near future ;-(
- Several solutions have been proposed and are under discussion:
  - *One Voice Initiative:* A minimal set of requirements for IMS voice service
  - *Voice as part of RCS:* RCS includes the voice call service
  - *Single Radio Voice Call Continuity (SR-VCC)* (3GPP TS 23.216)*:* IMS ICS based call control and handover from LTE to 2G/3G via dedicated IMS AS (SCC AS)
    - *IMS Centralized Services (ICS)* (3GPP TS 23.292)*:* IMS based solution evolved from older device centric Voice Call Continuity (VCC) and MMtel: MSC has to host IMS Client and MGw
    - *MMTel* (3GPP TS 24.173)*:* IMS based solution for providing PSTN supplementary services for VoIP plus multimedia session handling capabilities (RCS)

IMS

  - *Circuit Switched Fallback (CSFB)* (3GPP TS 23.272)*:* all incoming/outgoing voice calls are immediately handed over from LTE to 2G/3G before call setup
  - *CS over EPS* (3GPP TR 23.879)*:* MCS replacement by special EPS AS
  - *Voice over LTE using Generic Access Network (VoLGA)* (www.volga-forum.com) *:* EPS behaves like an RNC or a BSC (CS over IP re-using UMA) ➔ no MSC changes!

Voice in LTE Options (cont.)



Voice over LTE Comparison

Approach	3GPP	IMS	Additional Component		Modified Components	Main Advantage	Main Disadvantage
			Name	Function			
SR-VCC	X	X	VCC AS	Anchor sessions in the IMS domain	MME,MSC,UE	VCC is an existing method, which has been improved for Single Radio	Requires IMS and improvements in MSC and MME
ICS	X	X	SCC AS	Anchor and control sessions	MSC,UE	Handover to 2G, can be used by GSM mobiles as well, Supplementary services Compatible with SR-VCC	Requires IMS and complex AS
MMTel	X	X			UE	Only defines an interoperable way to handle speech sessions for IMS	IMS centric solution

Voice over LTE Comparison II

Approach	3GPP	IMS	Additional Component		Modified Components	Main Advantage	Main Disadvantage
			Name	Function			
CSFB	X				MSC,MME,UE	No support for voice in E-UTRAN under the supposition that it coexists with GERAN/UTRAN	Additional delay, suboptimal option
CS over EPS	X		eMSC	MSC with new interface towards UE and MME AS behavior towards PCRF and PDN-Gw	UE	CS signaling encapsulated over IP towards new eMSC	Not yet completed. Not PS native solution.
VOLGA			VANC	BSC or RNC behavior (A or Iu mode) towards CS, AS behavior towards PS	UE	CS signaling encapsulated over IP towards VANC. Follows the structure of already existing GAN specifications of 3GPP	Not yet 3GPP solution. Not PS native solution
			HOSF	Handover target selection			

Voice over LTE Comparison III

Approach	3GPP	IMS	Additional Component: Function	Modified Components	Main Advantage	Main Disadvantage
One Voice	X	X		One simplified IMS	Simplified IMS which supports only voice; Mature technology Interoperability	Passing directly to a VoIP solution
Voice as Part of RCS	X	X	Application servers for RCS	New AS, UE	Rich Communication Suite increasing the classic services	Depends on the large scale acceptance of RCS

One Voice Initiative

- One Voice Initiative's goal is to bring IMS as a solution for VoLTE
  - "To help industry secure a common standardized IMS voice solution, this specification defines a common recommended feature set and selects one recommended option when multiple options exist for single functionality."
  - One Voice is backed up by the GSMA (in parallel with RCS)

- IMS is considered as suitable basis for VoLTE
  - Simplification of the IMS specifications is required due to its increasing complexity
  - One voice is a minimal set of IMS features to sustain the previous CS domain services over IP

➔ Reducing the cost of the deployment of a voice solution over LTE

One Voice Initiative

- One Voice makes IMS easy deployable in the mobile environment
- However the interworking with the 2G/3G voice is still open

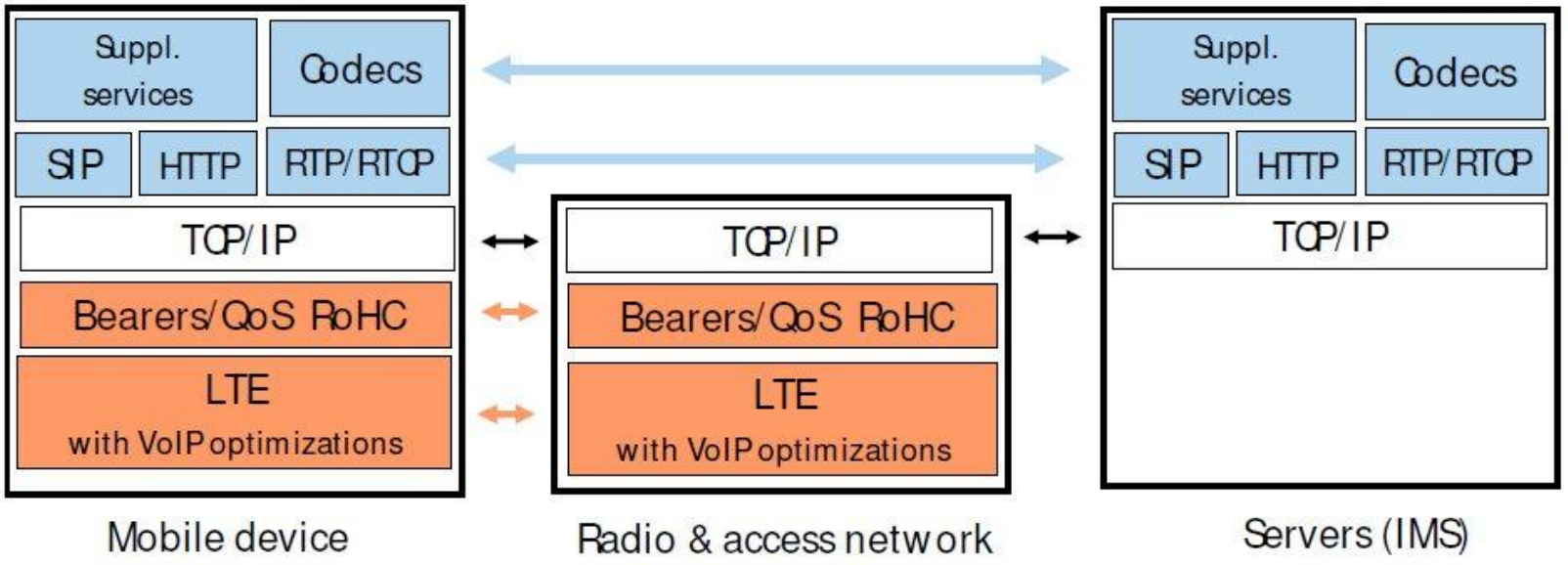
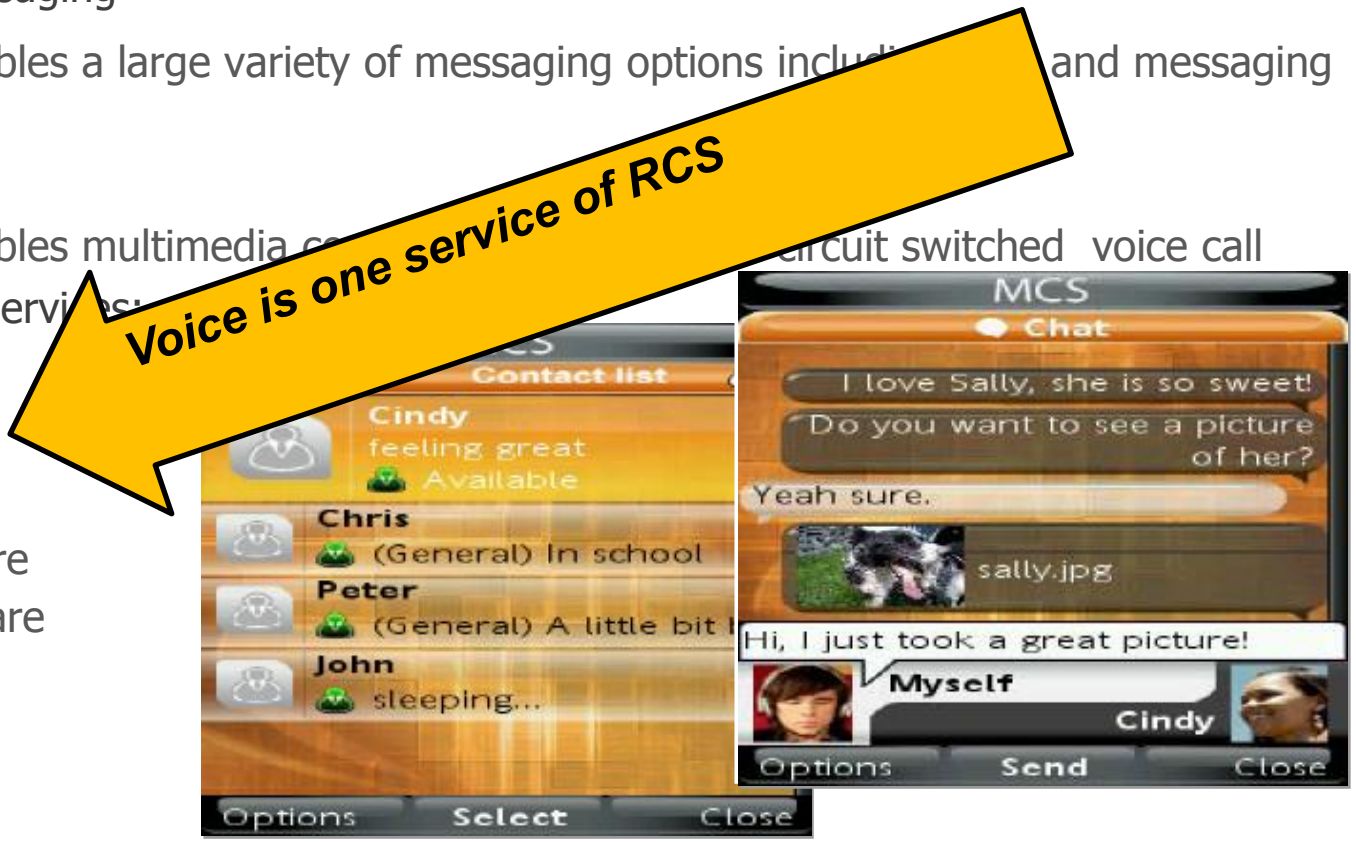


FIGURE 1: Depiction of UE and Network Protocol Stacks in One Voice

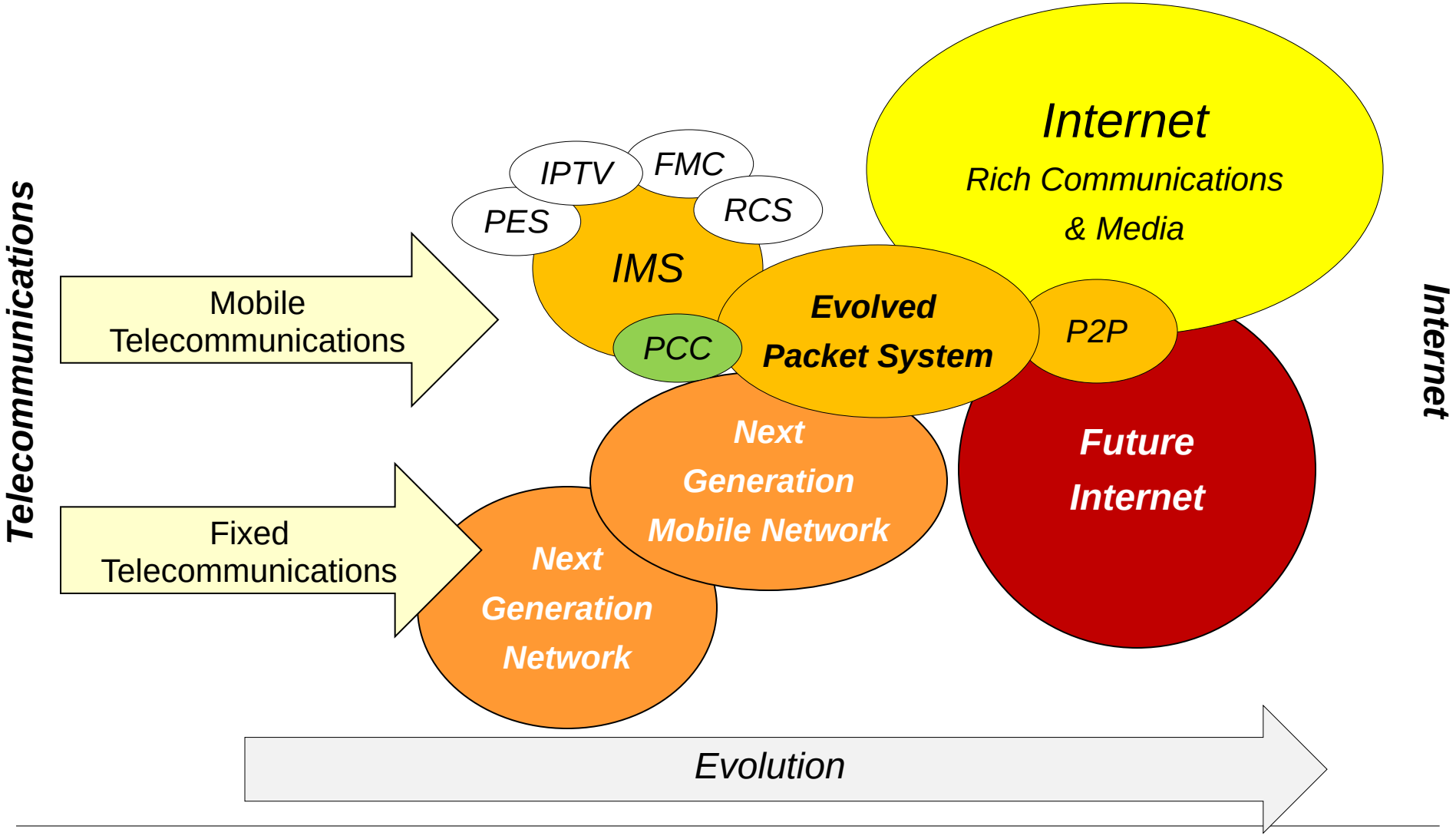
Source: „One Voice; Voice over IMS Profile“, Nov 2009

Voice In LTE Options (cont.)

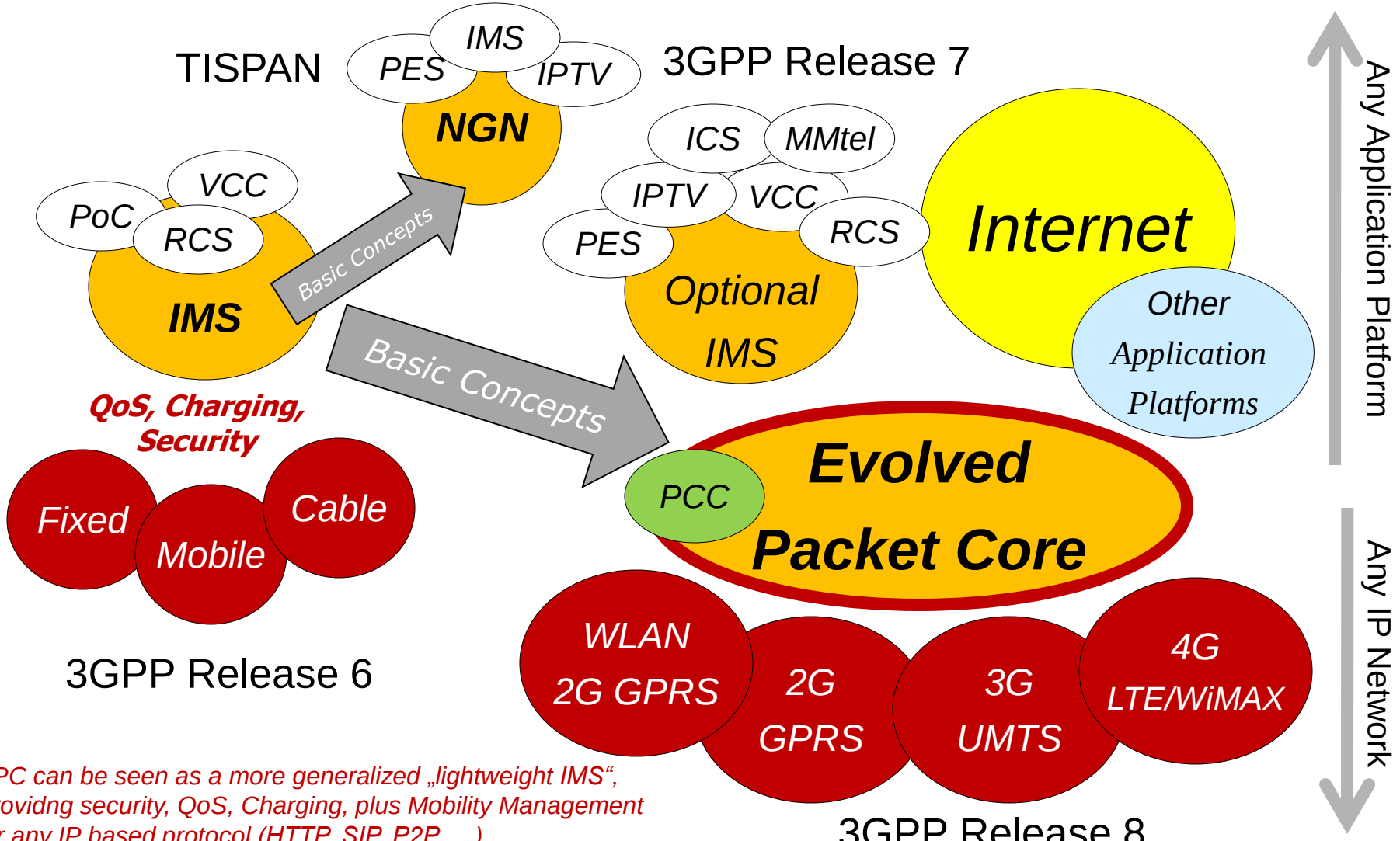
- Enhanced Phonebook
  - with service capabilities and presence enhanced contacts information
- Enhanced Messaging
  - which enables a large variety of messaging options includi and messaging history
- Enriched Call
  - which enables multimedia co ircuit switched voice call
- Standardized servi es:
  - Presence
  - Voice Call
  - IM
  - Video Share
  - Image Share
  - SMS
  - MMS



From NGN to mobile NGN: an important step towards the Future Internet



Concept Reuse: From IMS for NGN to EPC for all-IP

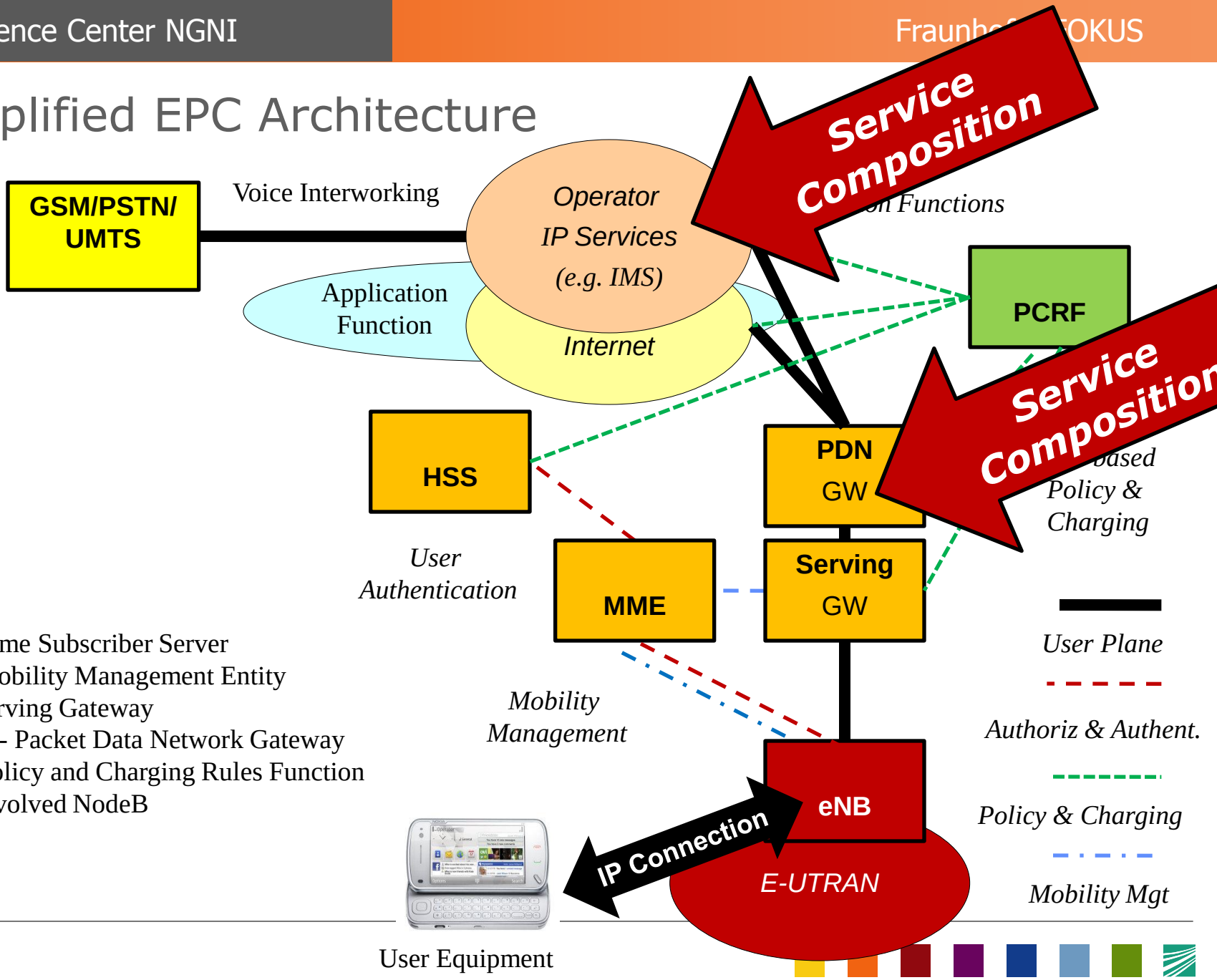


EPC can be seen as a more generalized „lightweight IMS“, Providng security, QoS, Charging, plus Mobility Management for any IP based protocol (HTTP, SIP, P2P, …)

FMC Comparison Matrix

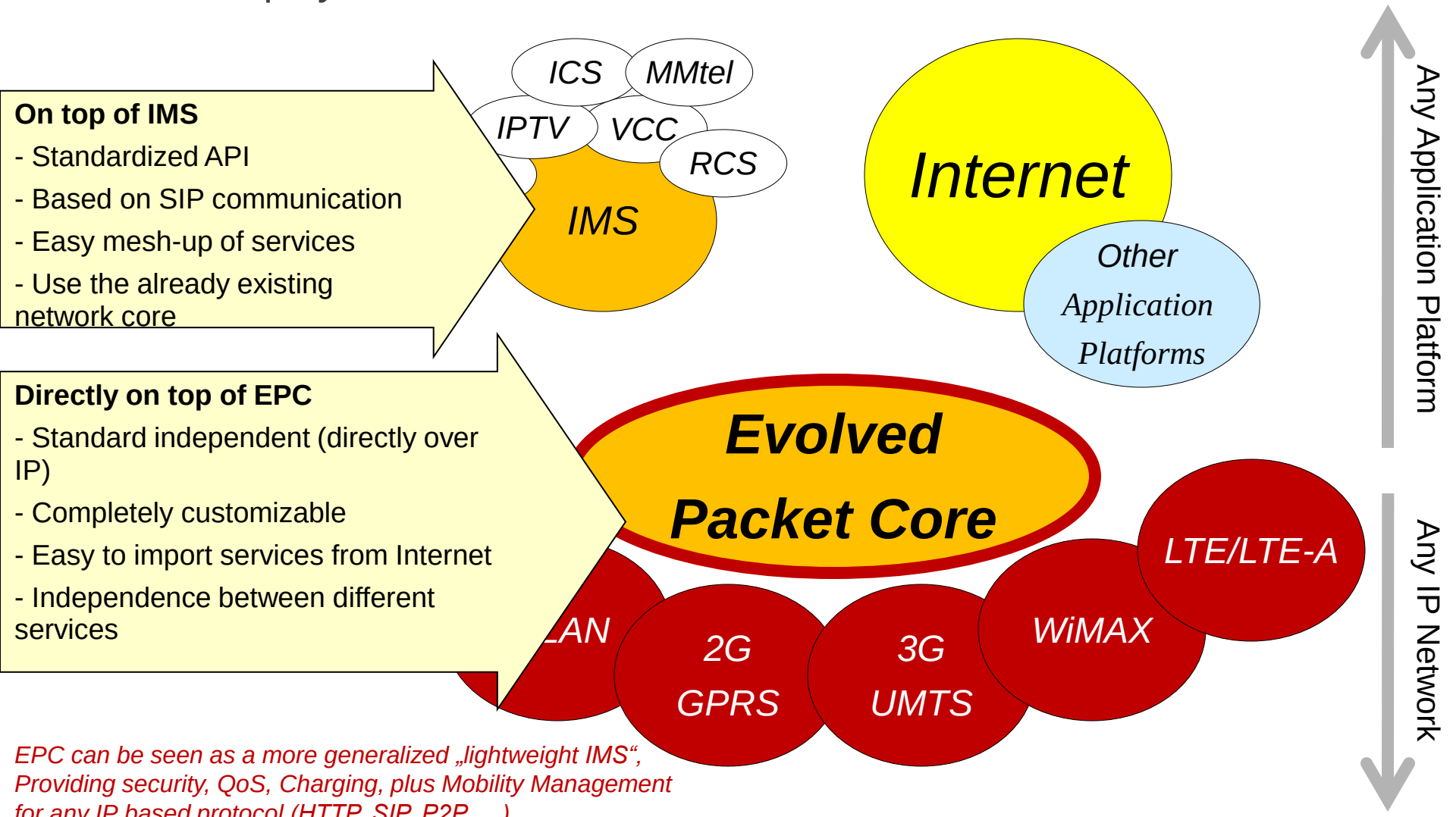
	IMS FMC	EPC FMC
Subscription based access control	Line subscription for fixed communication User subscription for mobile communication	One subscription per access device (fixed or mobile) – still missing/not hard to standardize
Data resource management	Access dependent IP bit-pipe	Access network independent - Based on subscription and flow information
Voice Resource Management	From service layer – Access Network Specific	Access network independent - Based on subscription and flow information
Mobility Management	At service layer – needs service platform support	At network layer – transparent to services
Transparency of access to service platform	No	Yes
Service platform independency	No	Yes
FMC support for SIP services	Yes – through IMS	Yes – through IMS
FMC for all IP services	No	Yes – service interaction/orchestration depends on service platform
Data Charging	Access network dependent	Converged
Voice Charging	Access network dependent	Seen as one of the types of data

Simplified EPC Architecture



HSS - Home Subscriber Server
MME - Mobility Management Entity
SGW - Serving Gateway
PDN GW - Packet Data Network Gateway
PCRF - Policy and Charging Rules Function
eNB – Evolved NodeB

Services Deployment in an IMS+EPC Environment



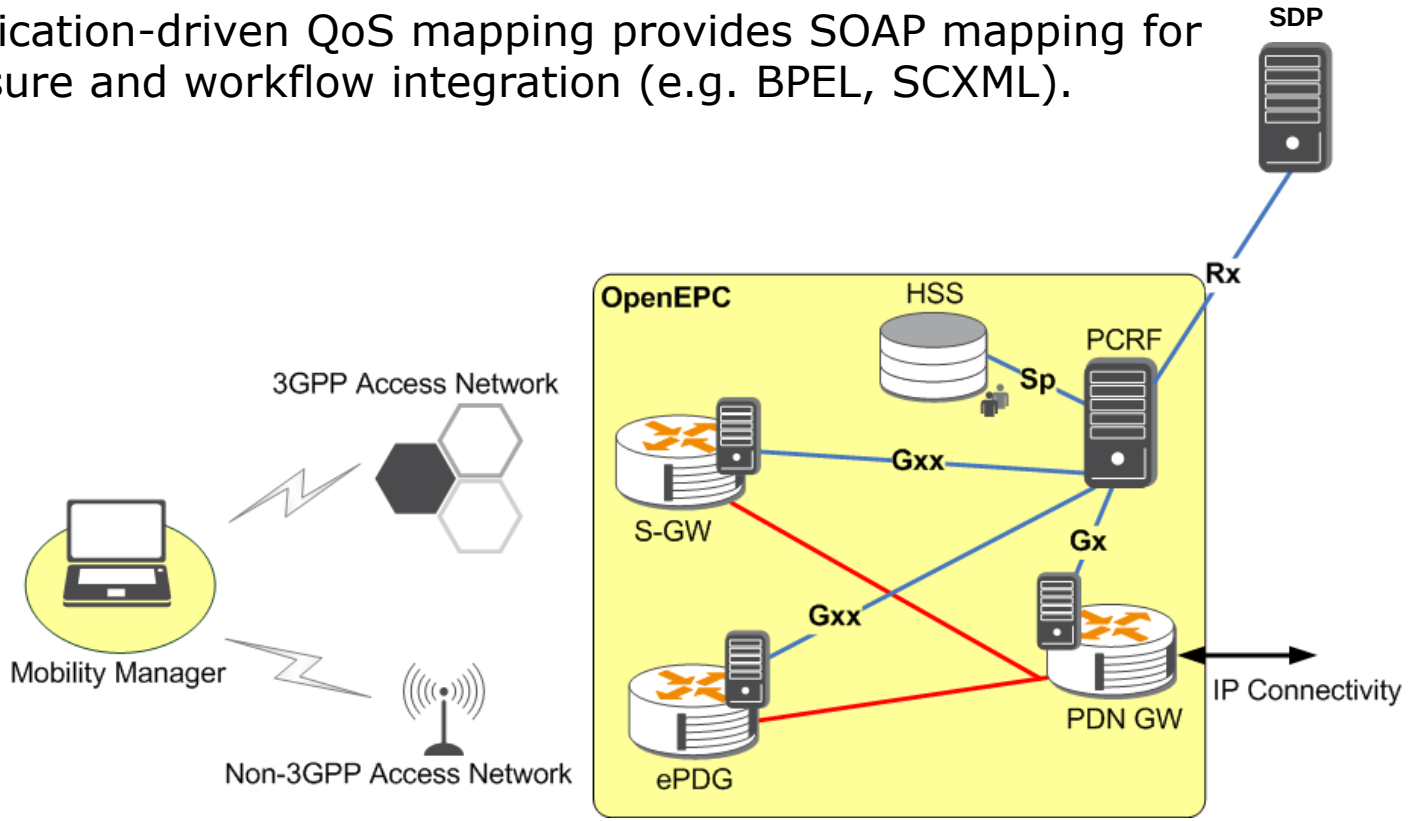
EPC can be seen as a more generalized „lightweight IMS“, Providing security, QoS, Charging, plus Mobility Management for any IP based protocol (HTTP, SIP, P2P, …)

EPC Support for Applications

EPC Support for Applications	Over-The-Top EPC Independent Apps	EPC Aware Apps	Apps using extensively EPC Enablers
Access Control	*	*	*
QoS Insurance	*	*	*
Seamless Mobility	*	*	*
Prioritization	*	*	*
Secure connectivity	*	*	*
QoS based on App requirements		*	*
Access Network Information		*	*
Location Information			*
Ambient Information			*
Same Identity			*

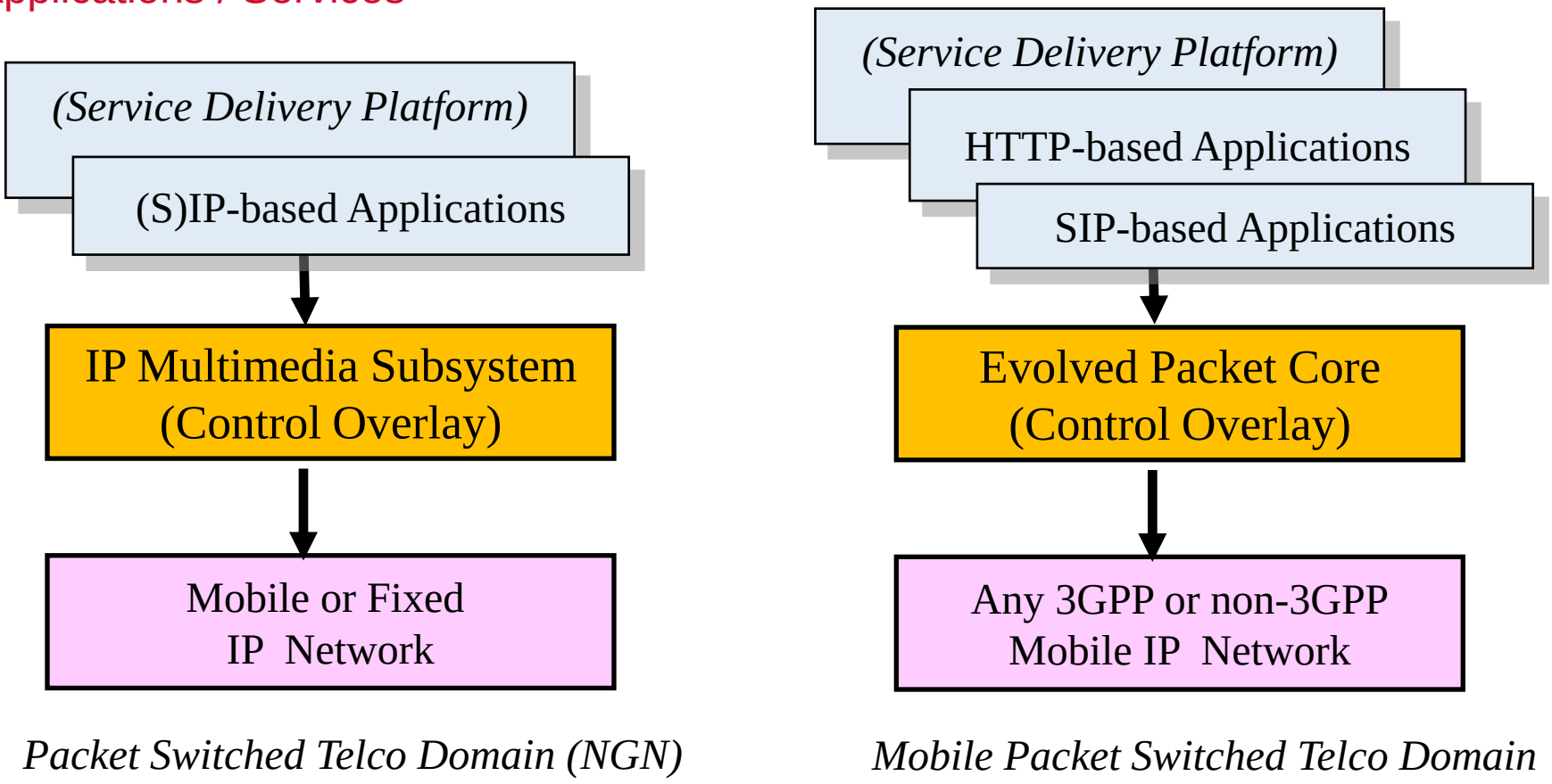
Network Control from the Service Layer
QoS Control through Rx interface

- Diameter-based Rx interface allows the integration of QoS control into the service layer.
- Parlay X Application-driven QoS mapping provides SOAP mapping for service exposure and workflow integration (e.g. BPEL, SCXML).



Summarize: IMS Concept Evolution toward EPC

Main Idea: Common Control Overlay Architecture abstracts from underlying IP network technology and provides common platform capabilities for any IP-based Applications / Services



Agenda

- Introduction
- IP Multimedia System (IMS) as Uniform All-IP Operator Service Platform
- Evolved Packet Core (EPC) Overview
- Future Internet (FI)
- Summary - Relating EPC, IMS, SDPs, and FI
- Q&A

Agenda

4. Future Internet (FI)

- FI Principles and global status quo
- Service Provision Principles in FI – Cross layer functional composition
- Towards FI Enablement: emerging FI Core platforms for FI Enabler
- Comparing Telco and FI Enablement principles
- Positioning EPC within the FI context
- Introduction of the FOKUS NGN2FI Evolution Lab

5. Summary - Relating EPC, IMS, SDPs, and FI

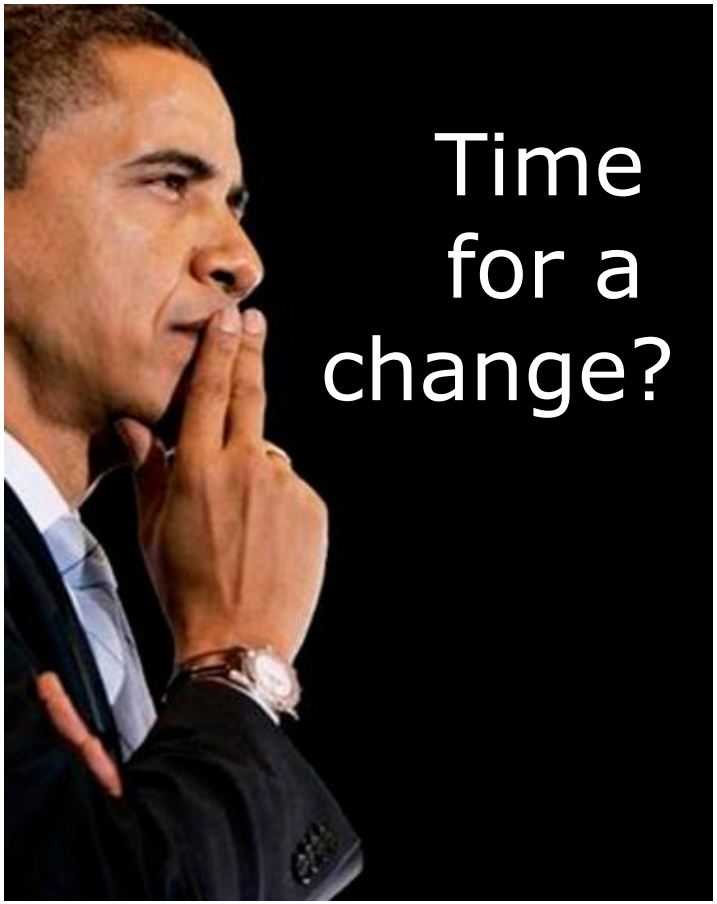
- Why IMS will be for seamless VoIP only and why EPC will become the universal all-IP service control platform
- Research Challenges ahead

Q&A

From Internet to Future Internet

- The current Internet technology has been invented in the sixties for the exchange of data between distributed research centers
- File transfer and email have been for many years the key applications
- Society started to recognize the Internet when first web browsers and web pages appeared
- Since then the Internet has been extended step by step to change our daily life: eBooks (Amazon), eCommerce (Amazon), music (P2P, iTunes), photos (Flicker), videos (Youtube), telephony (Skype, VoIP), TV (IPTV), web 2.0, communities (Facebook),
- Today we see the Internet entering serious domains: eGovornment, eHealth, eLearning, eProduction, Utilities, etc.
- Note that the Internet is used today for applications, it has never been designed for!
- But our daily life is dependent on the Internet
- International research is looking since some years for the future of the Internet in order to increase its robustness with revolutionary and evolutionary approaches

The current Internet



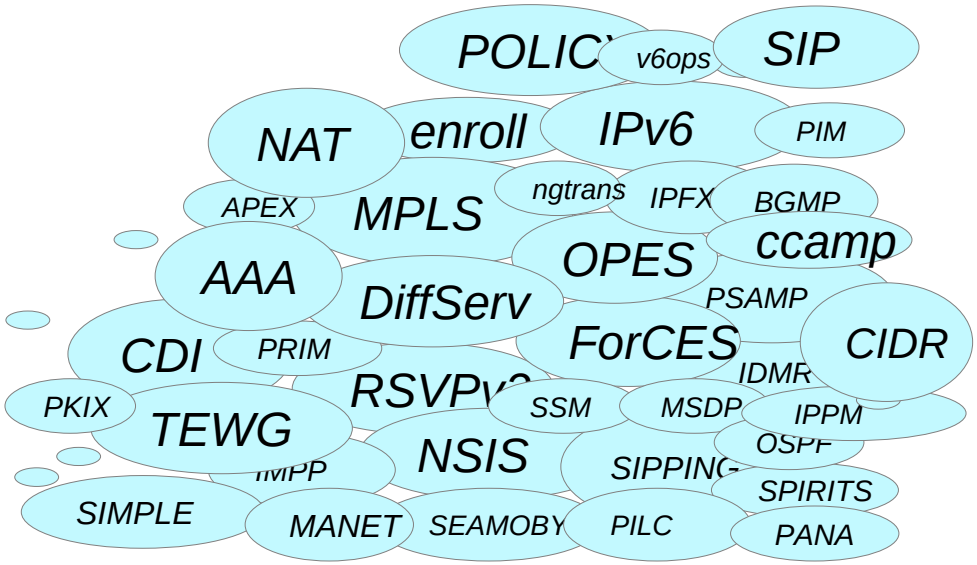
- Old, but successful
- Grown infrastructure
- Increased complexity
- Emerged applications
- Missing modularity
- Complex network maintenance
- Vulnerable against human errors
- Not flexible enough to develop new services
- Inventions like
  - Mobile IP (Mobility)
  - IPv6 (Address shortage)
  - AAA (Security)

  don‘t make it a new, innovative platform

Motivation for Future Internet Discussion

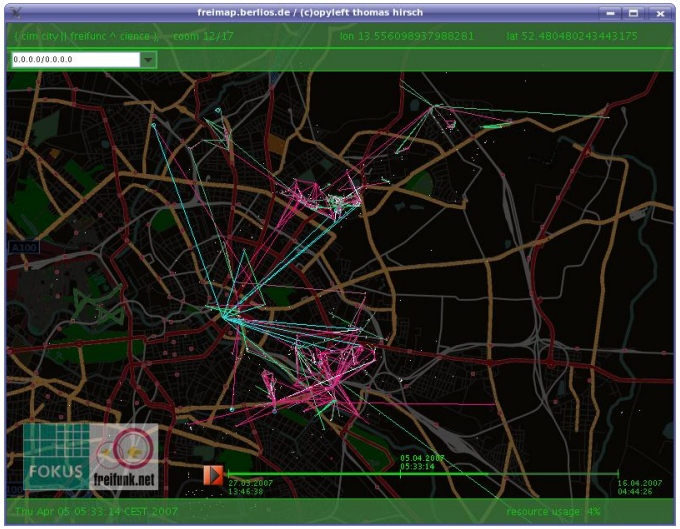
The Current Internet is a Huge Patchwork

- High Complexity
  - Many protocols
  - Patchwork Solutions
- Security Threats
  - Immense monetary loss
  - Fast adapting attack patterns
- High Management costs
  - Increasing network size
  - Increasing heterogeneity (technical, administrative)
- Lack of network support for users and applications
  - Mobility, quality, security levels, route options, privacy, ...



Reconsider Internet Design Principles

Future Internet Vision



Future Internet Structures

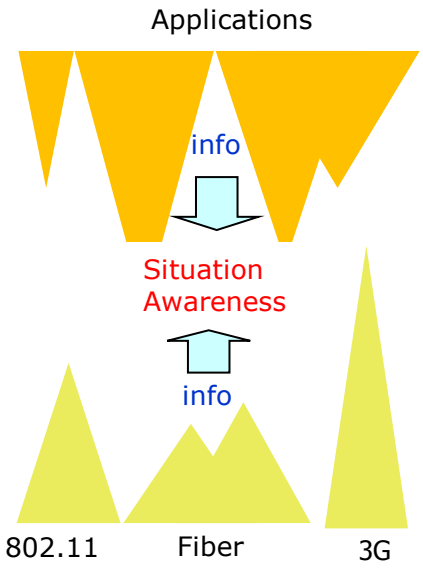
- Towards infinite number of nodes
- Heterogeneous technologies
- Dynamic *ad hoc/operator-free* structures

Future Internet Operation

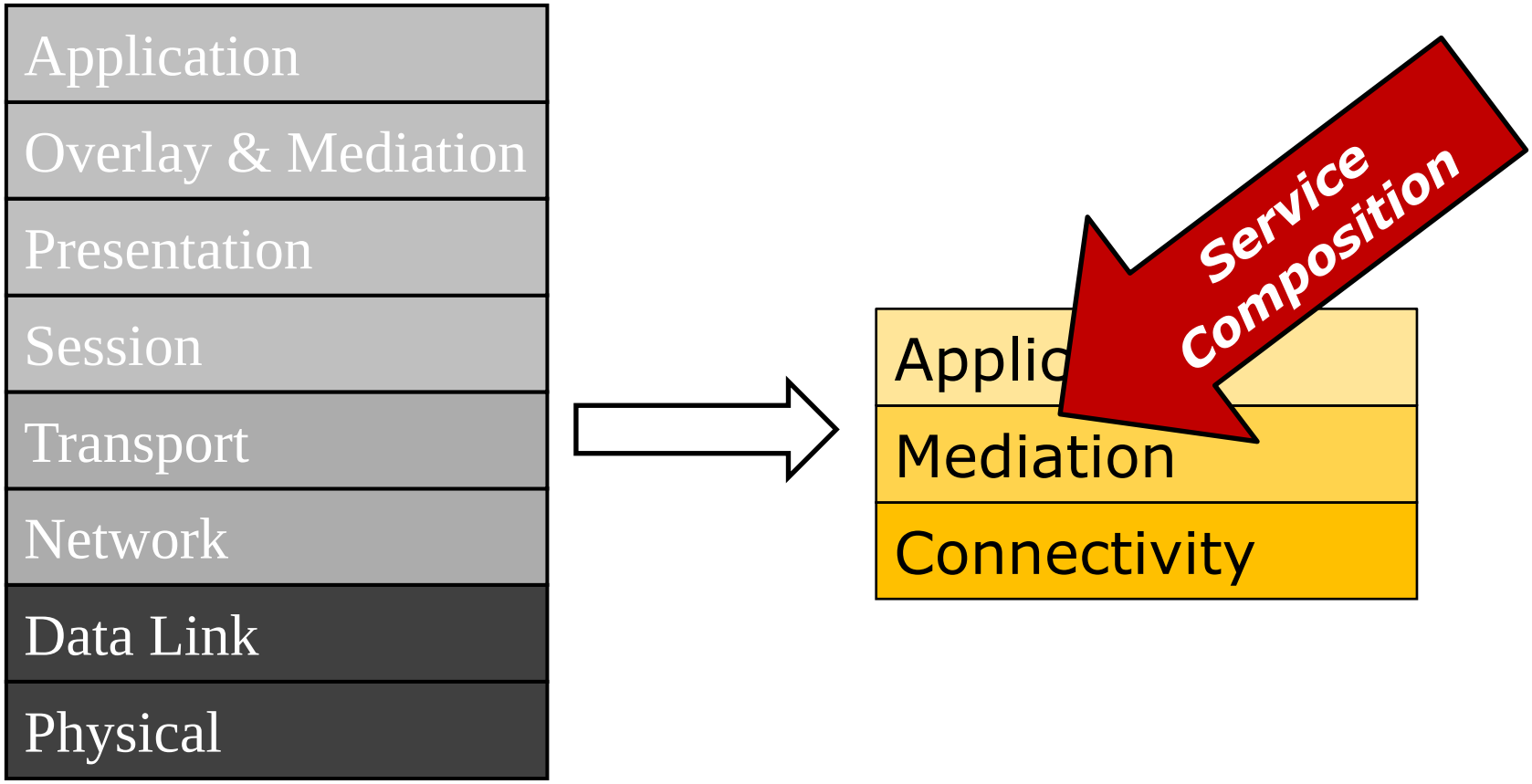
- "Application is King" ➔ network serves application needs
- Network self-protection (failures, attacks, congestion, …)
- Network self-management to reduce administrative costs

Enabler

- Strong cooperation between network and services
- Flexible network stack ➔ integration in router



FI = Towards a Thinner Application oriented Protocol Stack Forming Application specific Overlays

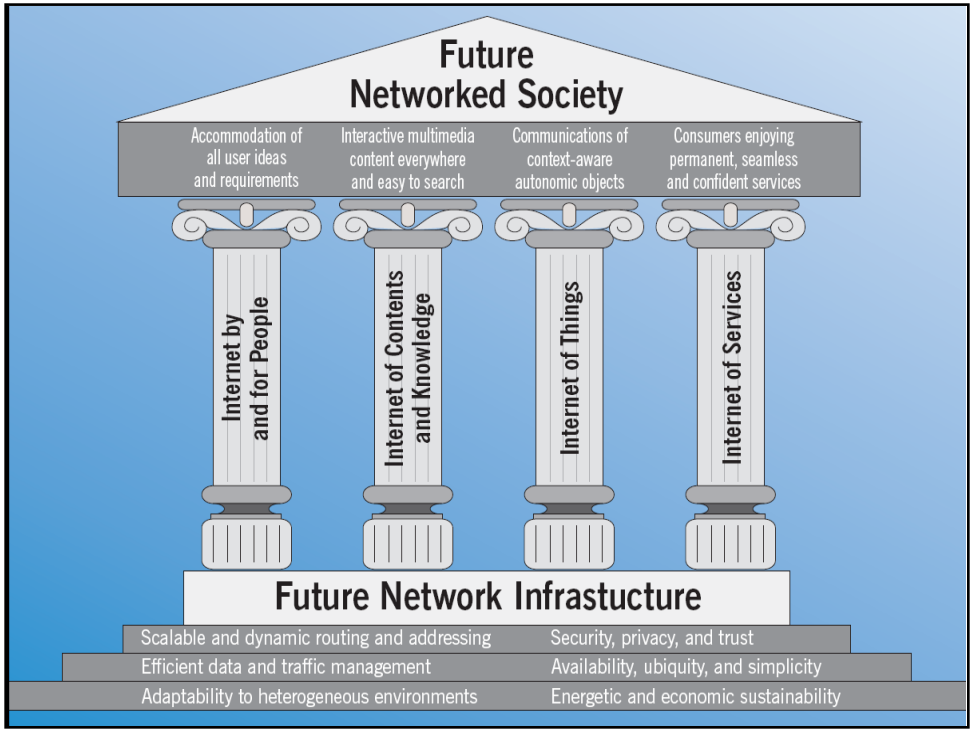


Clean Slate vs. Evolutionary Internet Design Approach

- Clean Slate
  - Re-think the current Network Stack -> Flexible and Functional Stacks
  - Functional Composition
  - New functionality integrated in protocol stack, dynamic re-configuration
  - Support for addressing Information/data and services
  - Identity/Locator split
  - Security, Privacy as integral part of the network
  - Network Resilience
- Evolution
  - Smooth interaction/co-existence of novel with current architectures, protocols and apps
  - Dynamic composition of functionality
  - Better support for applications
  - Autonomic properties
  - Support for mobility
  - Federation of networks
  - Integration of Sensor Networks / Internet of Things
  - Virtualization to lower the dependency from a specific physical location or entity
  - New infrastructure services for location information as well as measurements and monitoring

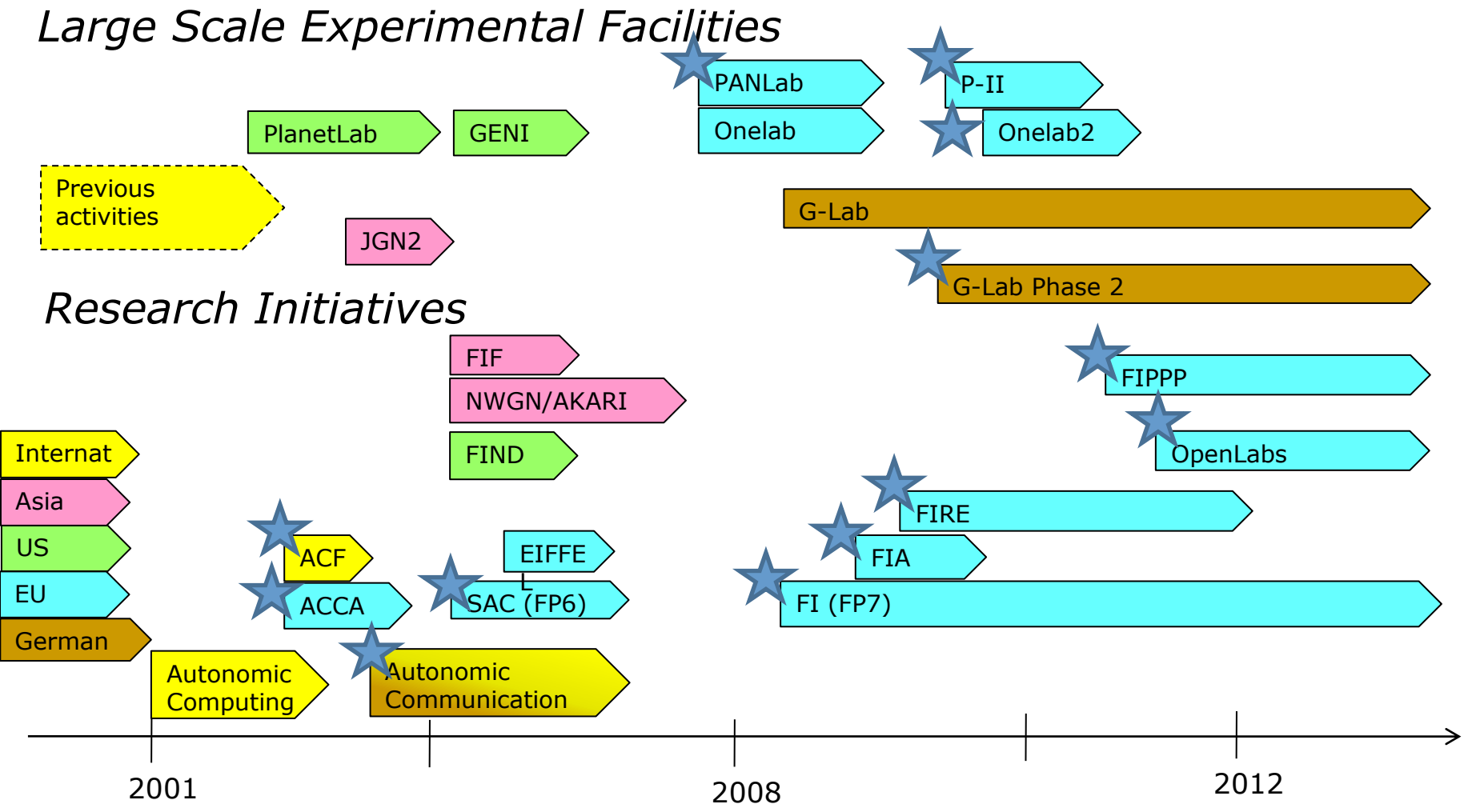
Dimensions of the Future Internet

- Future Internet Pillars
  - Network of the future
  - Internet of Content
  - ***Internet of Things***
  - ***Internet of Services***
- Infrastructure Foundation:
  - Network infrastructure / substrate that supports the pillars
  - Shall support capacity requirements of Future Internet



Future Internet, The Cross-ETP Vision Document, Version 1.0, 2009

Worldwide Future Internet Research Activities



with FOKUS and TUB contribution

Future Internet – A Global Research Issue

- European Future Internet Portal - www.future-internet.eu
- GENI - www.geni.net
- FIND - www.nets-find.net
- AKARI - http://akari-project.nict.go.jp/eng/index2.htm
- FIA - www.future-internet.eu
- FIRE – Future Internet Research & Experimental Facilities - www.cordis.europa.eu/fp7/ict/fire
- G-Lab - www.german-lab.de
- Future Internet Forum - www.fif.kr
- ACF - www.autonomic-communication-forum.org
- JNG2 Japanese NGN - www.jgn.nict.go.jp/english/about_us/index.html
- FP7 Future Internet Public-Private Partnership (FI-PPP) – http://www.fi-ppp.eu/

US GENI & FIND

- The Global Environment for Network Innovations (GENI) is a virtual laboratory for at-scale networking experimentation
- The GENI mission is to:
  - open the way for transformative research at the frontiers of network science and engineering; and
  - inspire and accelerate the potential for groundbreaking innovations of significant socio-economic impact
- FIND (Future Internet Design) is a major new long-term initiative of the NSF NeTS research program. FIND invites the research community to consider what the requirements should be for a global network of 15 years from now, and how we could build such a network if we are not constrained by the current Internet -- *if we could design it from scratch.*
- The philosophy of the program is to help conceive the future by momentarily letting go of the present

The European FI Private Public Partnership Program

- The Internet economy is valued at €500 billion with a staggering 12% annual growth rate. It is creating more jobs and paying higher salaries than virtually any other market. This future Internet economy will grow to 5.8% of European GDP or almost 800 billion euros by 2014.
- Yet today's Internet was designed in the 1970s, for purposes that bear little resemblance to current and future usage scenarios. Mismatches between the original design goals and how the Internet is being used are beginning to hamper its potential. Many challenges in the areas of technology, business, society and governance will have to be overcome if the future development of the Internet is to sustain the networked society of tomorrow.
- To answer these challenges, the European Commission has launched the Future Internet Public-Private Partnership Programme (FI-PPP) on May 3, 2011

- www.fi-ppp.eu

The European FI Private Public Partnership Program

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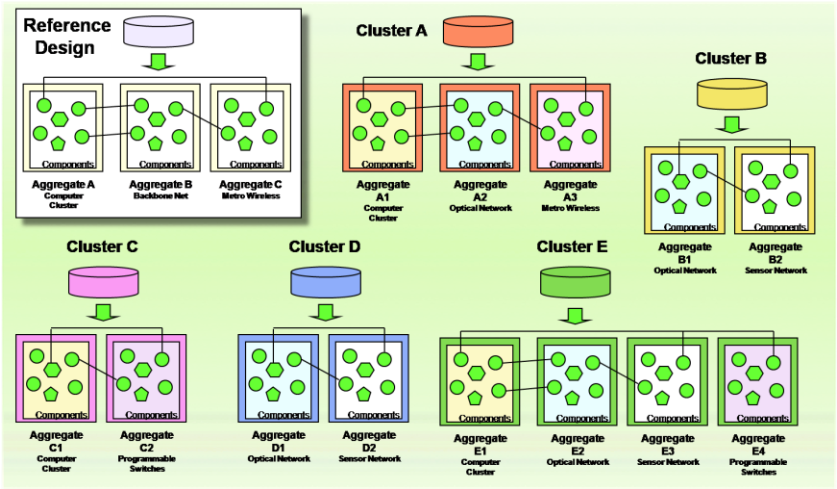
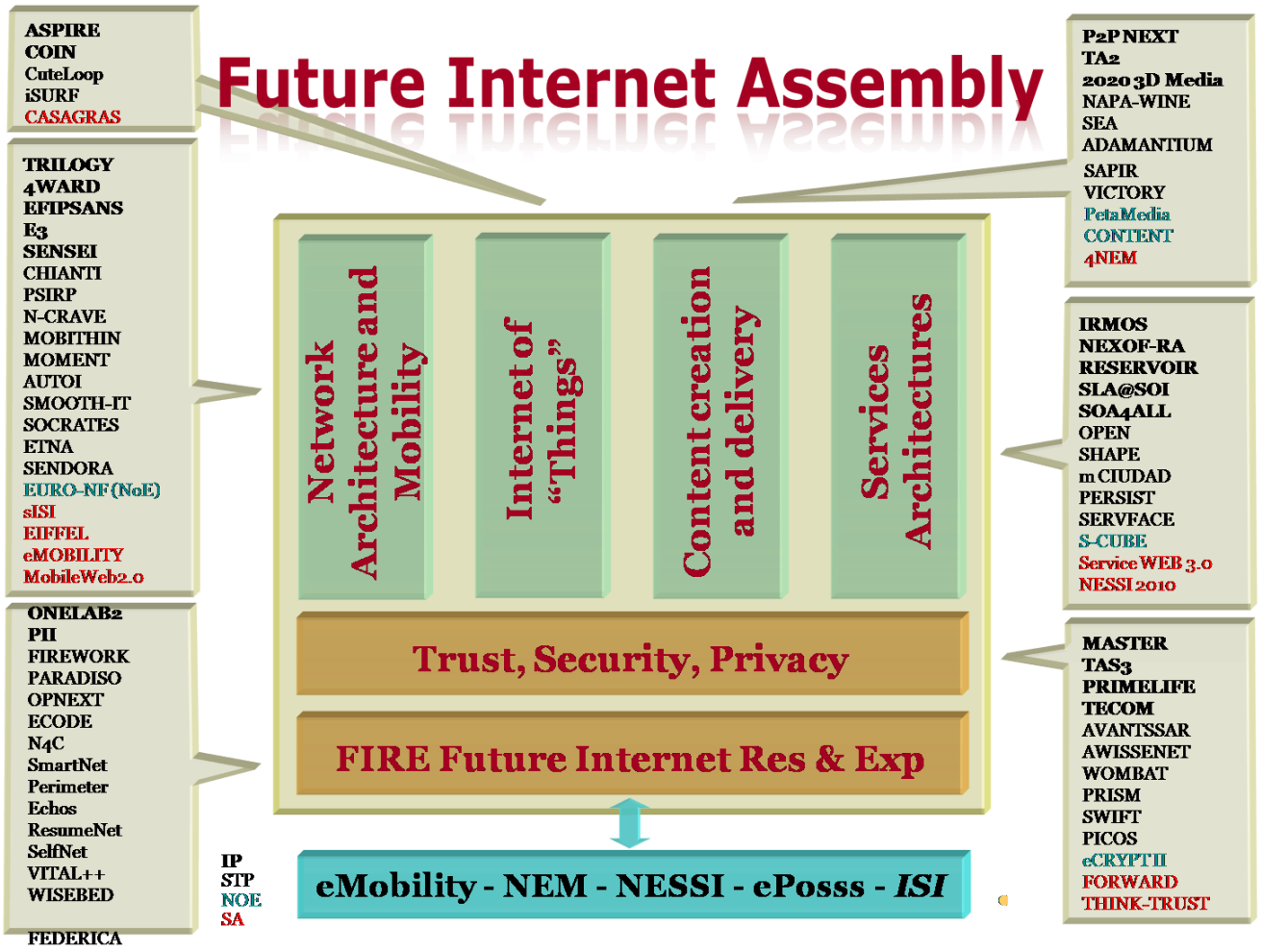
- To answer these challenges, the European Commission has launched the **Future Internet Public-Private Partnership Programme (FI-PPP)** on May 3, 2011
- **600 Mio Euro** will be invested in the **next 5 years** in this program

GENI – Future Internet Testbed Design

- Main architectural document: GENI CFA (Control Framework Architecture)
- The Control Framework is currently implemented as a prototype by 5 competing clusters:
  - DETER
  - PlanetLab
  - ProtoGENI
  - ORCA
  - ORBIT

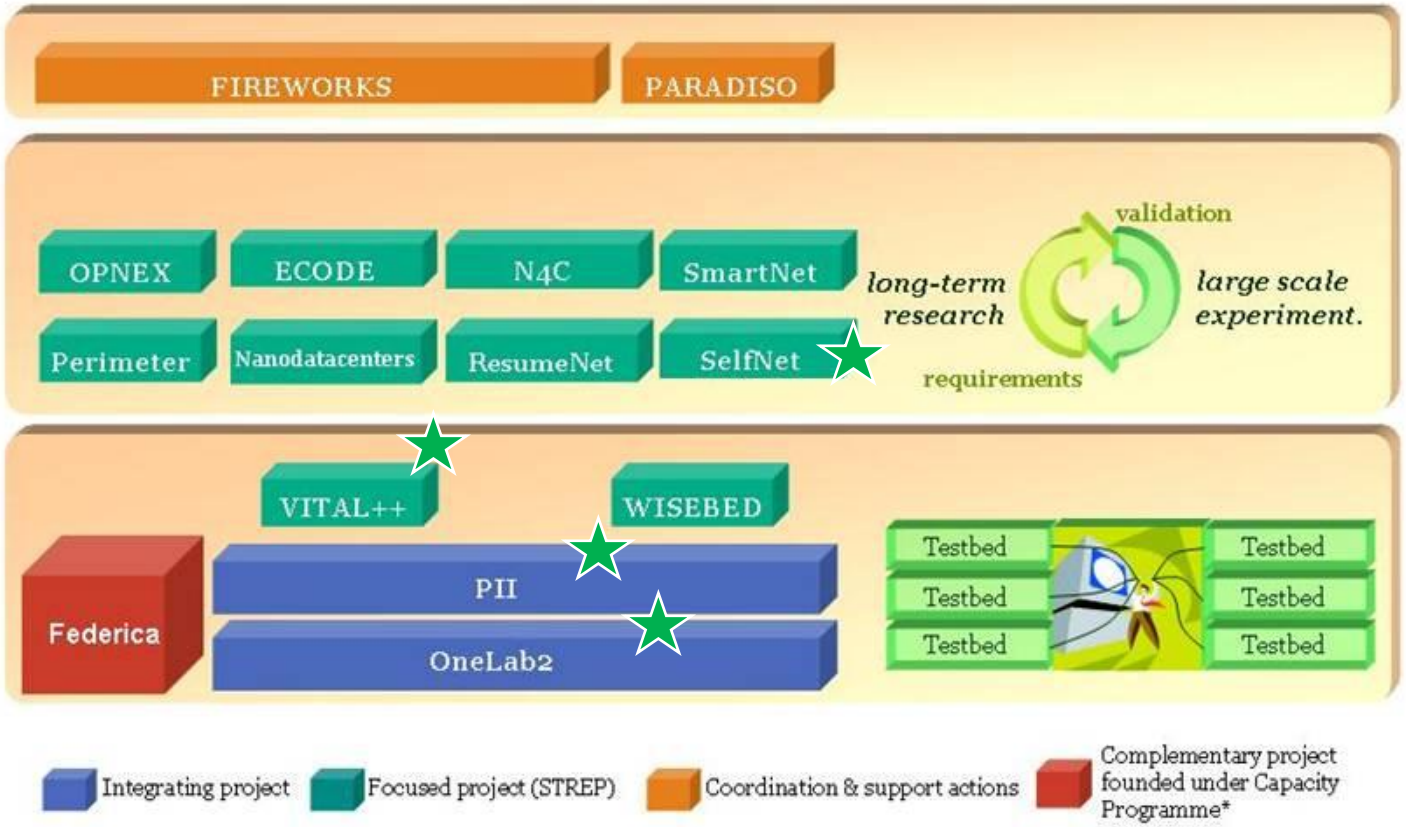


FI in Europe



The European FIRE Intiative - Overview and Potential. Dr Max Lemke, European Commission

European FIRE – Future Internet Research and Experimentation
Overview of Projects



★ with Fraunhofer FOKUS contribution

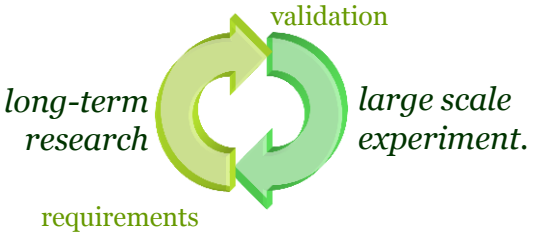
The European FIRE Intiative - Overview and Potential. Dr Max Lemke, European Commission

Purpose of FIRE

"***creating a research environment for investigating and experimentally validating highly innovative and revolutionary ideas***"

To investigate, test and compare, at large scale, new paradigms and future internet architectures, and their socio-economic impact

- e.g. transport/routing paradigms, dynamic topologies, service architectures ...
- e.g. socio economic impact of putting intelligence into the core, changing the end-to-end principle, ...



17 new projects, 50 M€ - Call 5 (tentative)

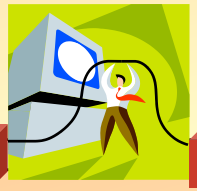
14 projects, 40 M€ - Call 2

Coordination and Support Actions

FIREBALL
MyFire
FIREstation
FIREworks
PARADISO 2
PARADISO

Building the Experimental Facility and stimulating its use

Smart Santander
BonFIRE
TEFIS
OFELIA
ONELAB2
PII
CREW
WISEBED
VITAL++
Users
Users



Experimentally-driven Research

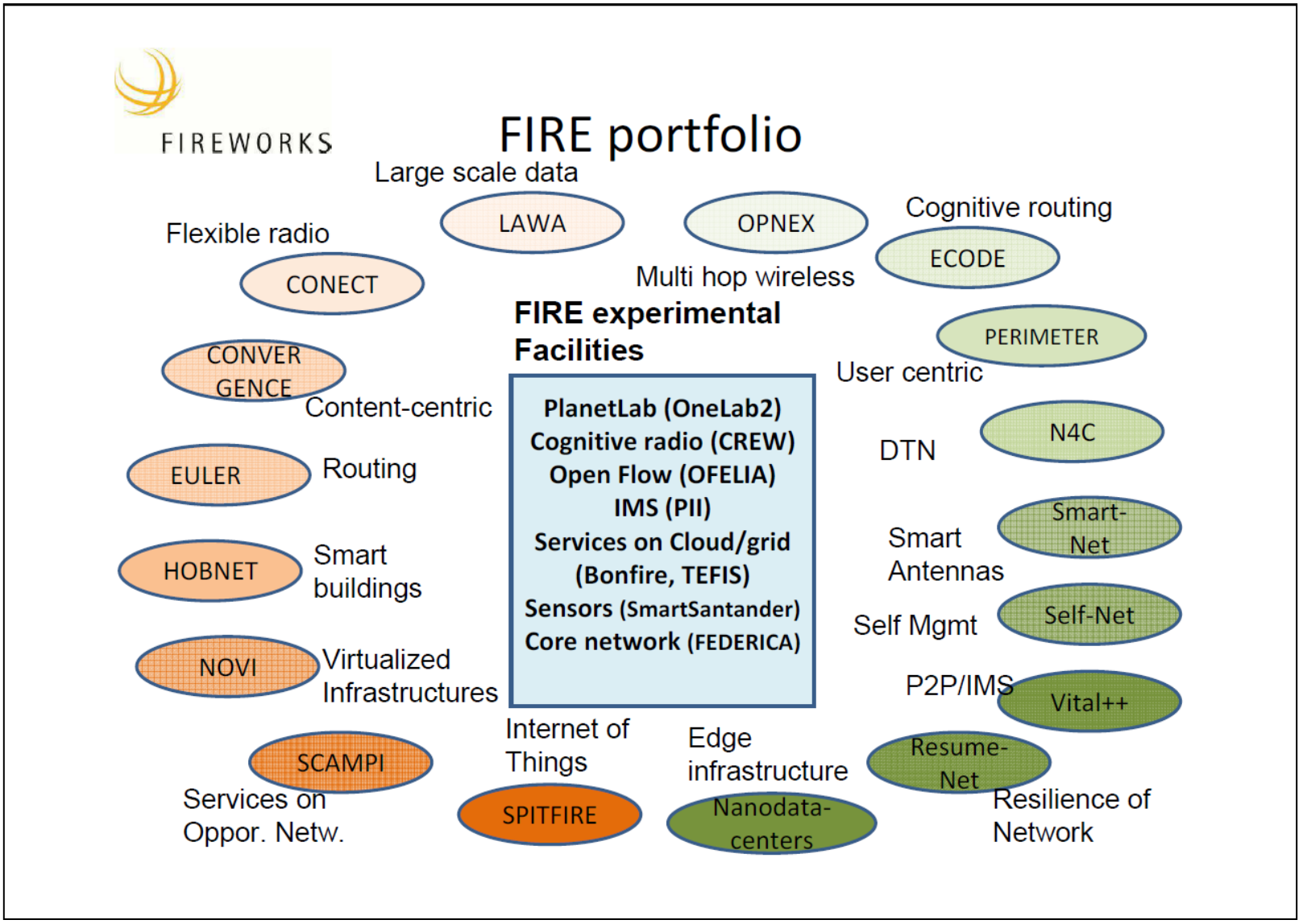
CONECT
EULER
BONFIRE
SPITFIRE
OPNEX
ECODE
PERIMETER
CONECT

Validation
Research
Experimentation
Requirements

SCAMPI
CONVERGENC
HOBNET
NOVI
N4C
SMART-NET
Nanodatacenters
SELF-NET

Facility Projects IPs Call 5
Focused project Call 5 STREPs
Coordination & support actions Call 5
Facility projects IPs&STREPs Call 2
Facility projects Call 2 STREPs
Coordination & support actions Call 2

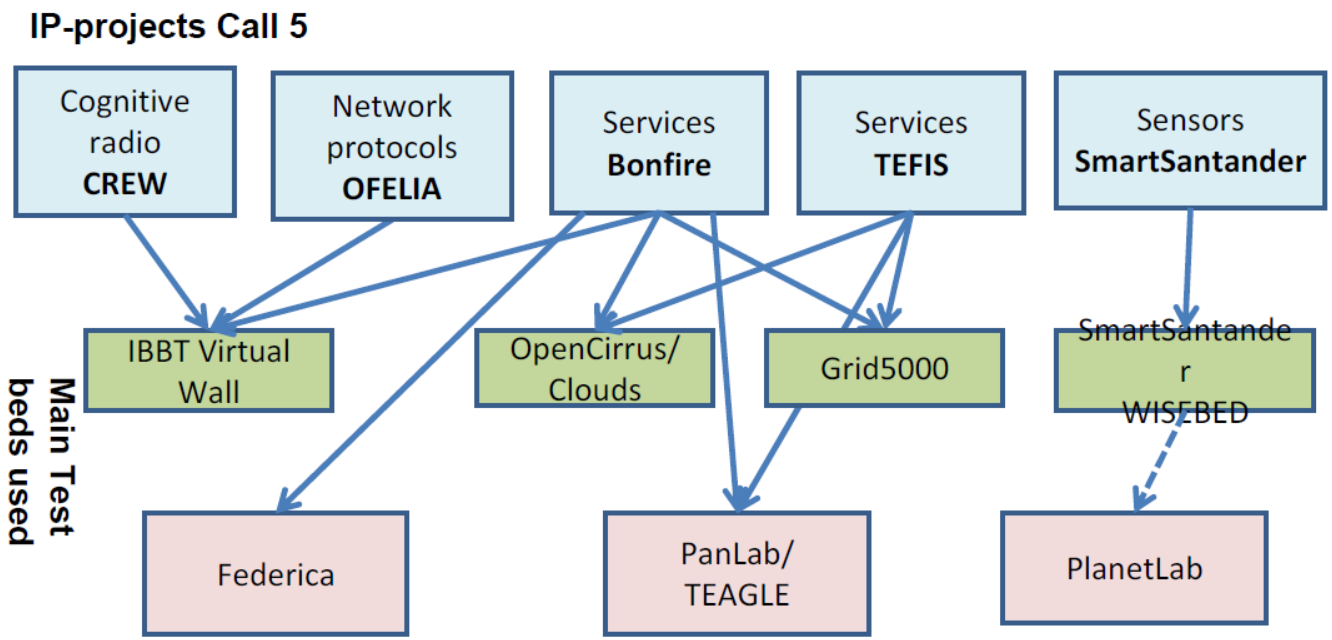
Information on Call 5 is tentative – contracts are under negotiation, tentative start in summer 2010



FIRE portfolio analysis June 2010. Scott Kirkpatrick, Jacques Magen, Dirk Trossen, Jerker Wilander

FIREWORKS

FIRE Facility projects (call 5)



FIRE portfolio analysis June 2010. Scott Kirkpatrick, Jacques Magen, Dirk Trossen, Jerker Wilander

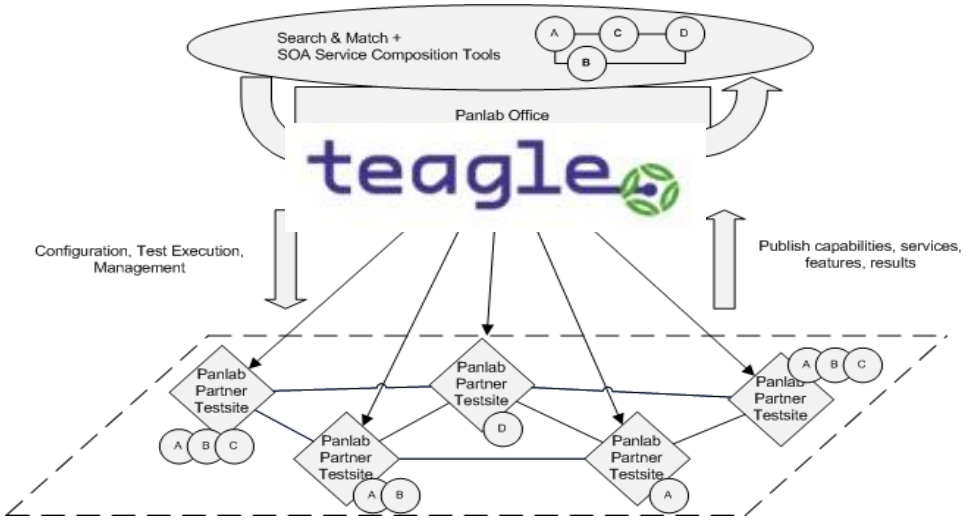
Example: EU FIRE Project PII PanEuropean Laboratory II

Panlab
Pan European Laboratory Infrastructure Implementation

Pan-European Laboratory Project (PII) develops SOA testbed federation tool Teagle

- **Support life cycle of testbed federation management via common management plane**
- **Provides repositories for testbed and component descriptions (registration)**
- **Search available resources, i.e. infrastructure and services (discovery)**
- **Orchestration of services and testing infrastructures**
- **Initiate automated deployment / provisioning**
- **Monitoring of federated resources (fault / performance) mgt**

Federated Testbed View



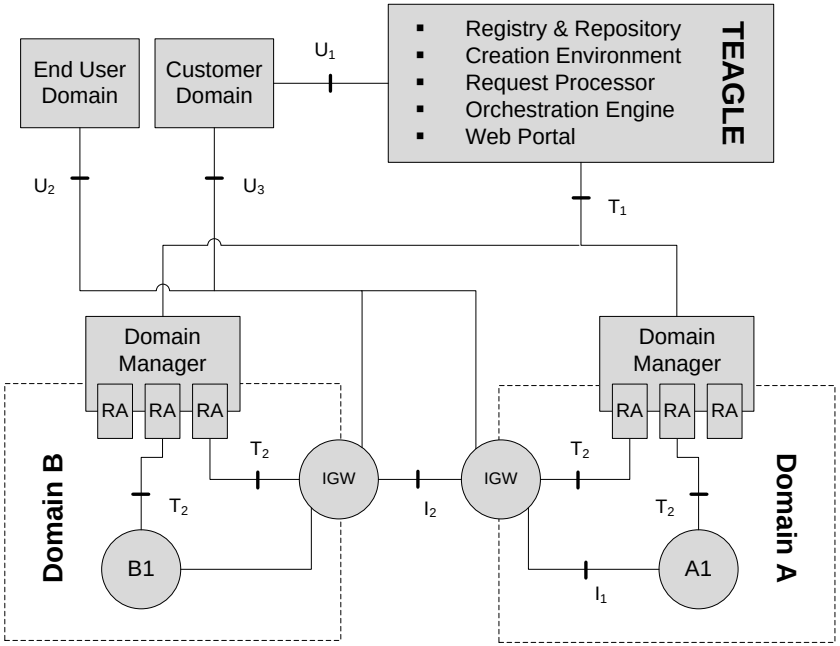
Different Testbeds

More about Panlab ➔ www.panlab.net

Teagle a tool for NGN/FI testbed federation

Heterogeneous Resources but a Common Control Framework

- Domain Managers control resources inside a partner domain
- Resource Adaptors (RA) are used like devices drivers to translate federation level management commands to resource specific communication (e.g. SNMP, CLI, proprietary) on interface T2
- Teagle instructs domain managers via a common control framework on interface T1
  - Generic control framework
  - CRUD operations (create, read, update, delete)
- Teagle provides user interfaces for experimental facility configuration and deployment, provides registries, information- / data models, creation environment
- Domain interconnections are handled by gateways



teagle

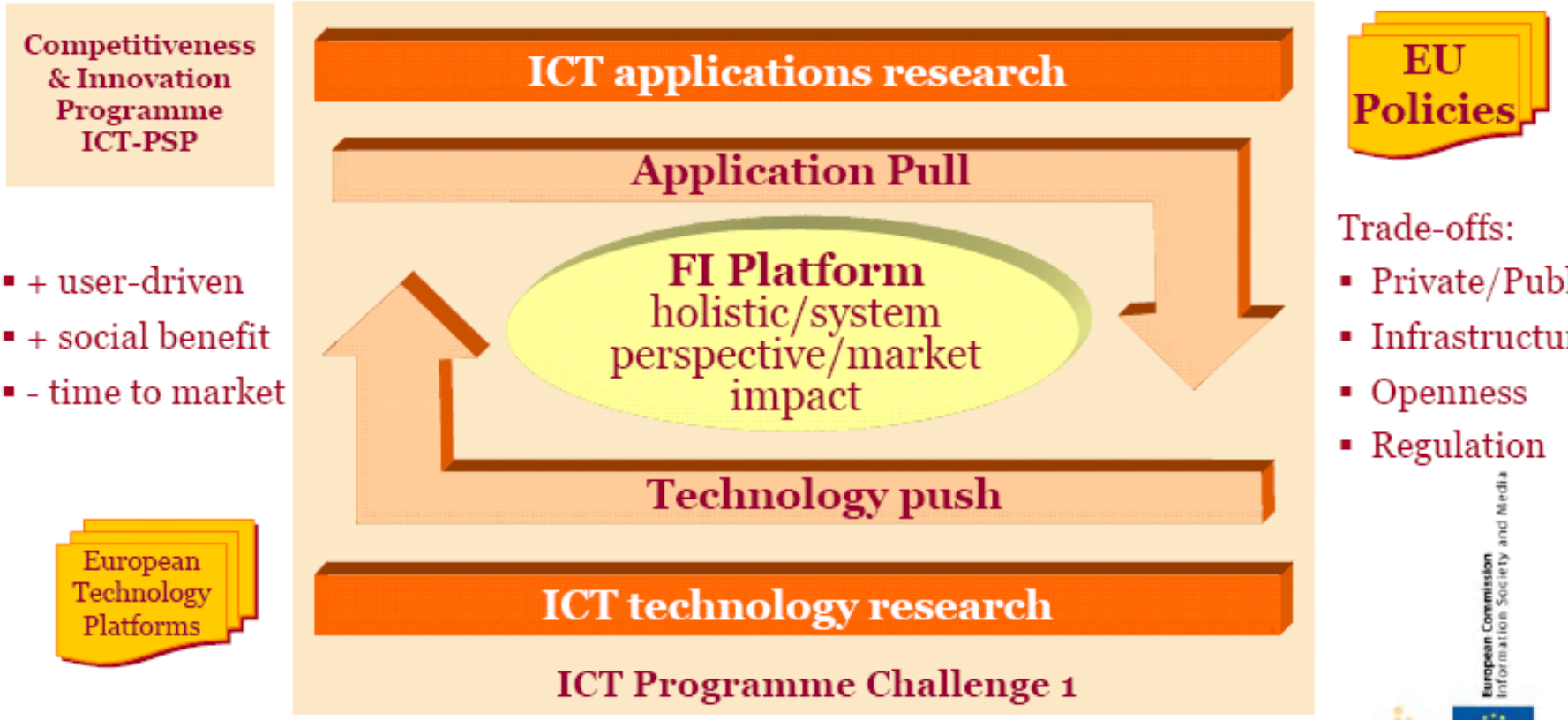
More on Teagle: www.fire-teagle.org

Towards a Common European Future Internet Core Platform

- Generic, trusted, open platform supporting various application domains
- Providing capabilities for:
  - upgraded network
  - sensor networks coupled to the Internet
  - versatile service infrastructure
  - information processing
  - real-time application
  - trust and identity
  - ad-hoc aggregation of resources
- Re-usable/composable in multiple usage contexts
- Generic enablers, key features
- Open interfaces, API, SDK

Towards a European Future Internet Platform

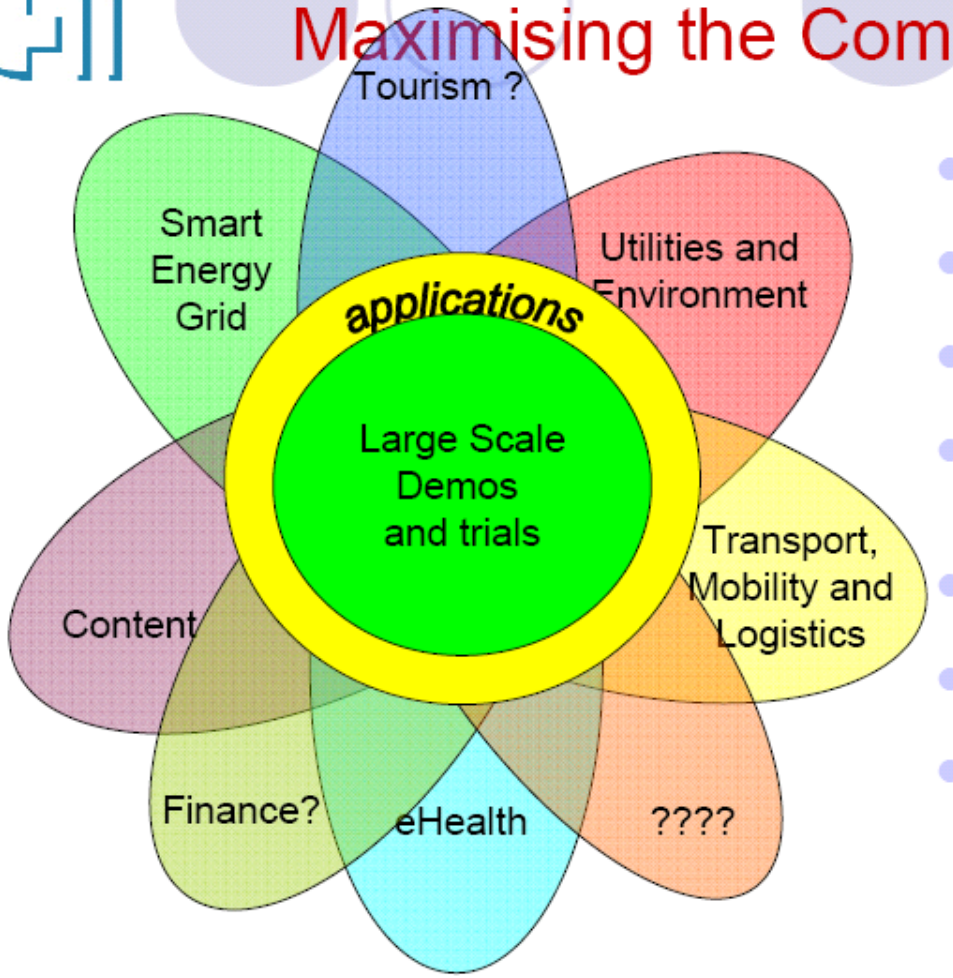
Making the world 'smarter' and accelerate sustainable innovation



Making Europe a world leader in Future Internet technologies

The Notion of Enablers within the European Future Internet Initiative

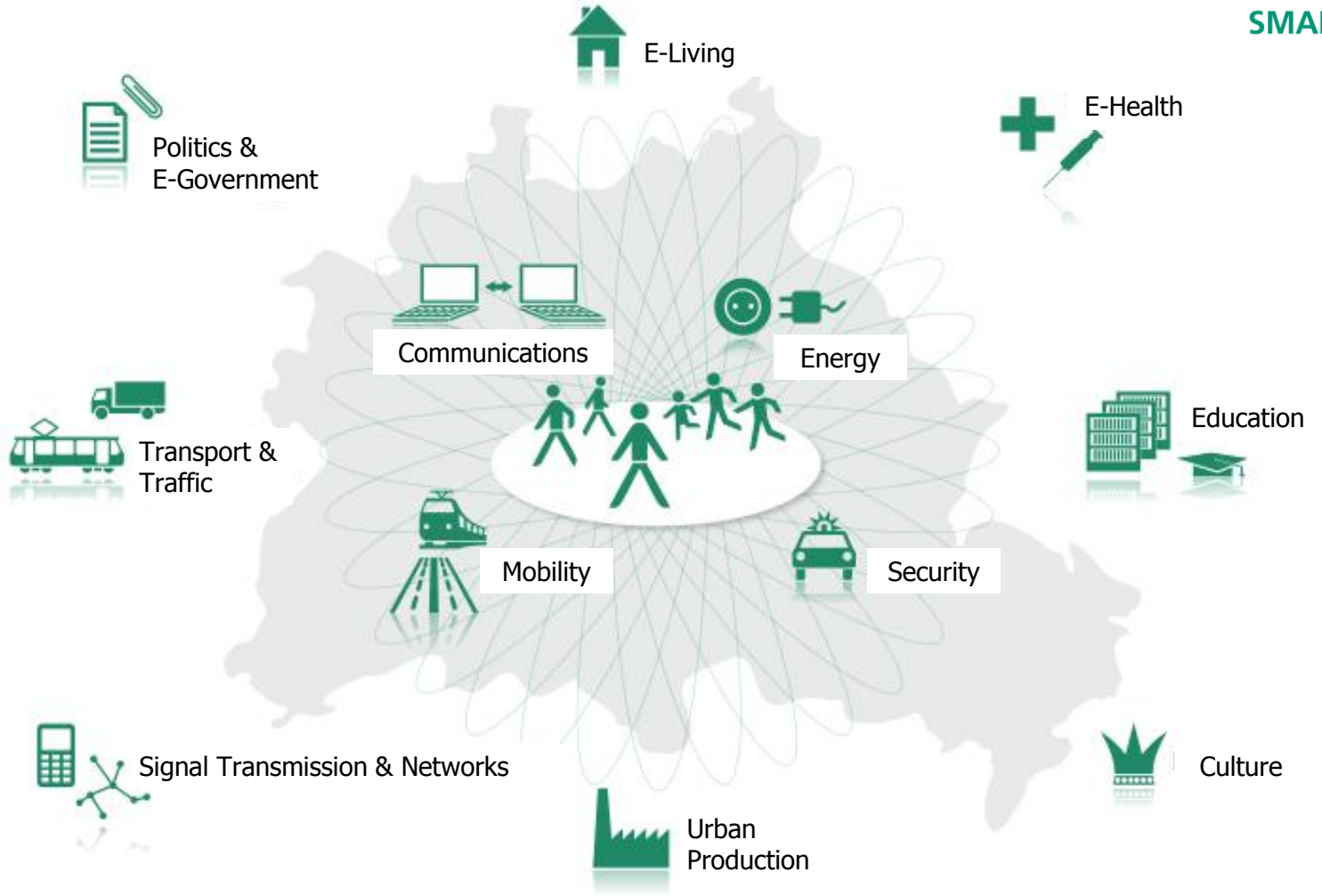
Maximising the Common enablers



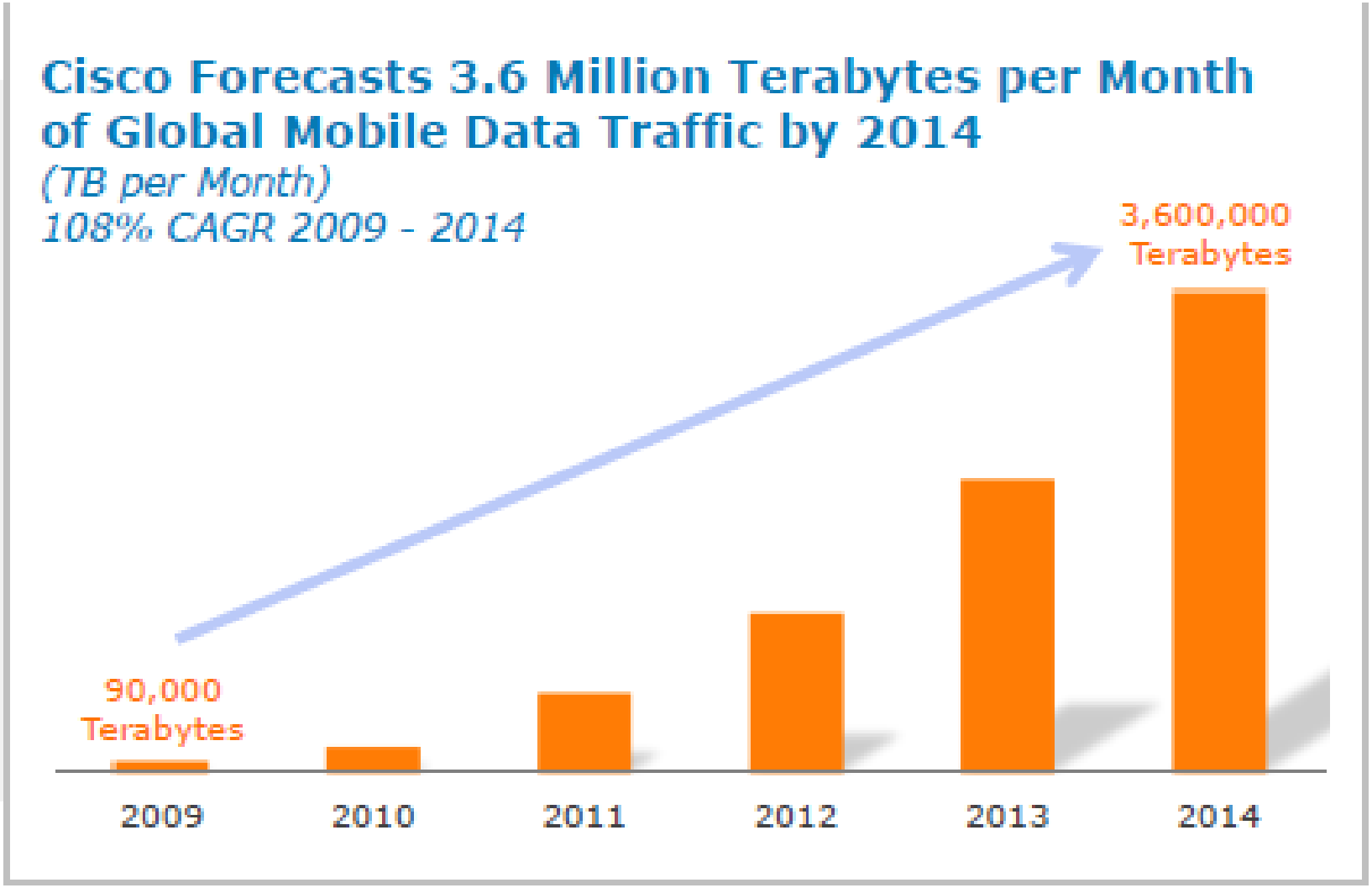
- Examine the basic enablers in each area
- Determine the common enablers
- Determine the enhanced enablers
- Work out how to provide a core platform that supports the enablers
- Build it and show the world
- Use it in large scale trials and tests
- Use existing advanced infrastructures to test future Internet function

Future Internet … to make our cities smart
Open Platforms Are Needed

Fraunhofer SMART CITIES

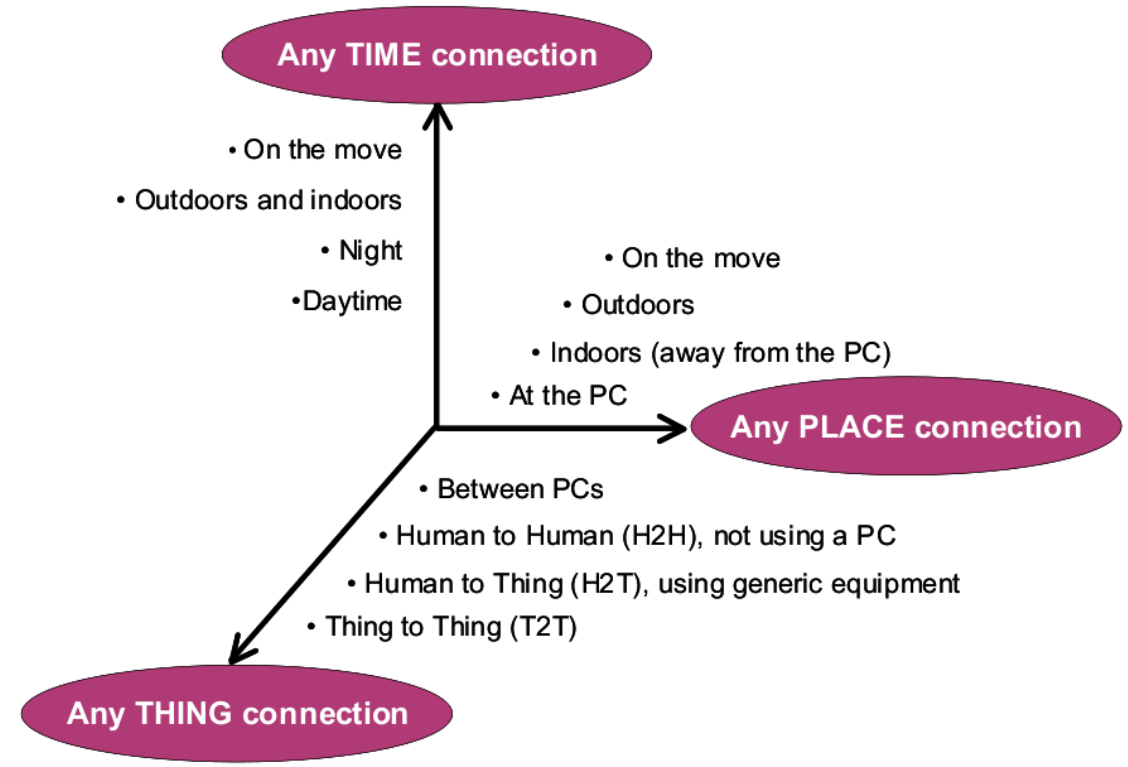


Mobile Data Traffic Forecasts



Source: Cisco, VNI Mobile, 2010

Internet of Things (IoT) – A Definition

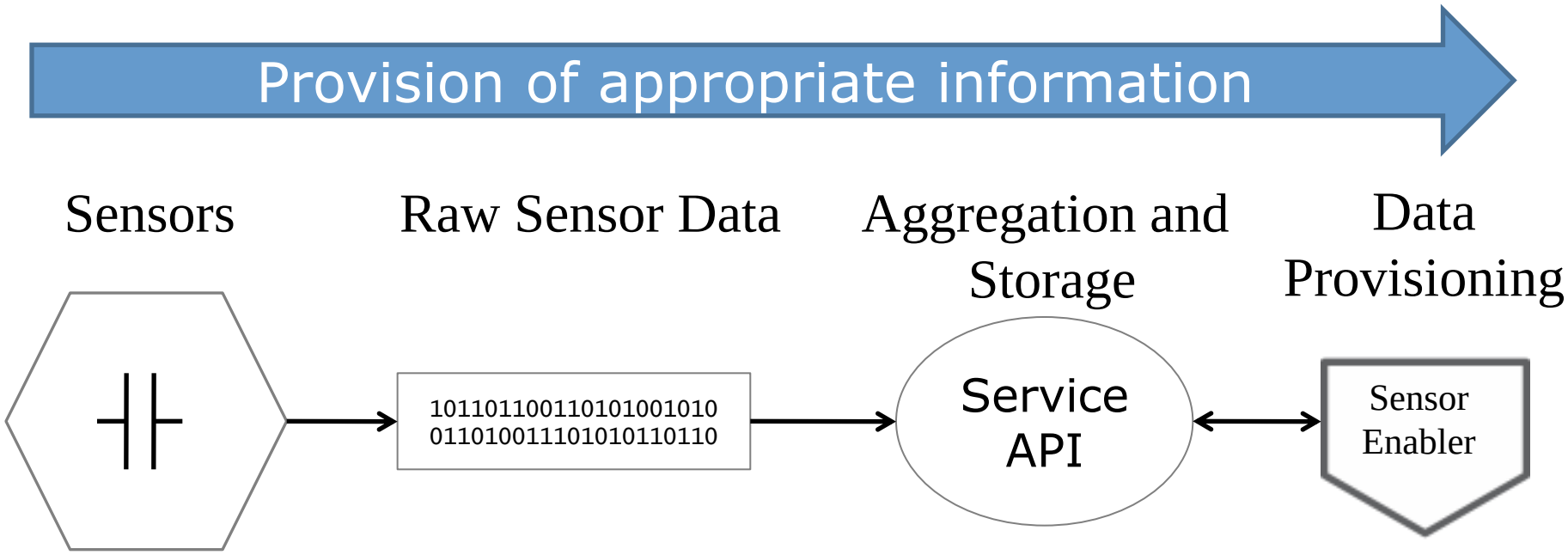


***Source*: ITU adapted from Nomura Research Institute**

"... embedding short-range mobile transceivers into a wide array of additional gadgets and everyday items, enabling new forms of communication between people and things, and between things themselves. A new dimension has been added to the world of information and communication technologies (ICTs): from anytime, any place connectivity for anyone, we will now have connectivity for anything."

From "ITU Internet Reports 2005: The Internet of Things – Executive Summary"

Sensor Data Chain for Smart Cities Applications



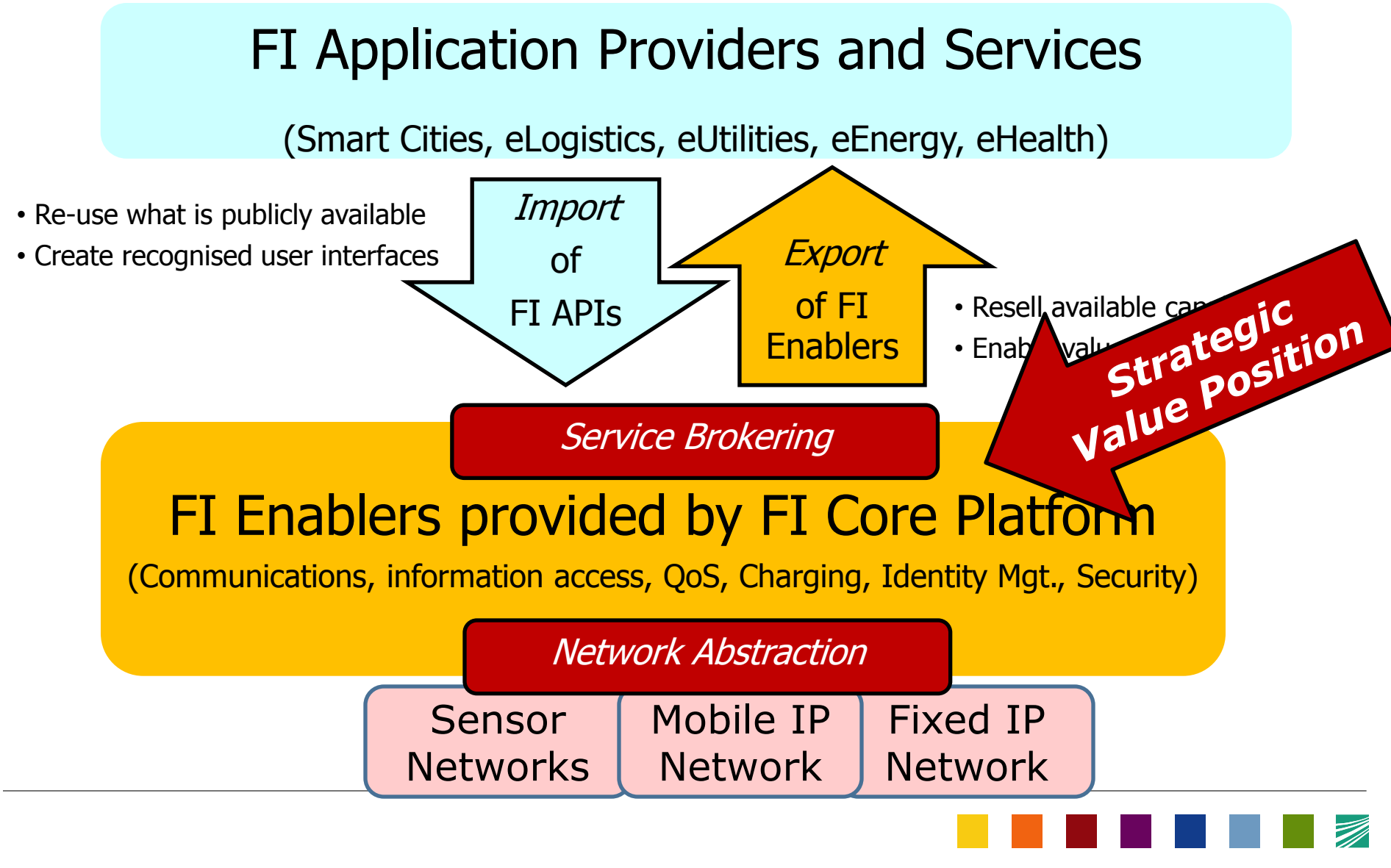
- Permanent Connection
- Piggy Backing
- Capture arbitrary parameters.
  e.g. traffic density, air pollution, etc.

- Sensor Specific
  - Format
  - Transport
  - Media

- E.g. Data Cloud
- Buffers Data
- Backhaul for Communication

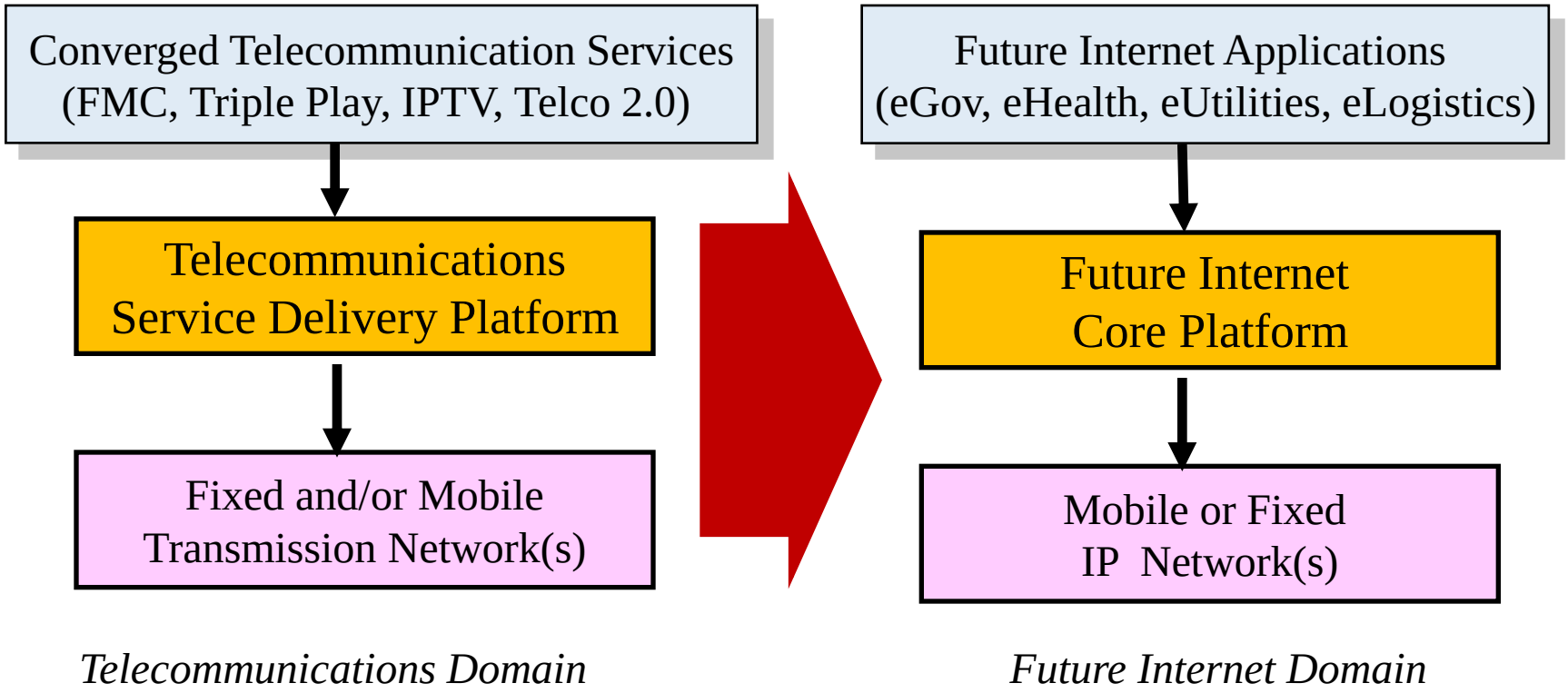
- Provide adapted sensor data to different services

APIs / Enablers in the FI Context …



From Telecommunications toward the Future Internet

Main Idea: A Core Platform provides reusable capabilities (➔ Enablers) for multiple applications hiding the details of underlying technologies



AV/FOKUS are participating in major NGN and FI Testbed Initiatives

- German BMBF Deep-G Project
- Work on FI Service Composition, Monitoring, Security

→ www.g-lab-deep.de

- Open NGN2FI Testbed and Tools
- Work on FI Monitoring, Federation, Service Composition,

→ www.ngn2fi.org

- FI PPP Support Action
- Catalogue of FI Testbeds

→ www.eu-infinity.eu

- Development of FI Monitoring

→ www.onelab.eu

- FI PPP Core Platform
- Extension of OpenEPC for Various FI Applications

→ www.fi-ware.eu

- NGN & FI Testbed Federation
- Lead in Teagle tool development

→ www.panlab.net

- Integration of Panlab and Onelab
- Federation of Testbeds

→ www.openlabs.eu

- Call 5 projects
- Building the FIRE facility

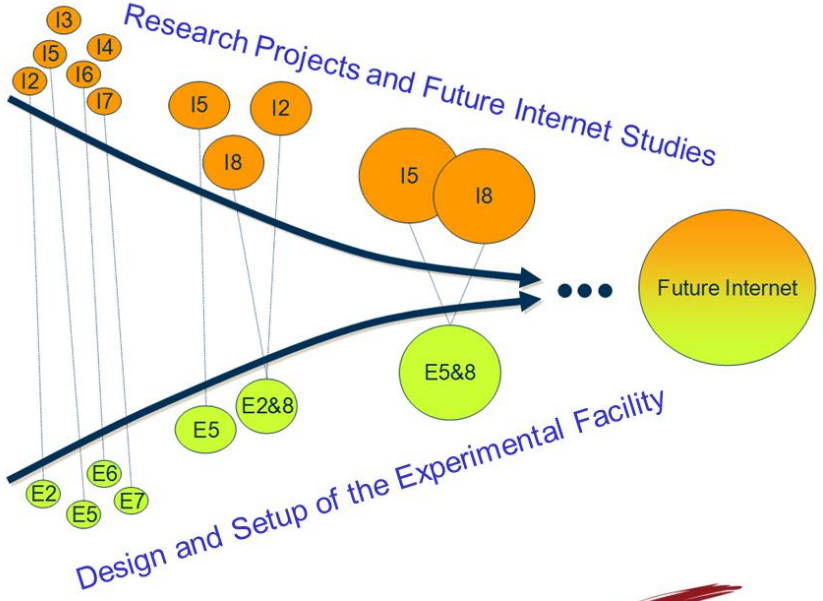
G-Lab
Vision of the Future Internet

SPONSORED BY THE
Federal Ministry of Education and Research

- Closing the loop between research and real-world experiments
- Provide an experimental facility for studies on architectures, mechanisms, protocols and applications towards Future Internet
- Investigate interdependency of theoretical studies and prototype development

http://www.german-lab.de/home/

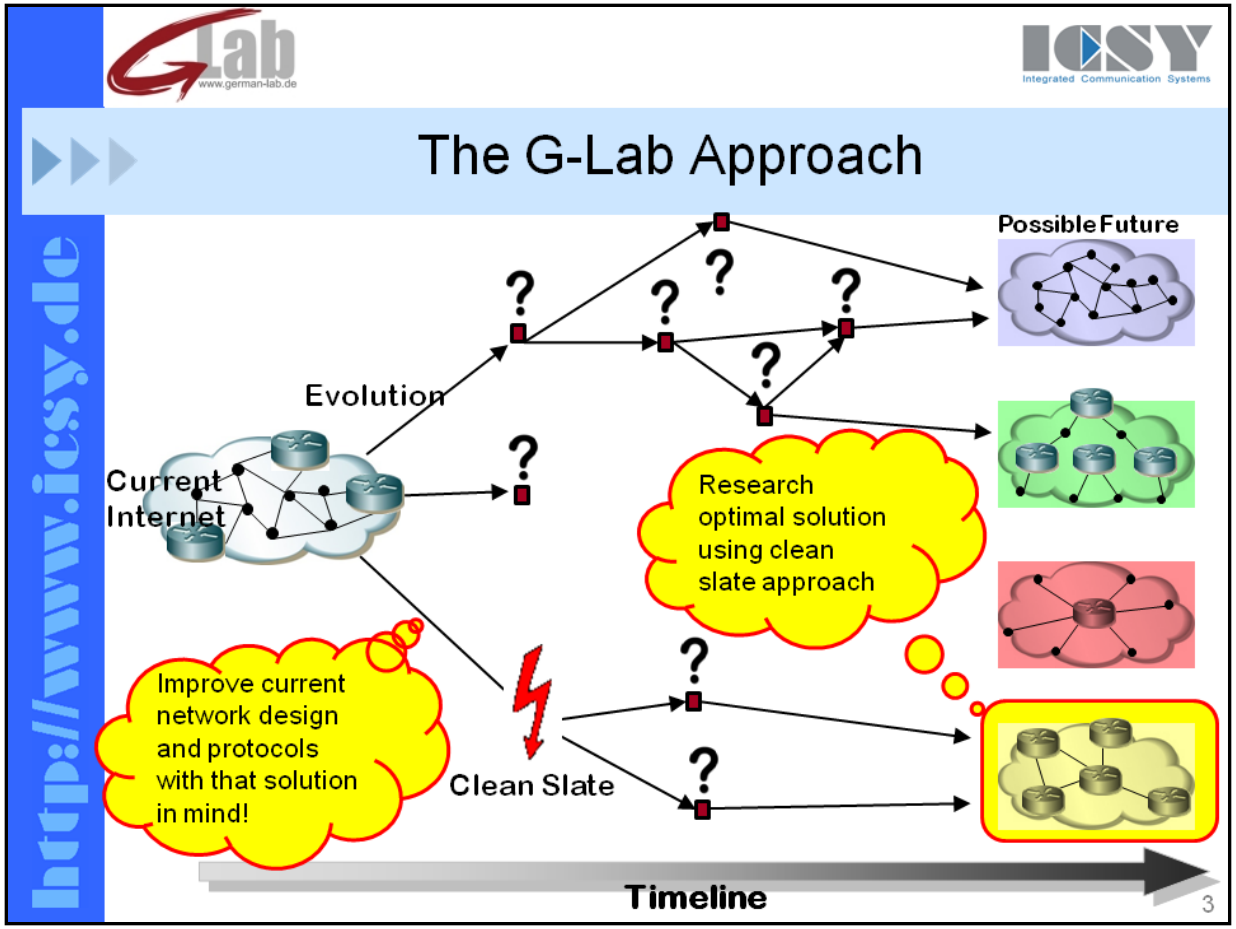
- G-Lab Publications:
  http://www.german-lab.de/publications



G-Lab www.german-lab.de

G-Lab

A Platform for Evolutionary as well as Clean Slate Research



G-Lab: A Future Generation Internet Research Lab. Paul Müller, University of Kaiserslautern

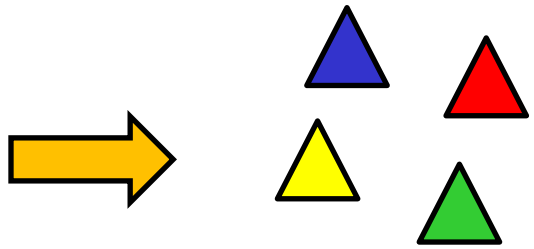
BMBF G-Lab DEEP Project

- *G-Lab DEEP - Deepening G-Lab for Cross-Layer Composition*
- Project within the second phase of German G-Lab project (www.german-lab.de)
- G-Lab DEEP started in October 2009, Duration is 3 years
- Goals
  - Research on innovative composition approaches between network and service layer with special focus on security in Future Internet.
  - Development of a functional composition concept for dynamic composition of functional blocks of the network and service layer.
  - Development of functional blocks on network and service layer in order to protect network components and services.
  - Extension of the G-Lab platform with a DEEP Boot image.
  - Evaluation of federation aspects to connect G-Lab with international Future Internet testbeds.
- Partners: Fraunhofer FOKUS, TU Berlin, University of Duisburg-Essen, TU Kaiserslautern
- Sponsored by BMBF

GEFÖRDERT VOM Bundesministerium für Bildung und Forschung

Service and Network Composition

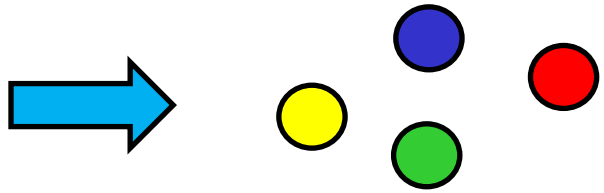
Services



Services Oriented Architecture:
- Web Services,
- Telco Services,
- Third Party Services,
- Business Processes
- etc.

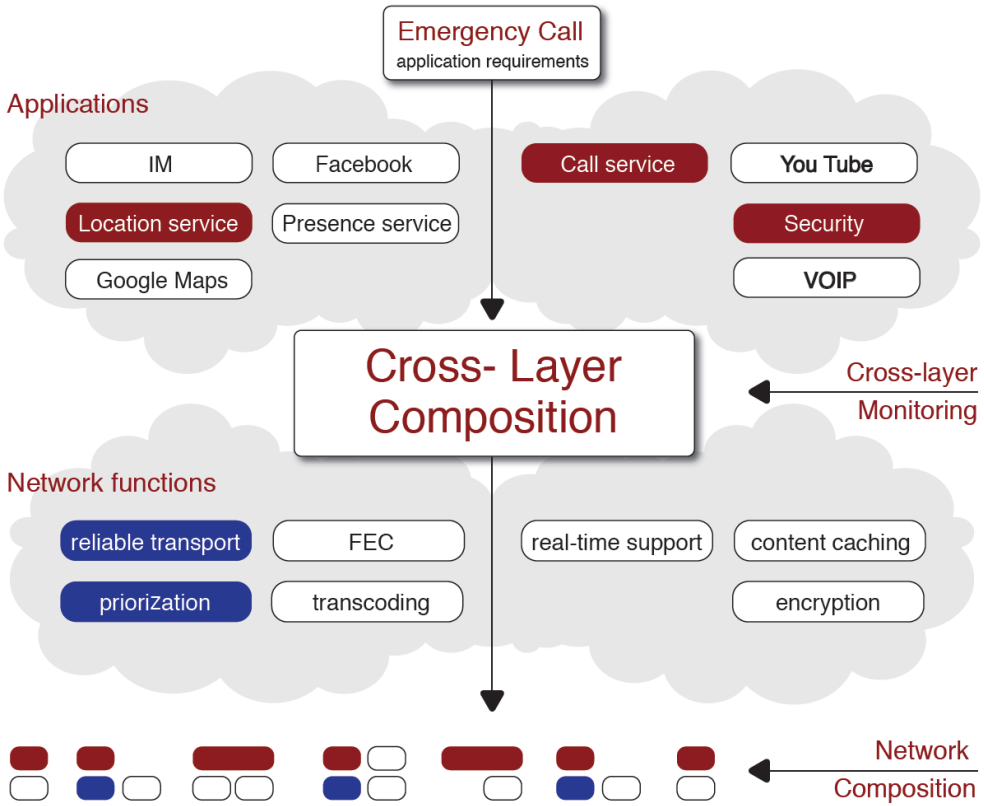
- Same Approach, same Problems, but different Scope

Network



Network Functionality
- Error Correction,
- Reliable Transport,
- Prioritization
- etc.

Cross-Layer Composition



- Service Composition offers:
  - Combined services to customers
  - Customer based personalization of the composed services
- Functional Composition offers:
  - Same SOA model on the network layer
  - Combined functional blocks which offers flexibility on selecting the appropriate blocks
- Cross Layer Composition:
  - Triggered at both layers (service and network) by customer requirements.
  - Decomposition of requirements in service and network requirements.
  - Accordingly selection and composition of services, respectively functional blocks
  - Mediation between the two layers.

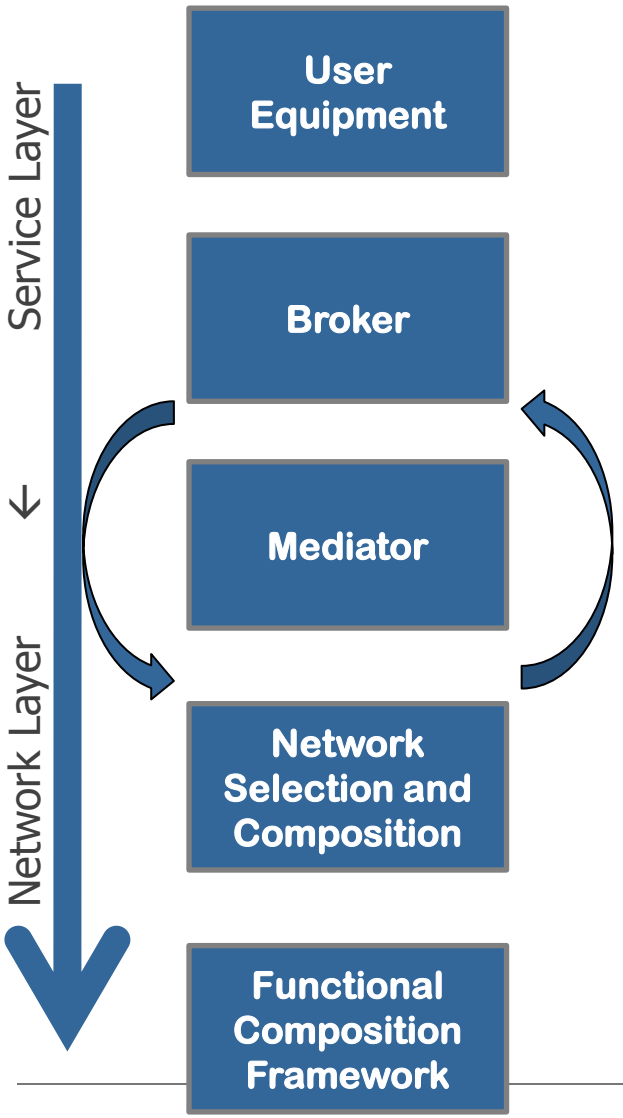
Taxonomy | State of the Art: Service Composition

	Academia			Projects						
Requirement \ Project	**SC in PE**	**SEGSEC**	**QOS BROKER**	**SPICE**	**CSP**	**MAMS**	**SERVICES4ALL**	**SUPER**	**S-CUBE**	**XPOSER**
Composition Behaviour										
Dynamic / Static Selection	dynamic	dynamic	dynamic	n.n.	dynamic	static	static	dynamic	dynamic	static
Automatic / Manual Composition	automatic	automatic	manual	automatic	automatic	manual	manual	manual	automatic	manual
Service Composition Time	design	design	design	ad hoc	ad hoc	design	design	design	des/ad hoc	design
Service Description Language	LATCH	CosMoS		SPATEL	IPO	SDL		OWL-S	BPM	OSGI Metadata
Composition Description			BPEL	CLM+				WSC	BPEL	SCXML
Security / AAA	no	no	no	yes	no	yes	n.n.			yes
Policy Enforcement	no	no	no	no	no	no	no		yes	no
Flexible Service Integration	yes	yes	yes	yes	yes	yes	yes		yes	yes
Composition Approach										
Architecture	centralized	centralized	centralized	centralized	decentralized	centralized	centralized			centralized
Request Translation	no	yes	yes	yes	no	yes	no	yes	yes	yes
Generator	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Evaluator	yes	yes	yes	yes	yes	yes	yes	yes	yes	no
Builder	yes	yes	yes	no	yes	yes	yes	yes	yes	yes
Characterization										
Optimal Solution	yes	yes	yes	yes	yes	user creates solution	user creates solution		yes	user creates solution
QoS Constraints	global	no	global	global	global				global	no
Reliable and Robust	yes	no	yes	no	yes	no			yes	no
State of the Approach										
State			ongoing	ended	ended	ended	ended	ended	ongoing	ongoing
Evaluation	available		available		available			available		

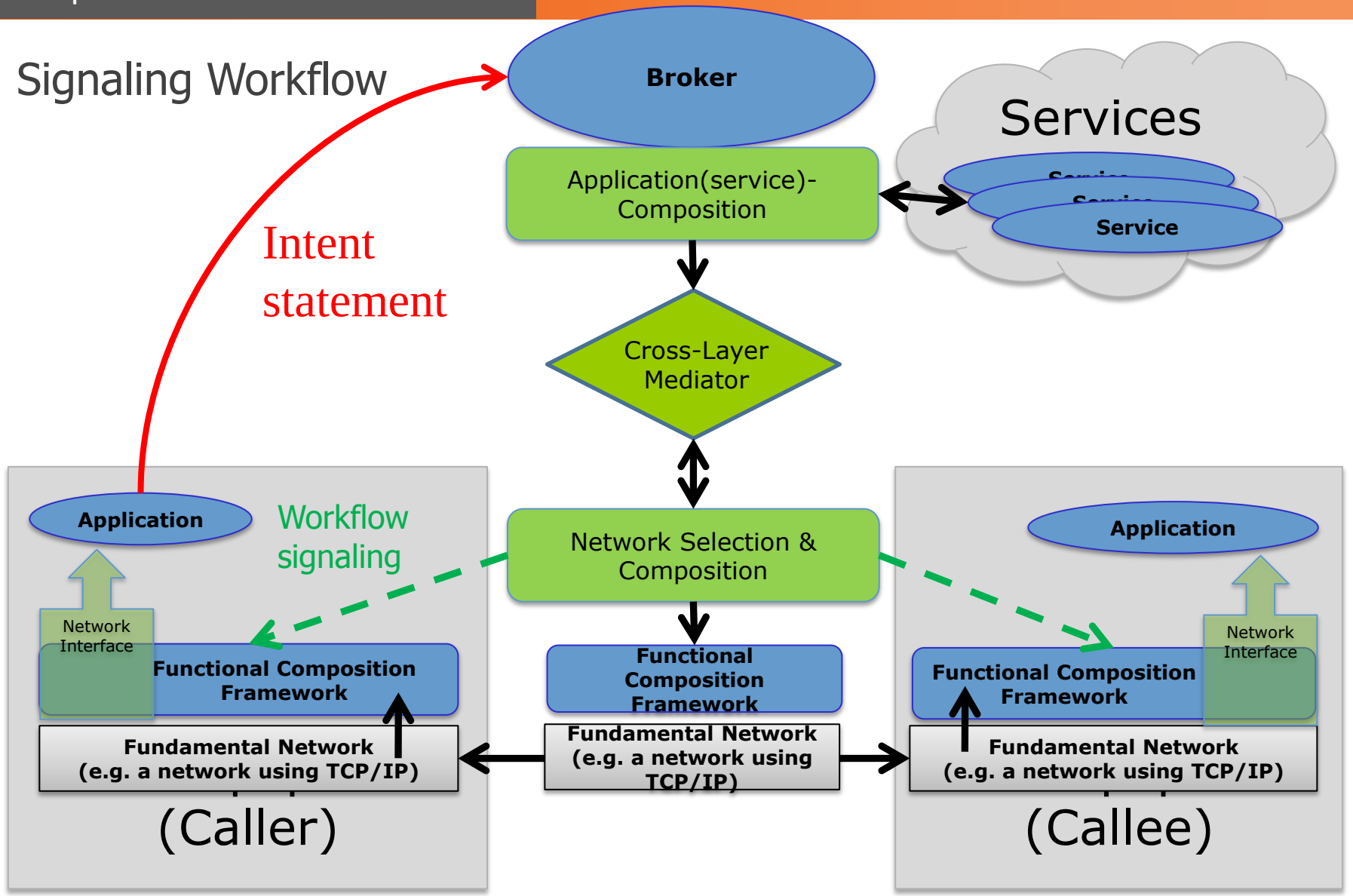
Taxonomy | State of the Art: Functional Composition

	DaCaPo	ANA	RBA	NetServ	Network Service Architecture	SILO	NetLets
Composition Behaviour							
Dynamic Composition	yes	yes	yes	no	no	yes	no
Automatic Composition	yes	yes	yes	n.A.	yes	yes	no
Service Description Language	no	key/value	only identifier	OSGI description	OWL	RDFS	no
Ontology Approach	no	no	no	no	OWL	RDFS	no
Composition Approach	graph theory	graph theory	n.A.	n.A.	situation calculus	graph theory	no - netlet selection
Flexible Service Integration	no	partially	yes	OSGI bundle	yes		partially - new virtual stack
Composition Architecture							
In-band / Out-of band signalling	out-of-band	in-band	in-band	out-of-band	out-of-band	out-of-band	out-of-band
Composition Engine Centralized / Decentralized	decentralized	decentralized	decentralized	n.A.	centralized / hierarchical	n.A.	n.A.
Layer-Architecture	partially	no	no	partially	no	partially	yes
Service Discovery and Routing Algorithm	n.A.		n.A.		DSMR / DSRP		no
Current Status							
Implementation Available	-	yes	no - concept	yes -Click-Router	yes - Emulab	yes	yes
ongoing project	no	ends 2010	-	yes	-	yes	ends 2010

From INTENT Statement to Data Flow (Components and Tasks)



- Formulates INTENT (call emergency center, demand a video-stream or brows a website)
- Transforms INTENT into REQUEST
  - Determines requirements of the INTENT
  - Performs AAA (Policy Engine)
  - Service Composition
  - Formulates application requirements in a REQUEST
- Maximizes the trade-off between demanded application requirements and offered network services
- Offers network functionalities (services)
- Selects functional building blocks, creates an execution workflow and establishes the data path
- Executes workflows and processes multiple flows according their requirements

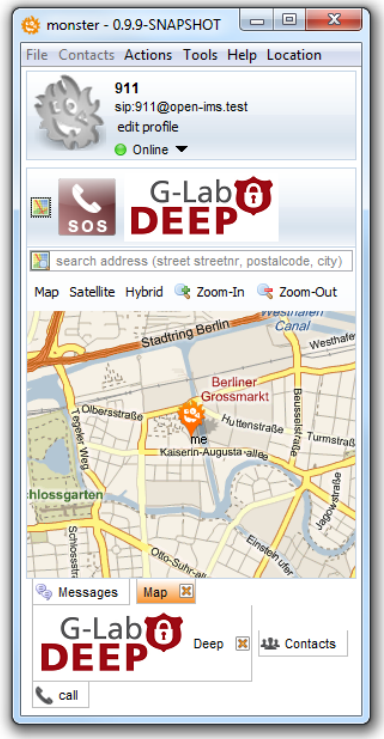

Signaling Workflow
Broker
Services
Application(service)-Composition
Service
Intent statement
Cross-Layer Mediator
Application
Workflow signaling
Network Selection & Composition
Application
Network Interface
Functional Composition Framework
Functional Composition Framework
Functional Composition Framework
Network Interface
Fundamental Network (e.g. a network using TCP/IP)
Fundamental Network (e.g. a network using TCP/IP)
Fundamental Network (e.g. a network using TCP/IP)
(Caller)
(Callee)

Cross-Layer Composition Demonstrator in BMBF DEEP-G Project

- G-Lab DEEP demo at EuroView 2010

(All scenarios extend the previous scenario!)

- Scenario 1: Successful voice call using Cross-Layer Composition
- Scenario 2: Massive attacks utilize the network
- Scenario 3: Failing voice call in a highly utilized network
- Scenario 4: Successful emergency call in a highly utilized network



Benefits

- Cross-layer data exchange brings benefits to all layers
- Composition brings in the needed flexibility
- Overall solution is complex, but can provide advances features
- Adoption with current Internet not always easy (e.g. overlays)
- Applications in a Future Internet with composition features will need:
  - extended application interfaces (standardised APIs based plus system libraries)
  - ability to signal requirements themselves.

G-Lab DEEP

Challenges

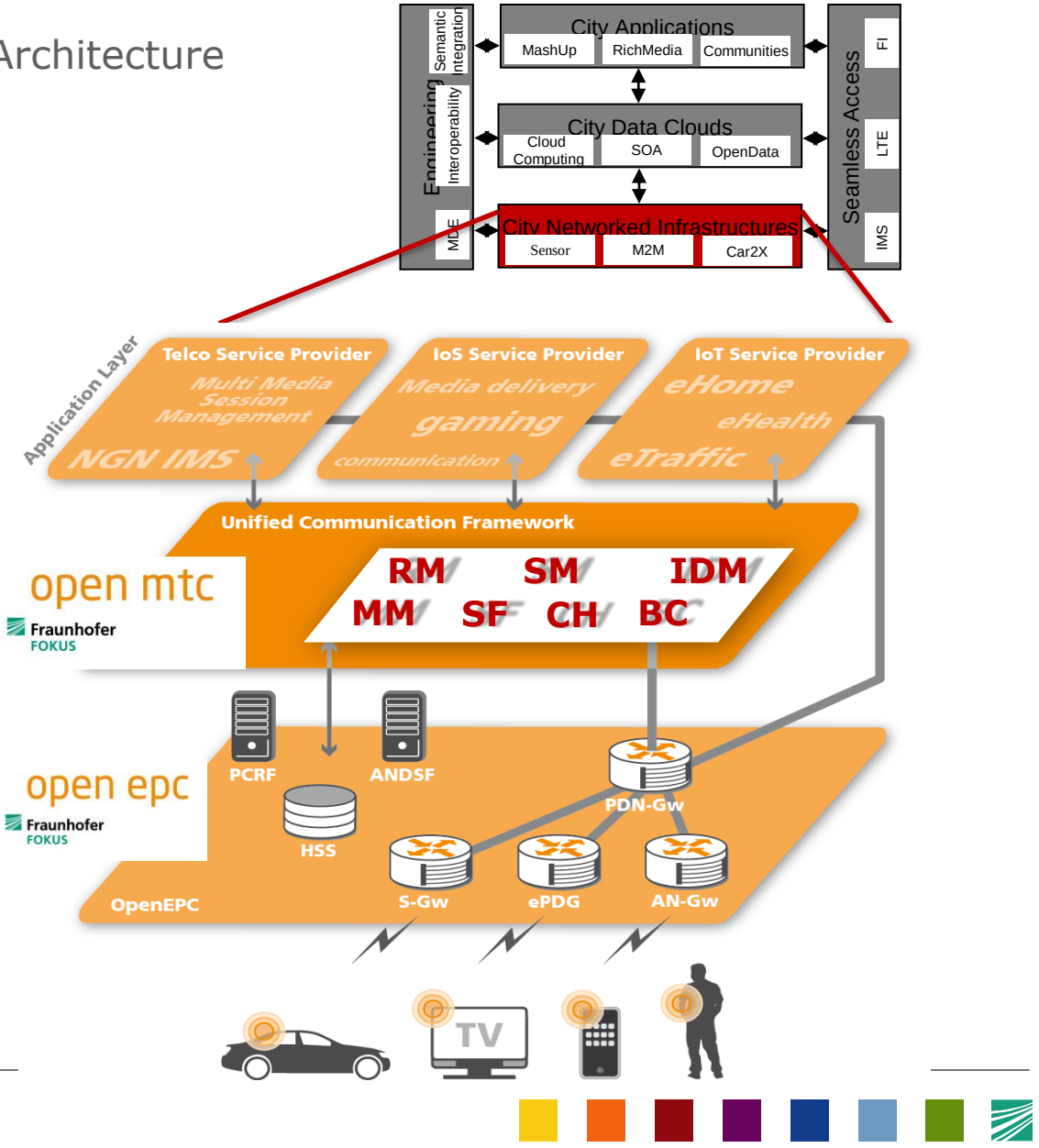
- Scalability and Performance
- Resolution of conflicting or unsolvable requirements
- Heterogeneity of networks (technical)
- Federation of networks (technical and management-wise)
- Generality of the solution
- Chicken and Egg Problem wrt. Requirements Spec. and Data Traffic
  - Will finally need "Future Internet"–aware applications!

Mobile M2M

- *Title* - Mobile M2M
- *Position statement/message*
  The provisioning of open M2M oriented APIs in a Next Generation Mobile Network offers the chance for innovative Future Internet enabled services in the emerging area of machine type communication, enabling new businesses models for a smart city.
- *Short description*
  Today's M2M Communication is either based on specific, use case oriented solutions, or "abuses" mobile networks that have been designed for human-to-human communications.
  In a modern city, requirements for mobile machines and related services set new standards for network access, data processing and treatment in mobile networks.
  The FOKUS Mobile M2M Platform offers APIs for controlling network capabilities as well as network contained intelligence for services that are unaware of the capabilities of the underlying network. Thereby, the efficient management of huge quantities of endpoints (e.g. city sensors / cameras) over mobile networks becomes possible.
- *Target customers*
  - Service providers
  - Equipment vendors
  - Public administration
- *FOKUS offer*
  - SotA for M2M and mobile NGN
  - Design and piloting of an Mobile M2M Platform
  - Design and integration of a use case scenario and demonstrator
- *Keywords*
  - Open API
  - M2M
  - Sensor Network
  - NGN
  - Future Internet
  - Mobility

Instantiation of the Reference Architecture

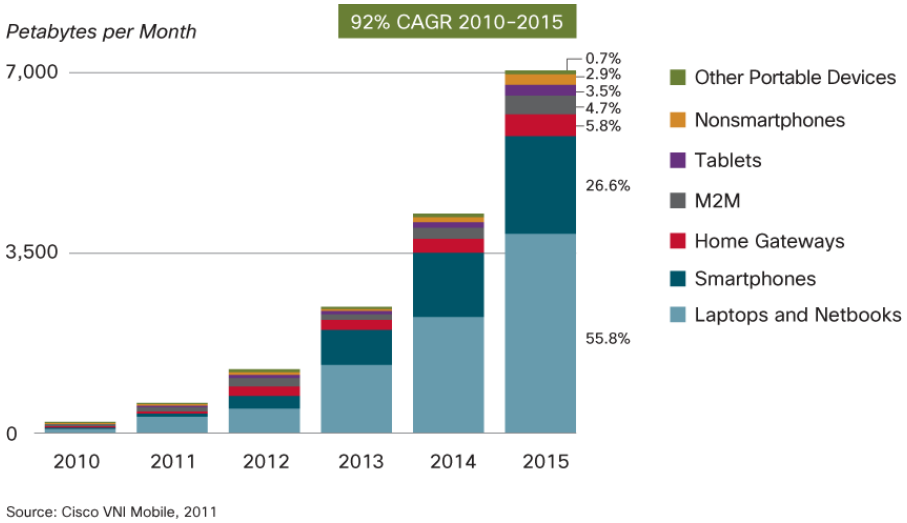
- Main components:
  - Bearer Control
  - M2M Session Mgmt.
  - M2M Charging
  - M2M IDM
  - M2M Resource Mgmt.
  - Domain Selection
  - M2M Mobility Mgmt.



NGN2FI Evolution Lab

Global Data Traffic Forecast

- Mobile data traffic increase is parallel to the increase in number of devices
- The device capabilities are spanning
  - From: Simple sensor nodes
  - To: High Definition video cameras
- The comm. requirements are spanning
  - From: a "four byte" fire alarm
  - To: continuous real-time video streaming from video camera



Source: Cisco VNI Mobile, 2011

Device Type	Growth in Users, 2010-2015 CAGR	Growth in Mobile Data Traffic, 2010-2015 CAGR
Smartphone	24%	116%
Portable gaming console	79%	130%
Tablet	105%	190%
Laptop and netbook	42%	85%
M2M module	53%	109%

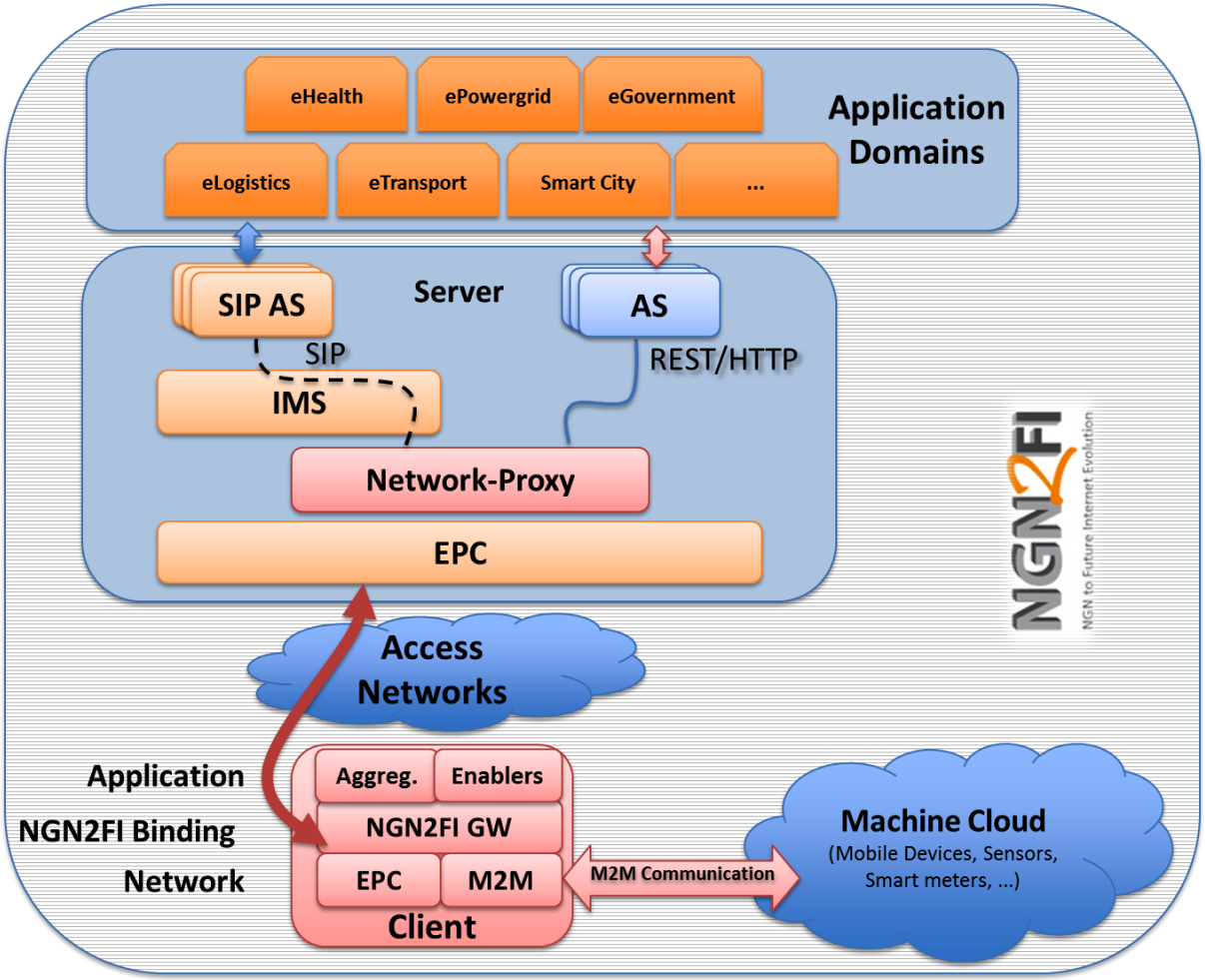
Source: Cisco VNI Mobile, 2011

Open MTC Motivation

- Increasing number of mobile non-human communication endpoints (machines)
  - WWRF: 7 trillion devices by 2020 (London 2010)
  - Vodafone: Plans for trillions of devices (M2M Now)
  - ETSI & 3GPP have working groups on M2M
- IMS was designed for H2H and H2M multimedia communication
  - Significant signalling overhead for short data communication
  - SIP only based signalling
- EPC designed for IP connectivity (QoS, Security, AAA, Charging, Mobility Management) - uniform signalling and functionality for all the devices
  - Shared IP connectivity services among application domains (QoS and Charging, authentication and authorization)
  - QoS and Charging are established based on session signalling
  - Not all wireless connected devices require mobility management
  - ISIM/SIM/IMSI concept not suitable for the small devices

1 trillion = 10^{12}

Providing a Universal Communication Service Interface above (Open)EPC

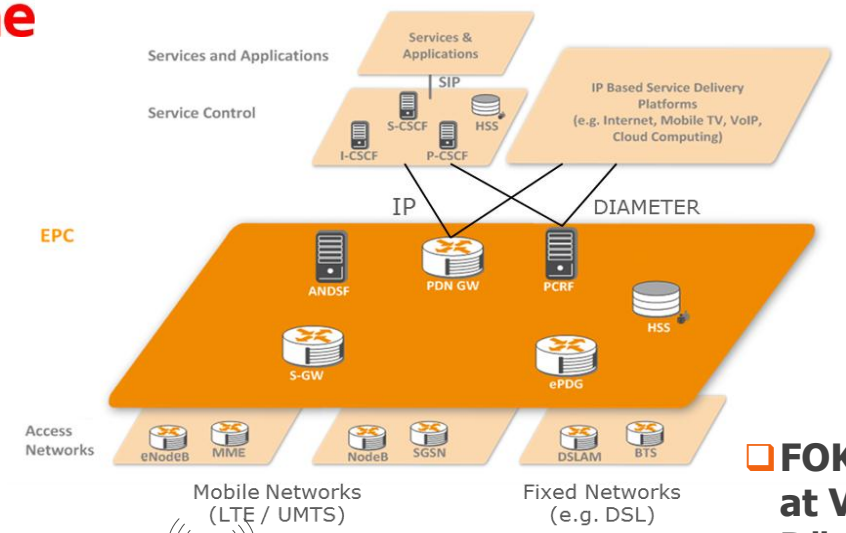


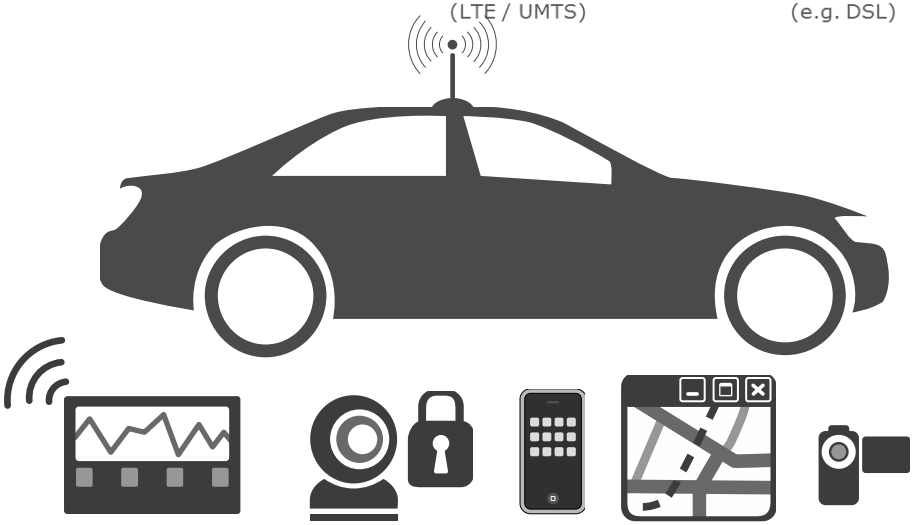
Starting Point: An Automotive Testbed Trial for M2M

vodafone

osims
Fraunhofer FOKUS

open epc
Fraunhofer FOKUS

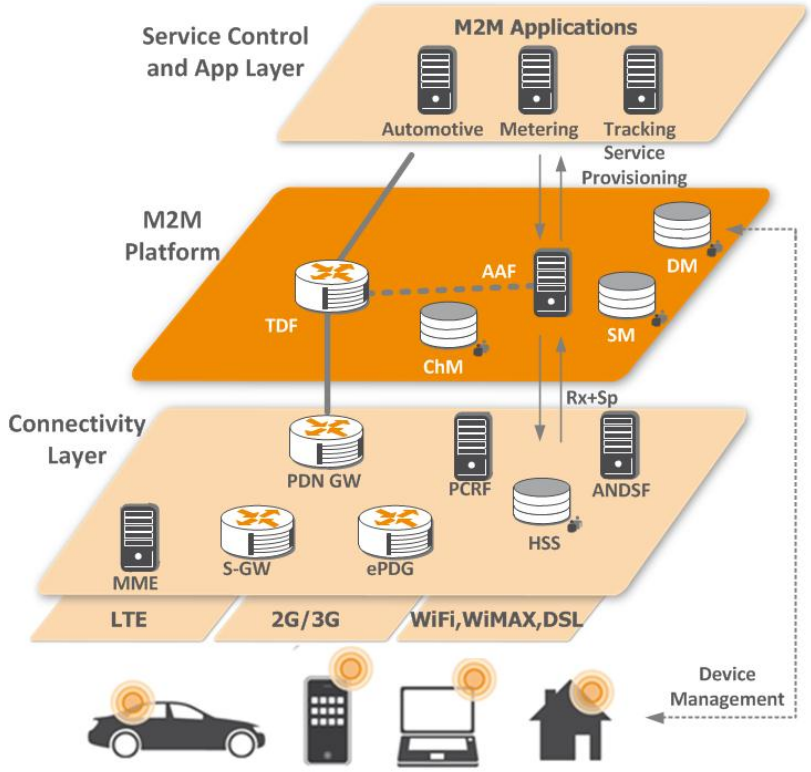




- **FOKUS OpenIMS and OpenEPC deployed at Vodafone Multi Vendor IOP Testbed in Düsseldorf, Germany (BMBF COCARS-X)**
- **5 Use cases featuring**
- Multimedia Content Streaming
- Application download
- Social Networks
- Car Data Diagnostics
- Charging and Billing
- All over IMS and EPC

M2M Platform for Mobile Machine Type Communication (OpenMTC)

open mtc
Fraunhofer FOKUS



Defining an intermediary M2M Platform which handles the:

- Device Management (Communication Management)
- Session Management
- Bearer and Charging Management

Based on:

- Initial provisioning of the M2M apps
- Subscription profile
- Current active communication
- CORE or other communication

Providing requirements towards:

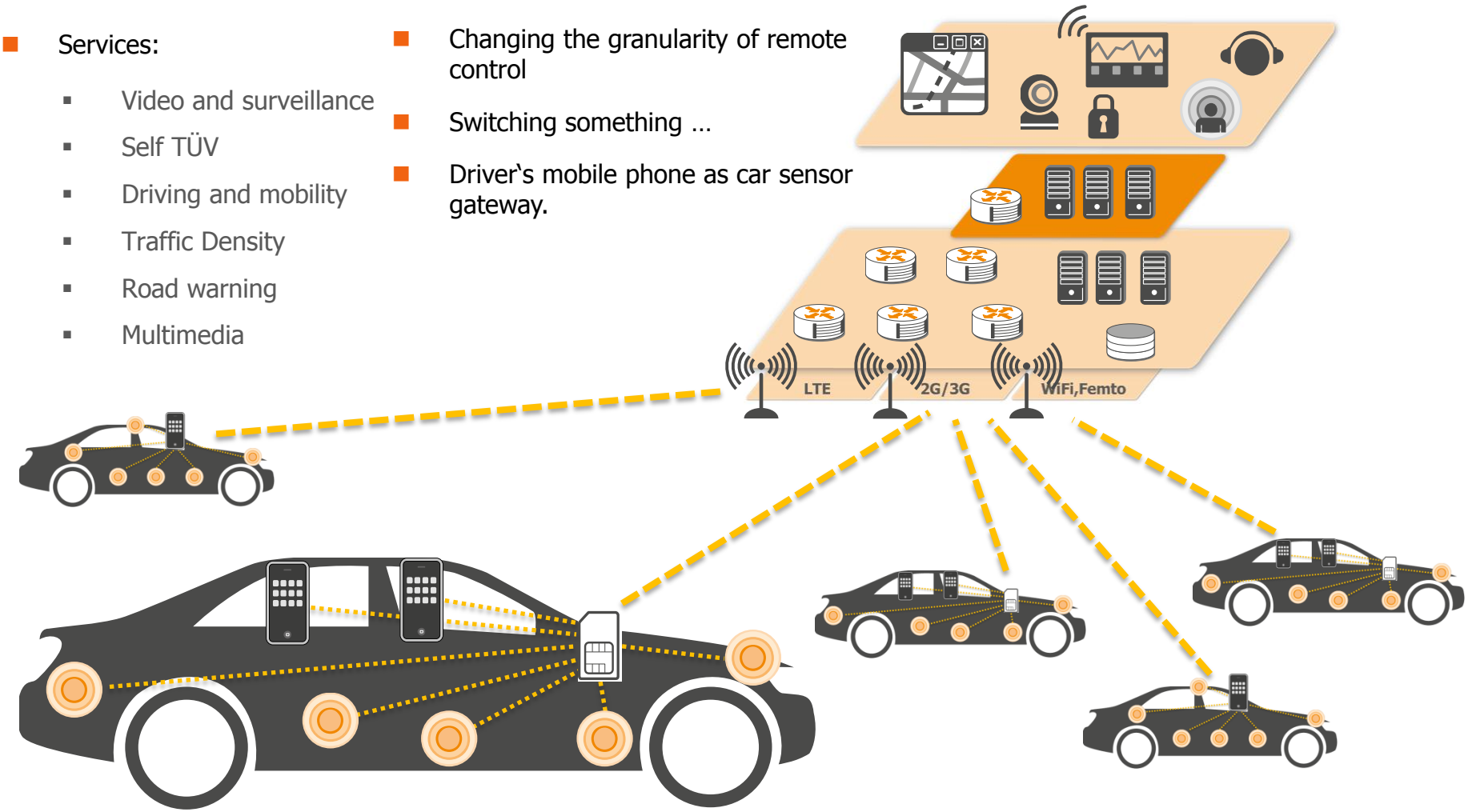
- Traffic Detection Function
- Evolved Packet Core
- Machine Terminal

Automotive – Remote Control

open mtc
Fraunhofer FOKUS

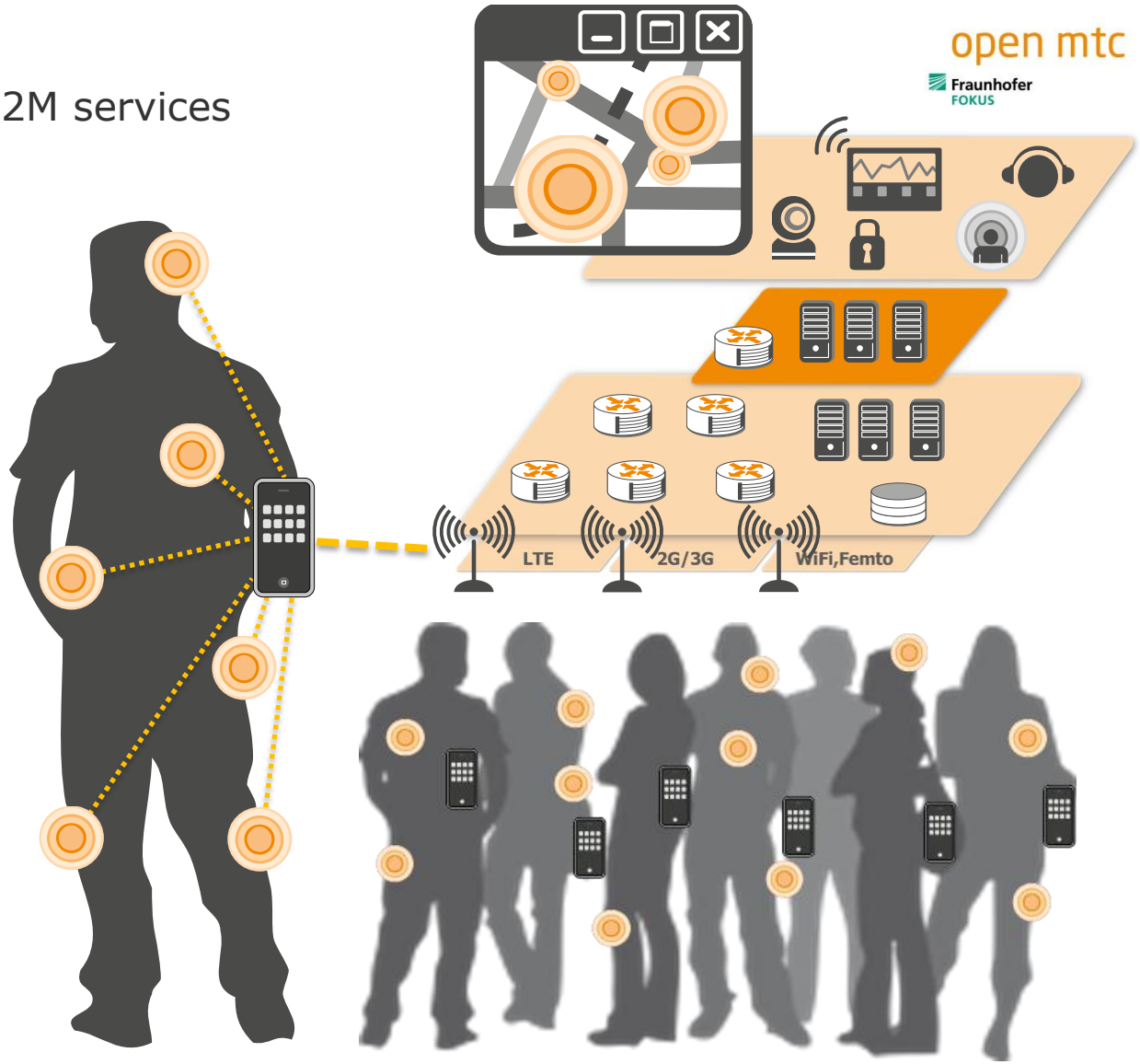
- Services:
  - Video and surveillance
  - Self TÜV
  - Driving and mobility
  - Traffic Density
  - Road warning
  - Multimedia

- Changing the granularity of remote control
- Switching something …
- Driver's mobile phone as car sensor gateway.



Healthcare
Real Time & Proximity M2M services

- Real-Time Services:
  - Heart Beat …
  - Alarm Service
  - Changing the "health" level
- Proximity Services:
  - Environment measures
  - Warning Device
  - Privacy & Identity
- Broadcasting/multicast:
  - Calamity warning
  - Real-time device mgmt updates
  - Changing the "monitoring" level



Summary - Future Internet

- Challenges of today's Internet
- Manifold definitions of the term "Future Internet"
- FI addresses problems of today's Internet
- Academia and industry develop architectures, concepts, prototypes and pilots
- Evolutionary and revolutionary approaches
- Large scale distributed experimental facilities provide the base for realizing novel ideas
- National and international funding schemas

Agenda

- Introduction
- IP Multimedia System (IMS) as Uniform All-IP Operator Service Platform
- Evolved Packet Core (EPC) Overview
- Future Internet (FI)
- Summary - Relating EPC, IMS, SDPs, and FI
- Q&A

Agenda

4. Future Internet (FI)

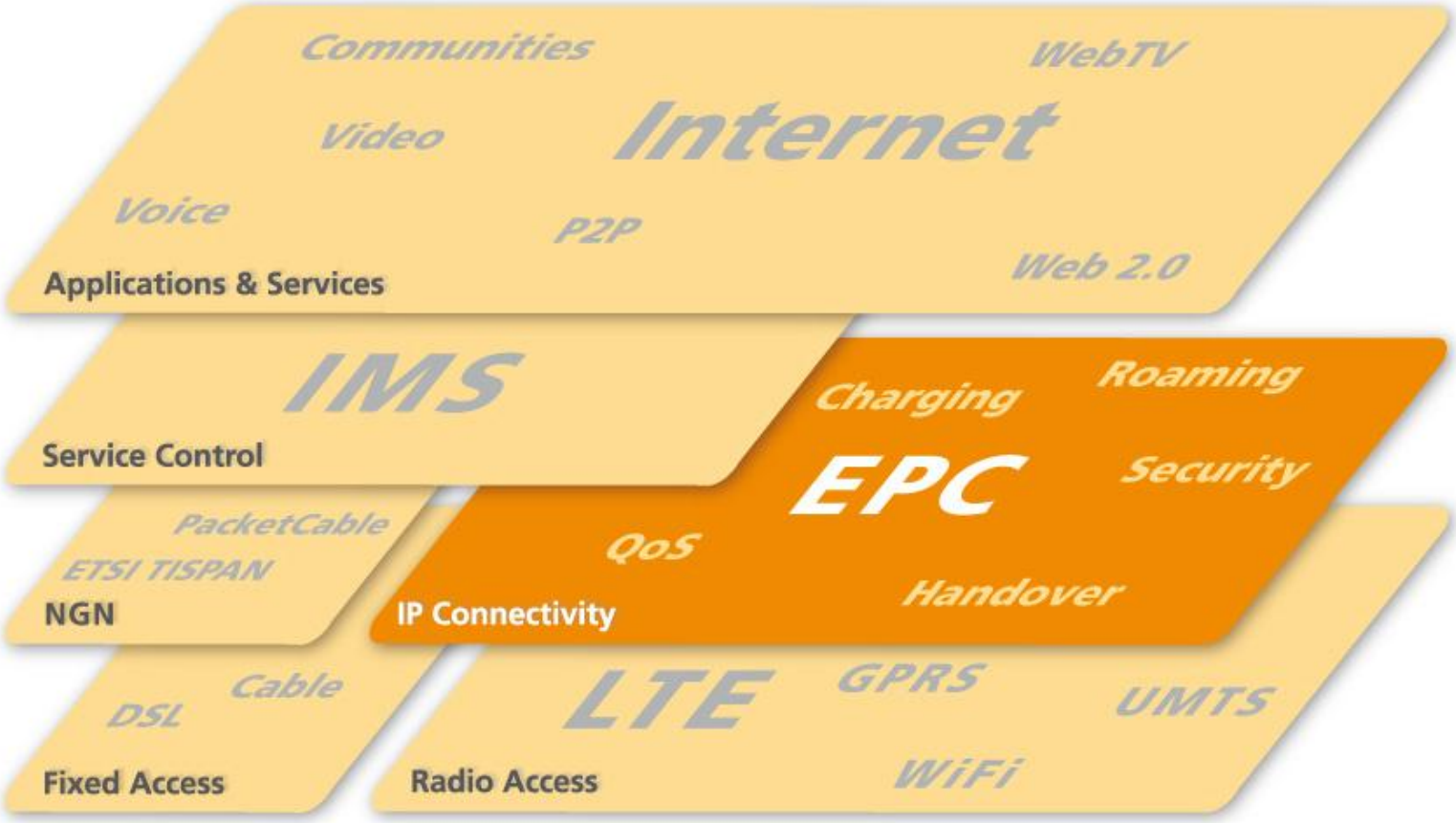
- FI Principles and global status quo
- Service Provision Principles in FI – Cross layer functional composition
- Towards FI Enablement: emerging FI Core platforms for FI Enabler
- Comparing Telco and FI Enablement principles
- Positioning EPC within the FI context
- Introduction of the FOKUS NGN2FI Evolution Lab

5. Summary - Relating EPC, IMS, SDPs, and FI

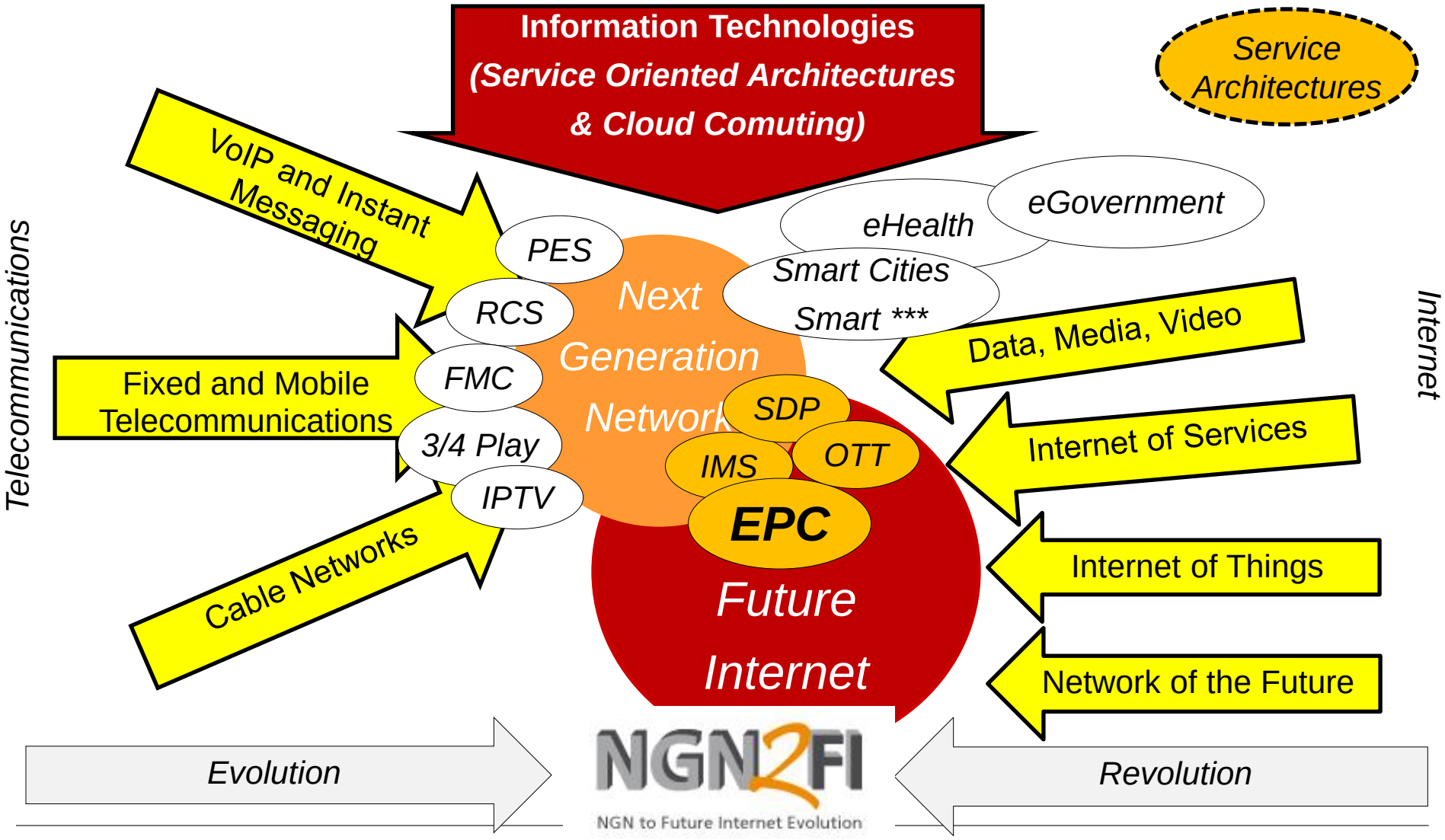
- Why IMS will be for seamless VoIP only and why EPC will become the universal all-IP service control platform
- Research Challenges ahead

Q&A

Relating SDPs, IMS, EPC, and FI



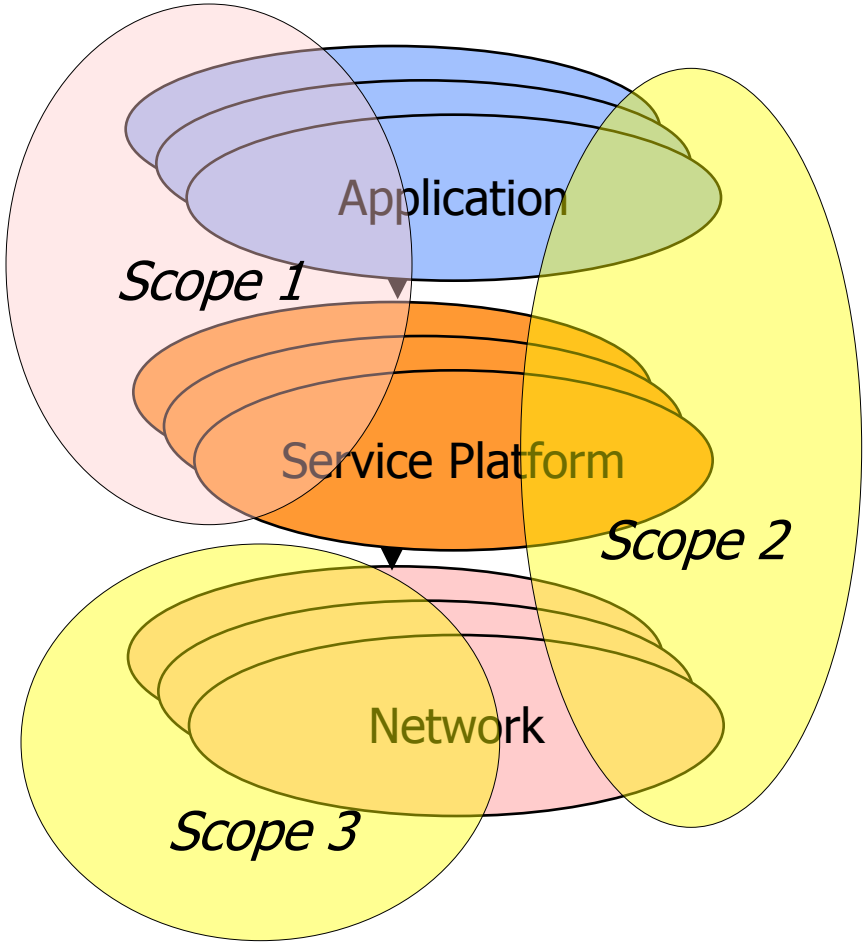
EPC is in the Middle of the two Domains



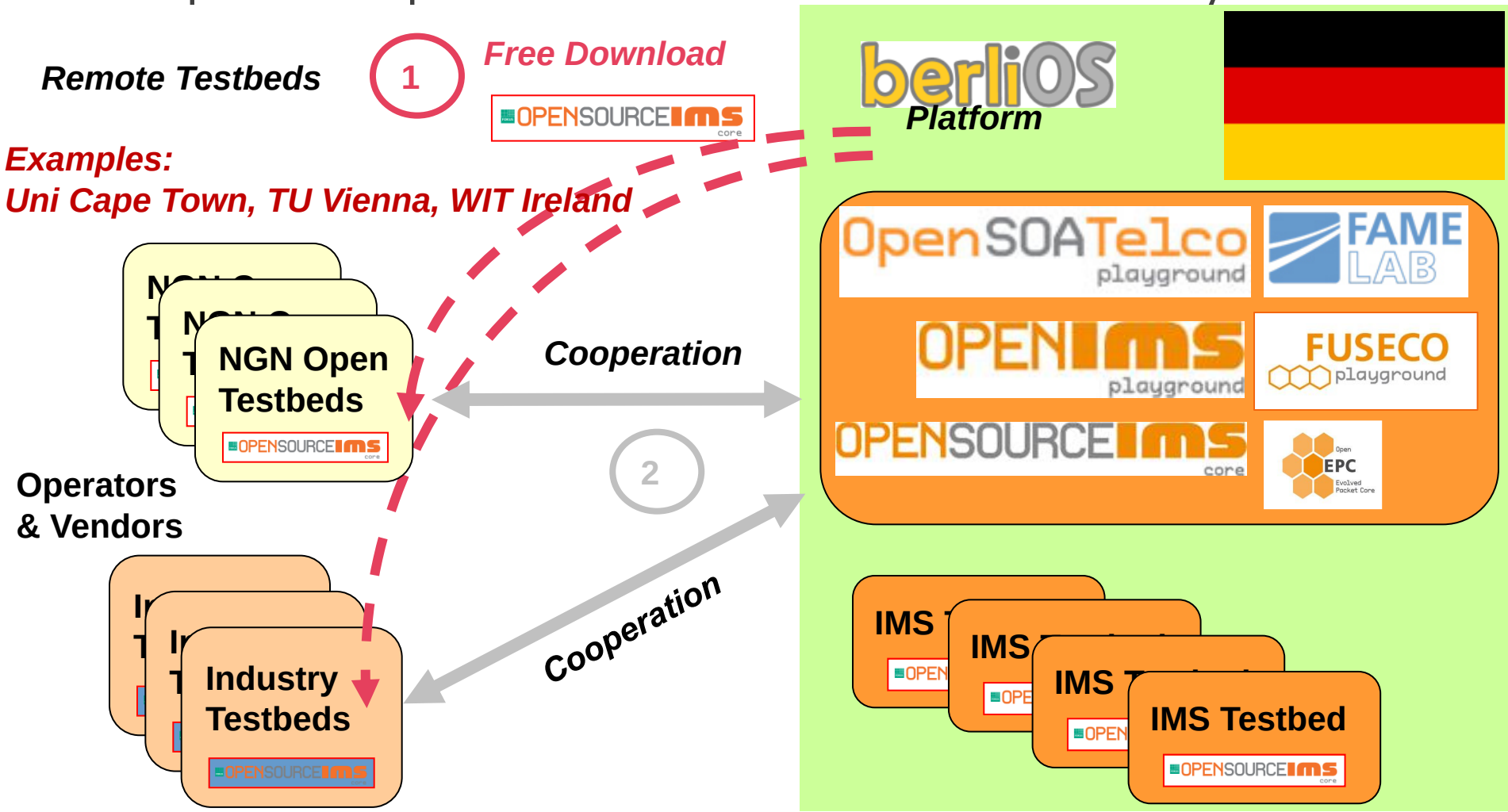
The Challenge of Testbeds and their potential Federation

Different Application and Testbed Scopes

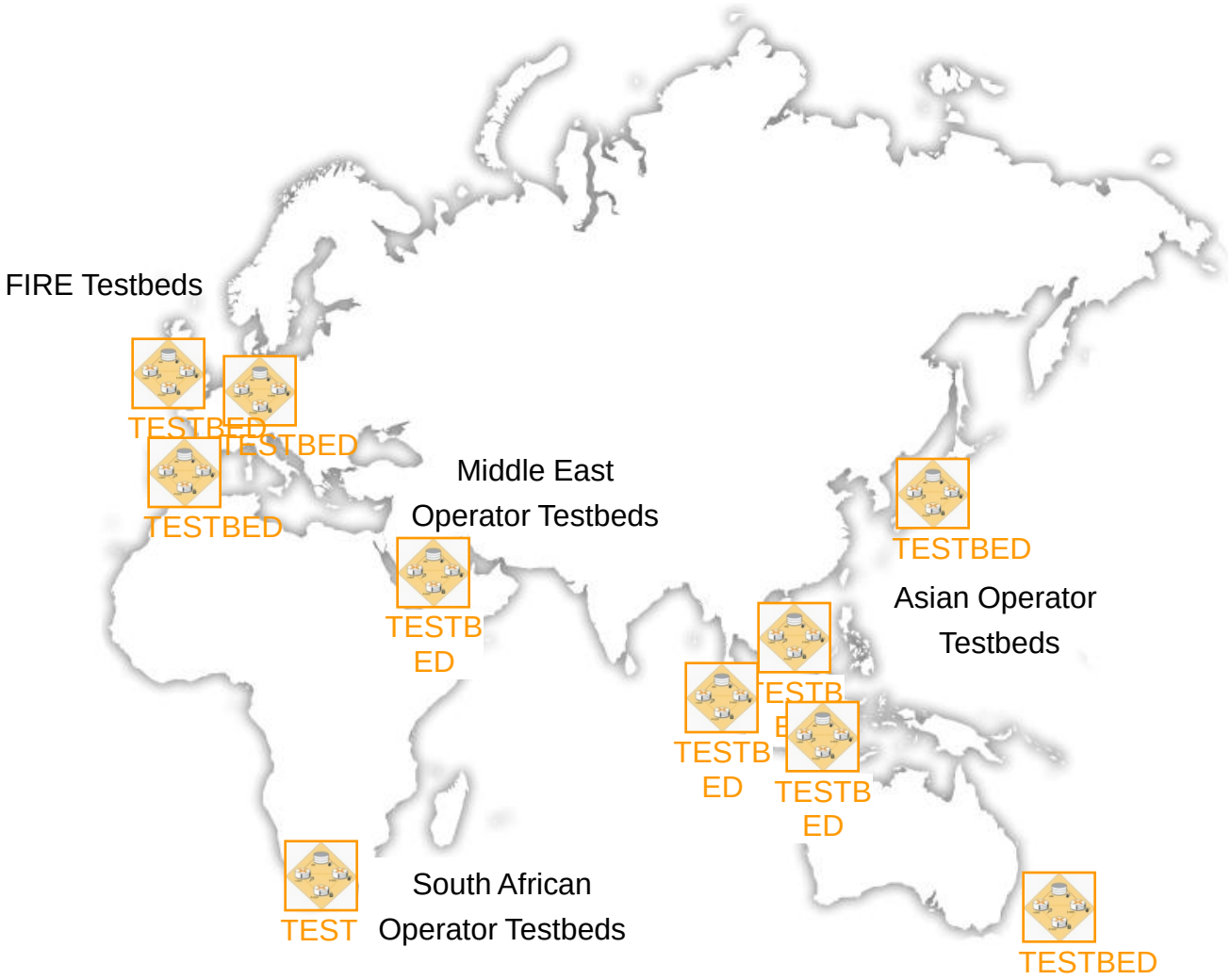
- Innovative multimedia applications
  - eHealth, eGovernment, e/mCommerce, interactive TV, web 2.0, telco2.0, etc.
- Service delivery platforms
  - IP Multimedia System, P2P systems, broadcasting systems, etc.
- Network technologies
  - 3G beyond, Wimax, LTE, Fixed Broadband, etc.
- Sometimes also beta test user communities
- Sometimes mixture of all above domains



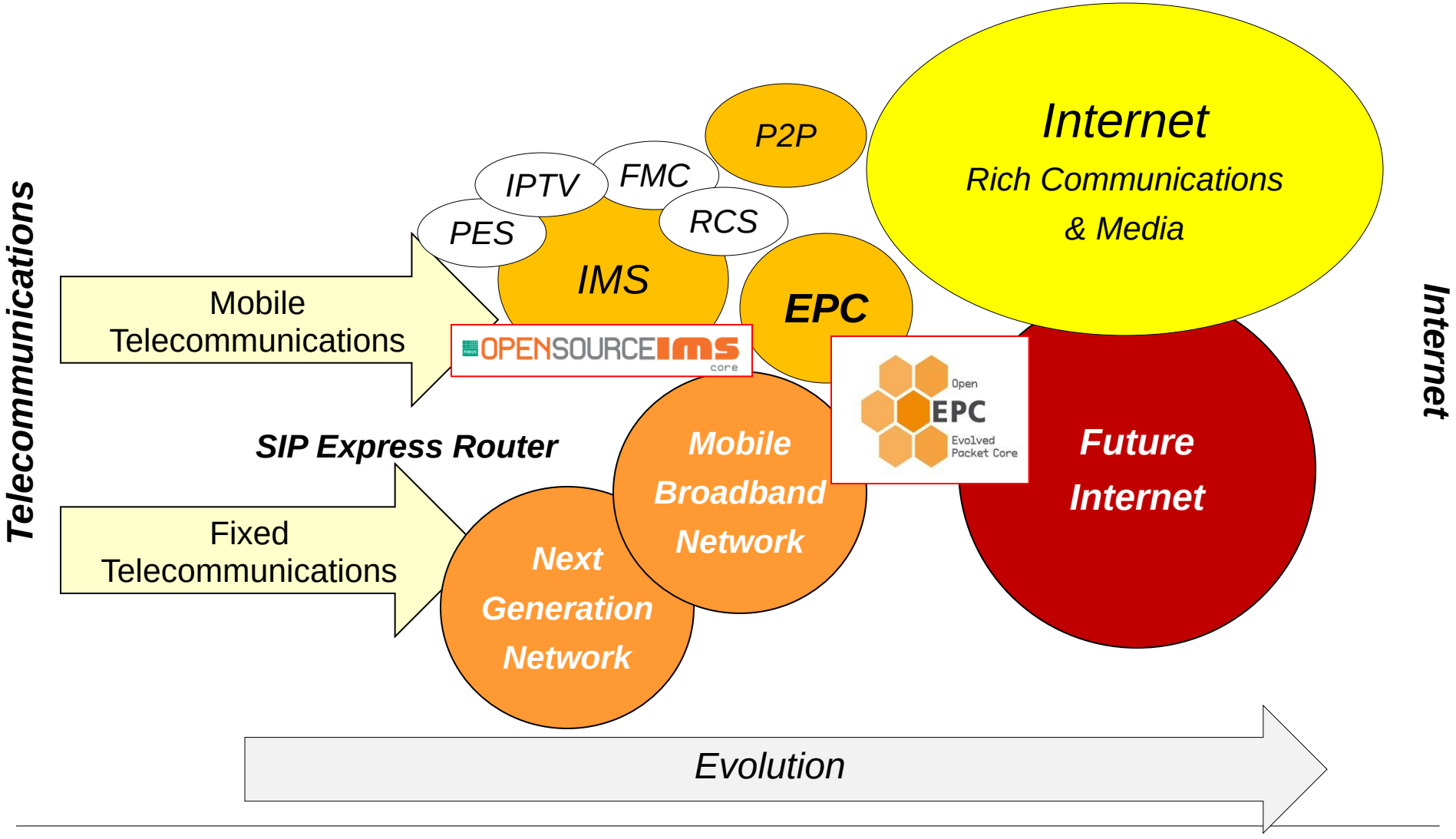
FOKUS provides Open Testbeds to Academia and Industry



Commercial NGN Testbed Deployments around the world

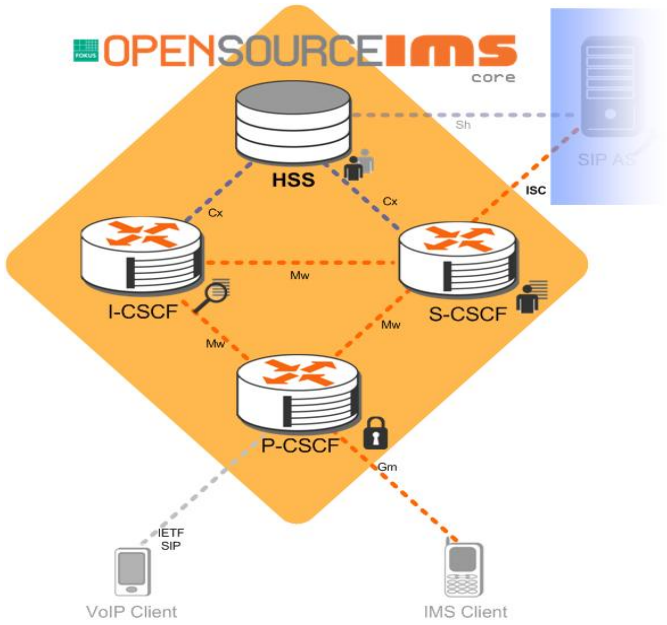


From SER, Open IMS to Open EPC: Importants Tool for Prototyping



Open Source IMS Core System (2006)

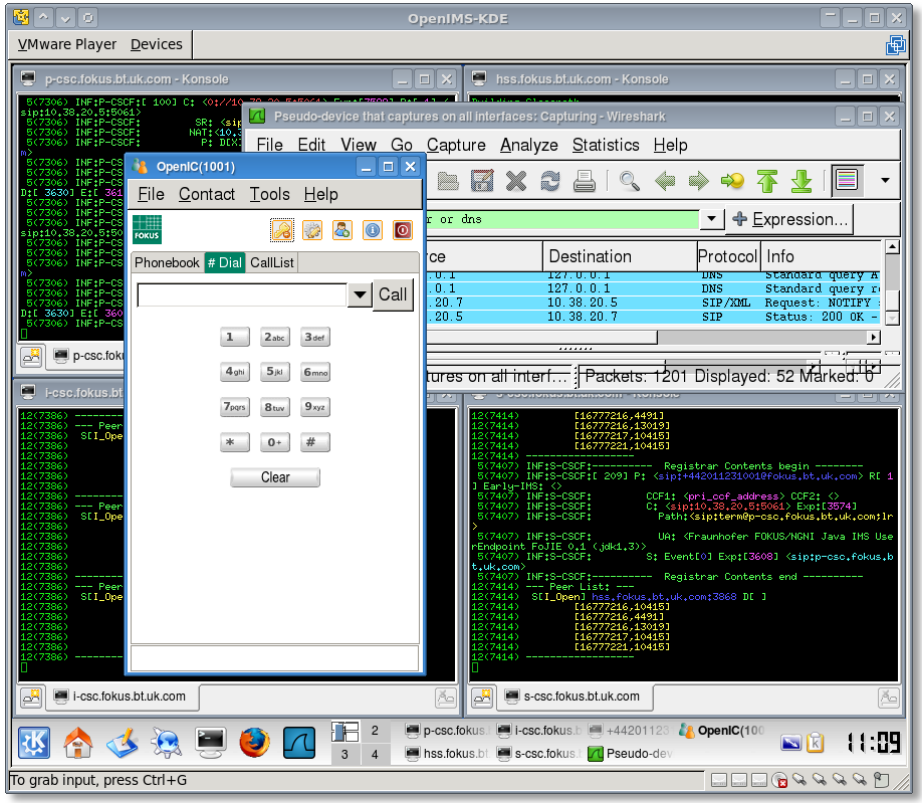
- In November 2006 the FOKUS ***Open Source IMS (OSIMS) Core*** System - the core of the **Open IMS playground** - has been offiically released to the general public via the BerliOS Download site
  - www.openimscore.org
- OSIMS allows industry and academic institutions to setup own testbeds (with or without FOKUS support and components)
- Since then OSIMS has been downloaded many thousand times from all over the world
- See also www.open-ims.org



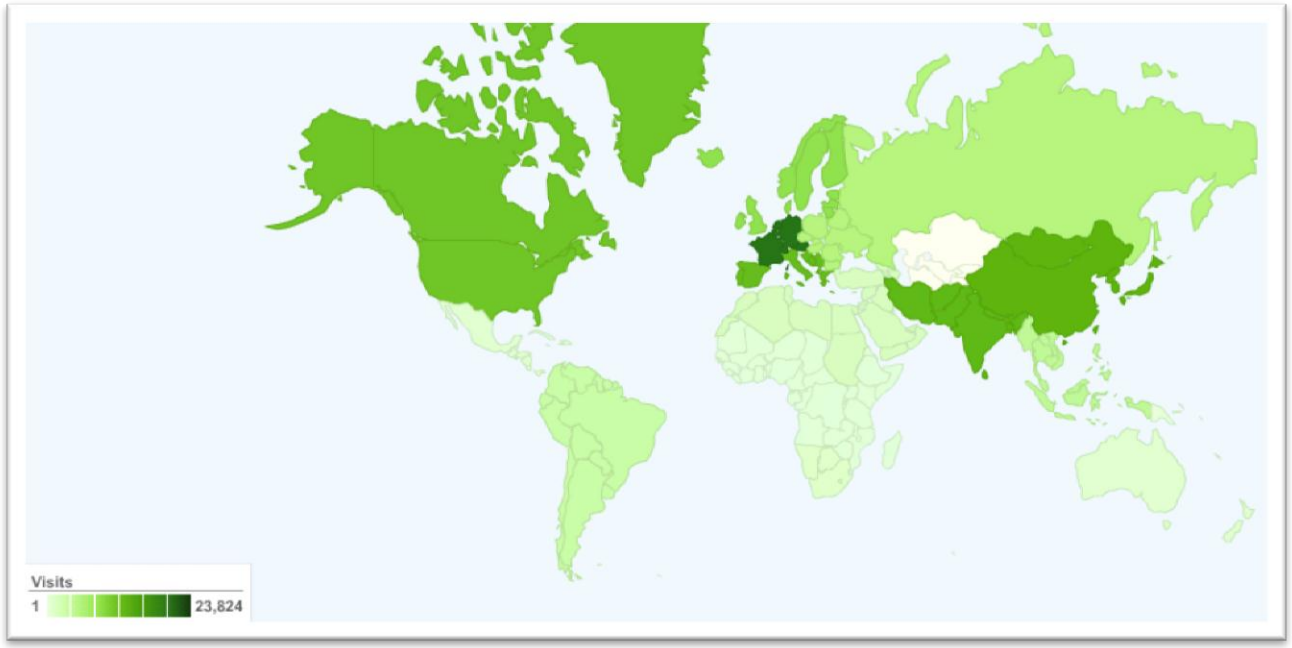
OPENIMS playground

IMS-in-a-bottle

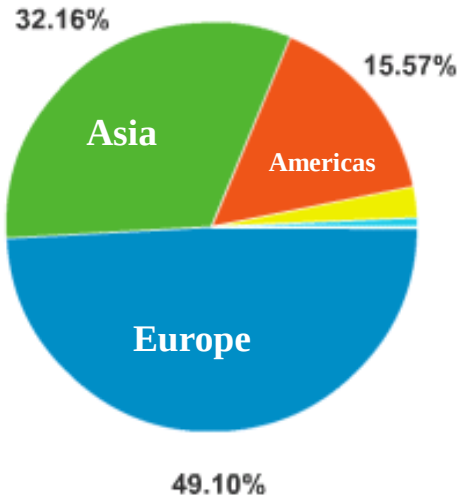
- A full Linux Operating System (Gentoo) with a 2.6.23 kernel configured to suit most of your needs (IPv6, IPSec, etc)
- A complete Open IMS Core installation, starting by default as a service (watch tty 7->10 for debug messages and 11 for a simple SIP traffic dump)
- The default couple Alice & Bob pre-configured in the HSS.
- HSS provisioning web-console
- The free OpenIC_Lite IMS User Endpoint preconfigured for Alice & Bob
- Additionally in the KDE version, for debugging: Wireshark



Some feedback so far… what we see.

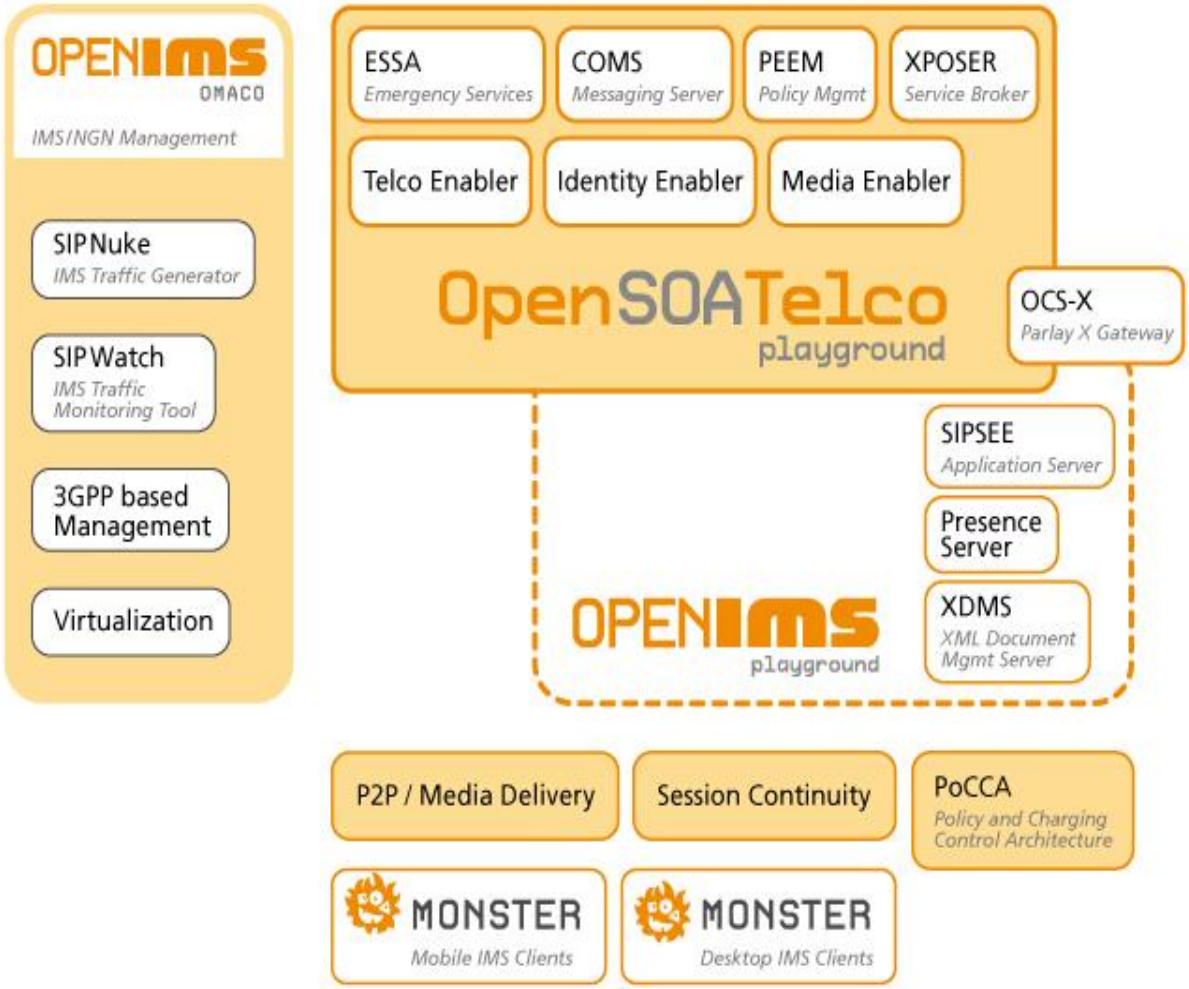


Google Analytics



- > 150.000 visits from over 140 countries
- > 52.000 unique visitors
- approx. 150 visitors/day

IMS Playground - non Open Source Add On Components – 2008/9



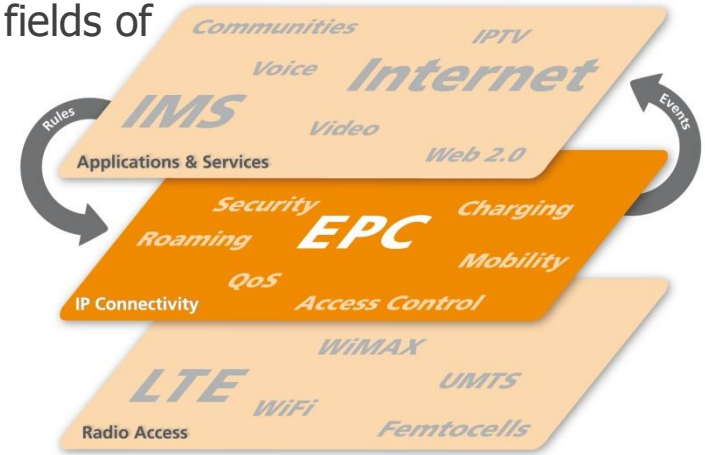
open ims playground

Fraunhofer FOKUS

What is the FOKUS OpenEPC Platform ?

- In Next Generation Mobile Networks multi access network support (incl. fixed & cable) and multi application domain support (OTT, IMS, P2P etc.) will become key for multimedia service delivery
- Based on the success of the Open IMS Core, Fraunhofer FOKUS is developing a **NON-OPEN SOURCE** EPC platform, enabling academia and industry to
  - integrate various network technologies and
  - integrate various application platforms

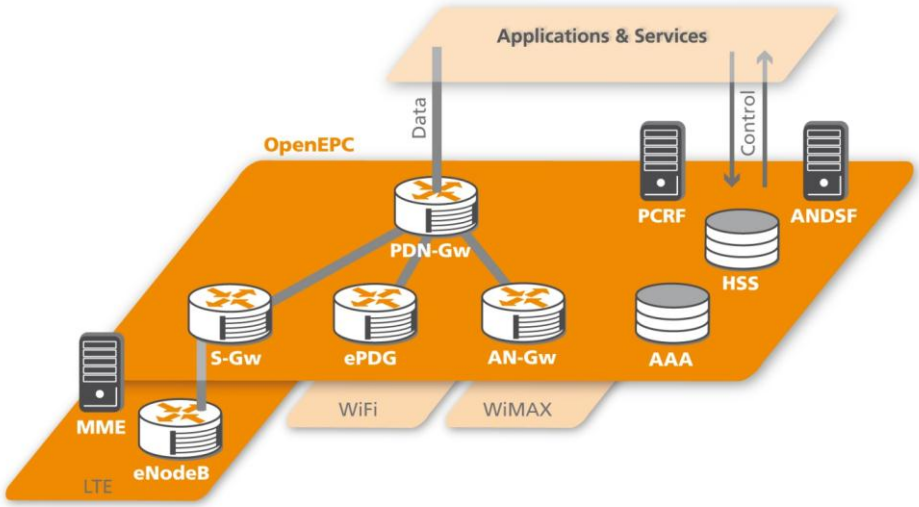
  into a single local testbed, thus lowering own development costs
- This platform can be used to perform R&D in the fields of
  - QoS, Mobility, Security, Management
- OpenEPC is aligned with 3GPP specifications:
  - high performance
  - adaptable to different deployments
  - extensible to specific research needs
  - configurable
- More information: www.OpenEPC.net



OpenEPC Rel. 2

- OpenEPC includes the main functionalities of 3GPP's Evolved Packet Core (Release 9)
- The principles of standard alignment, configurability and extensibility have been respected in the overall architecture and in the specific components implemented
- In Rel. 2, a subset of functionalities and features is available as depicted below
  - Subscription based procedures for
    - Always Best Connected
    - Resource Reservation
  - Mobility Support (GTP and PMIP)
  - Core Network support for LTE
  - Mobile Equipment support for EPC

PLEASE NOTE: OpenEPC does not claim 100% standard compliance, but allows for early prototyping

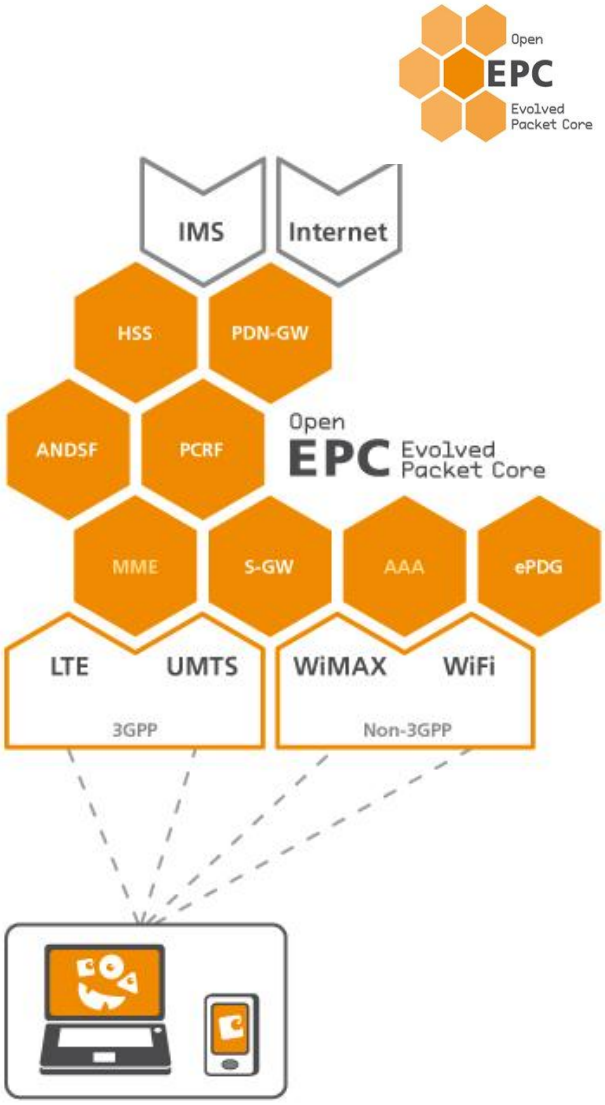


OpenEPC Rel. 1: Capabilities
Features, Functionality and Components

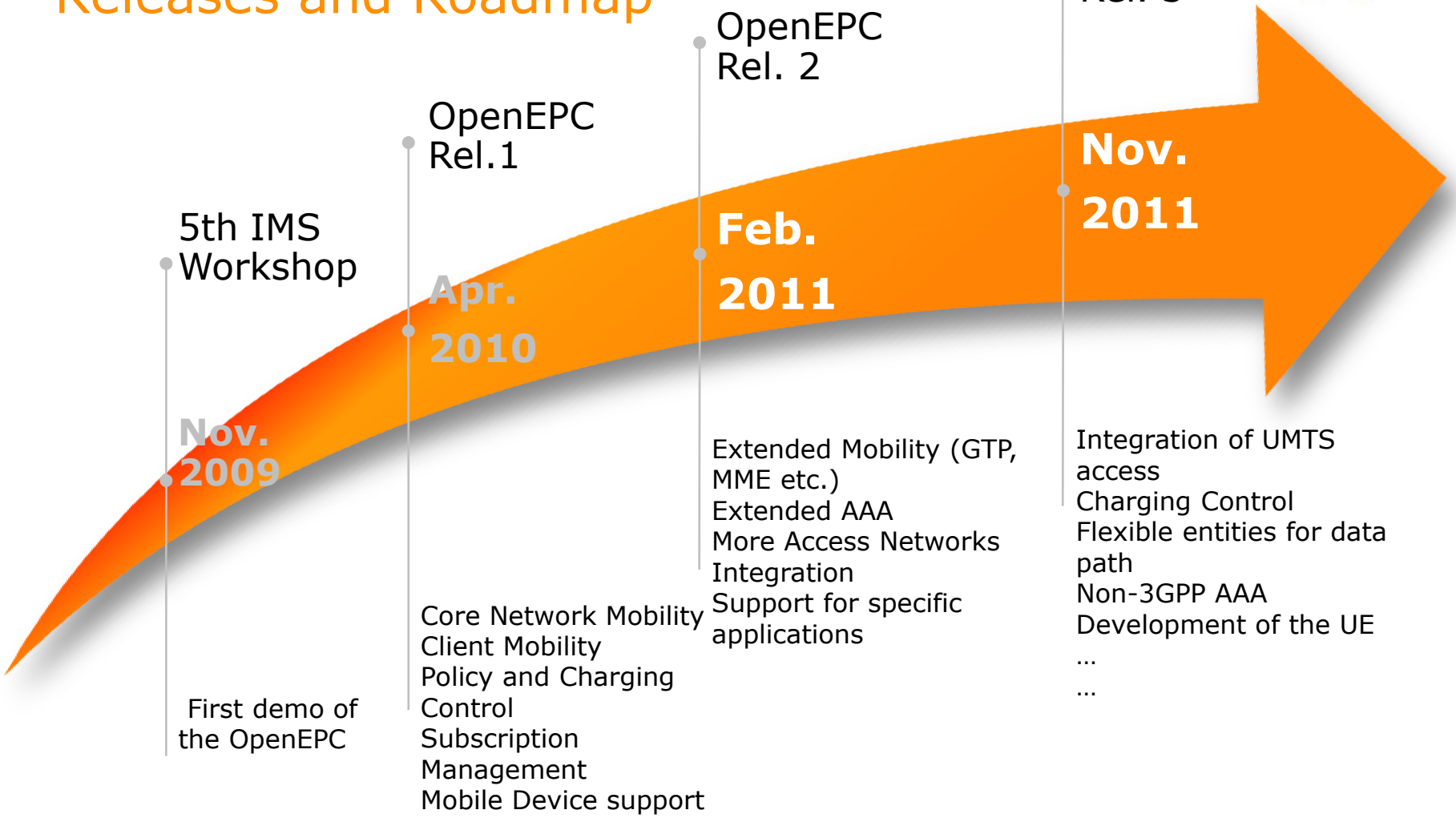
- Core Network Mobility Management
- Policy and Charging Control
- Client Mobility Management
- Subscription Management
- Interconnection with Access Networks
- Interconnection with Applications and Services

OpenEPC Use Cases

- **Operators** are using OpenEPC to prepare for the upcoming all-IP NGN and Mobile Broadband world and have an open and vendor independent testbed infrastructure.
- **Manufacturers** of individual EPC components are using OpenEPC to test their products in concert with a standards based Mobile Broadband Network environment.
- **Manufacturers** of full EPC platforms are using OpenEPC for practical research on new concepts and protocols in an easier to maintain platform.
- **Application developers** are using OpenEPC to certify that their applications work in Mobile Broadband Environments and take advantage of the functional capabilities offered by EPC to the applications domains.
- **Research institutions and universities** are using OpenEPC for practical mobile broadband networks research, including usage of OpenEPC as black box for applications prototyping, or extending individual or multiple EPC components and/or developing new EPC components and protocols to provide new capabilities for integrating new networks or enabling new applications.



OpenEPC
Releases and Roadmap



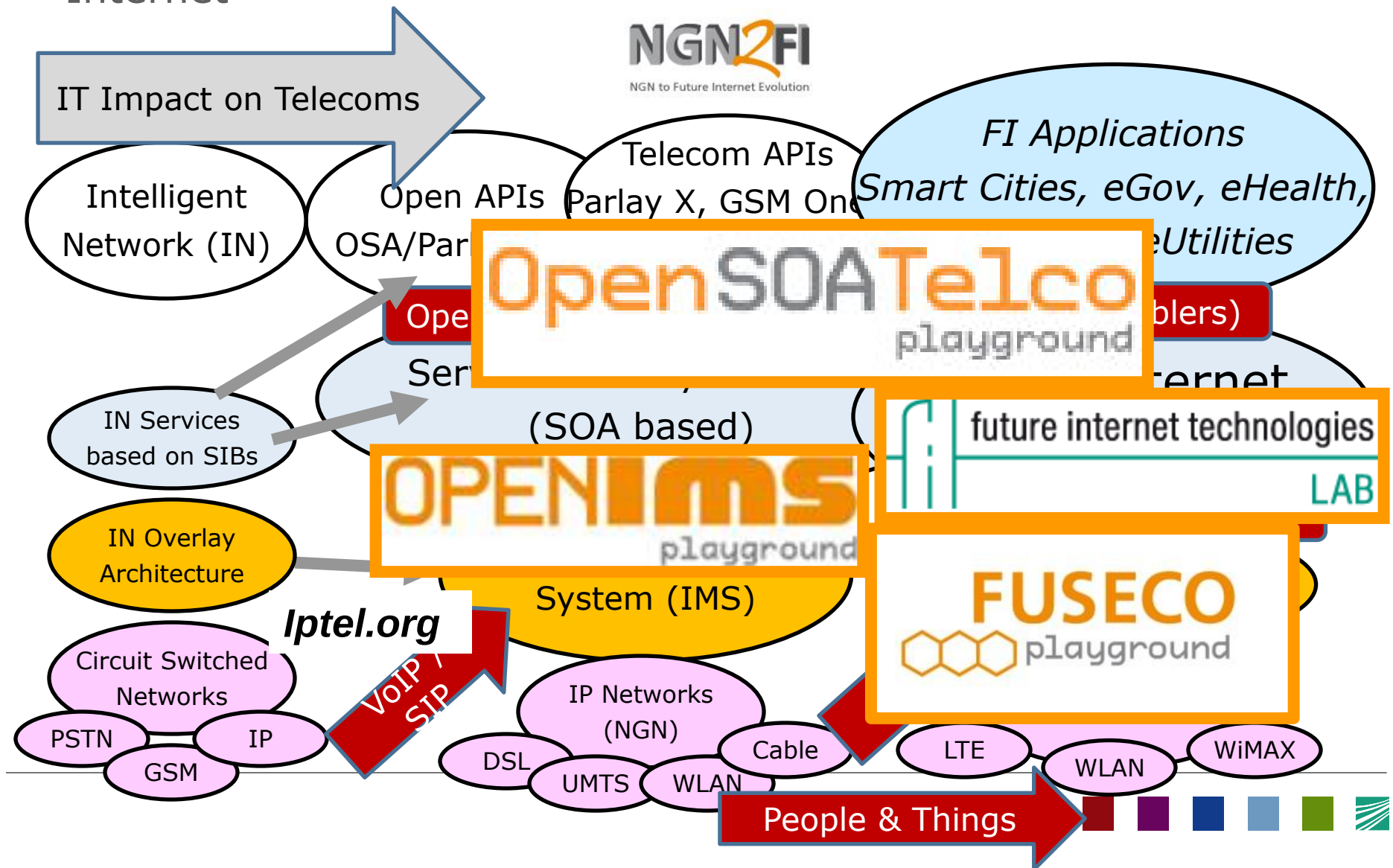
OpenEPC
Expected Features in Rel. 3

- Integration of UMTS access
  - Goal: completing the OpenEPC as access networks
  - Development of a SGSN and S-GW for the integration with the femto-BTS
- Charging Control
  - Goal: completing the PCC with the charging functionality
  - Development of the Offline and Online charging functions
- Further development of the LTE core
  - Goal: completing the core network functionality towards LTE access
- Flexible entities for the data path
  - Goal: flexible installation of the PCC rules and events
  - Development of the entities on the data path which forward the data traffic
- Extensions of the AAA functionality
  - Goal: to be able to use the AAA functionality for non-3GPP accesses
  - Development of the AAA Server and of its reference points
- Development of the UE
  - Orchestration of mobility and resource management from the UE

OpenEPC
Licensing & Availability

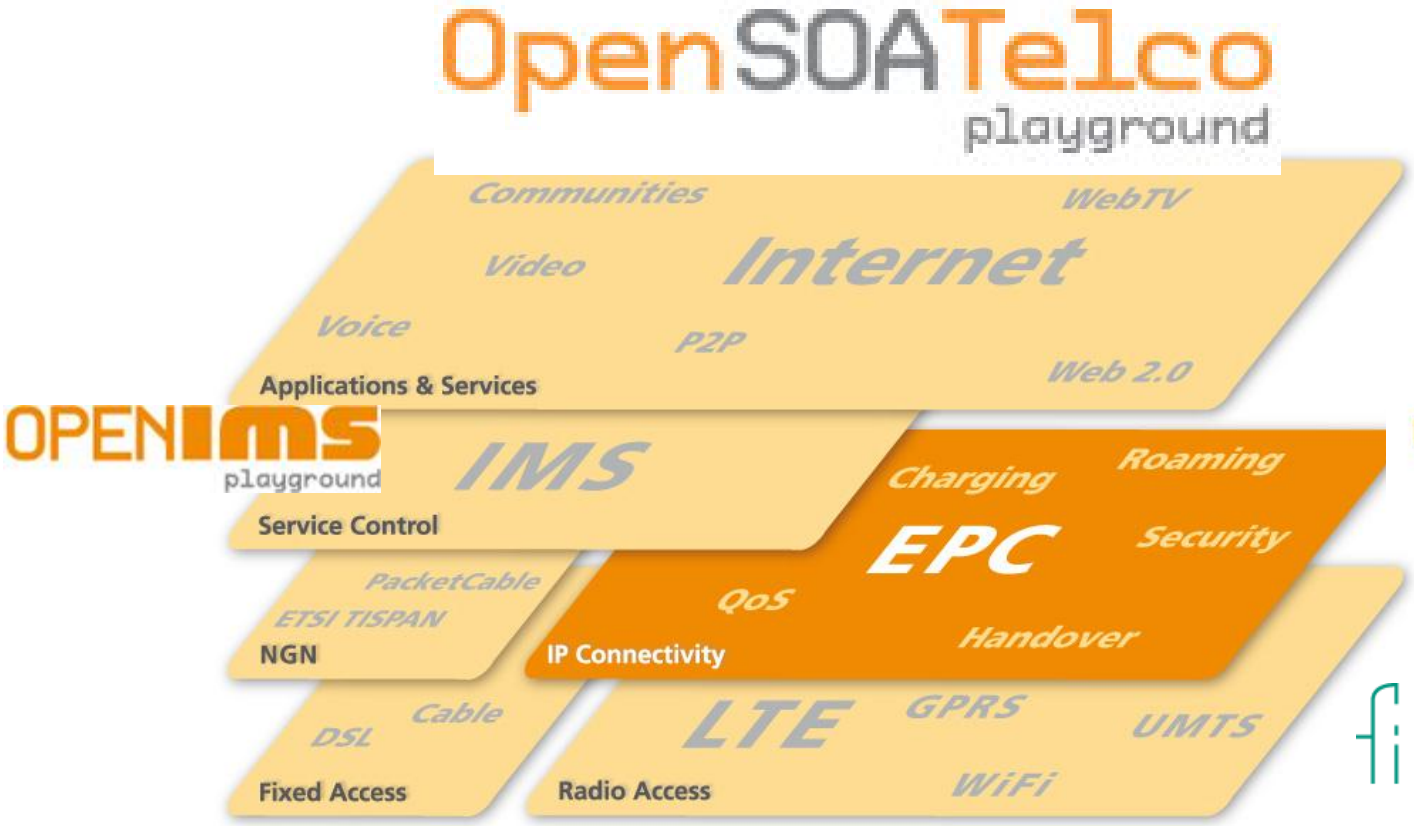
- OpenEPC integrates with various access network technologies and different services platforms to provide a complete mobile broadband core network solution.
- OpenEPC is available for **licensing with full source code** either as a complete testbed or as individual components for research and development purposes.
- The available releases of OpenEPC are
  - **April 2010: Rel. 1** of OpenEPC offers mobility options, roaming configurations support and support for security procedures
  - **November 2010: Rel. 2** with OpenEPC additions for AAA, extended mobility management etc.
- We are able to provide **add-on services** like on-site coaching, local deployment and integration activities, support, as well as extensions to OpenEPC components to meet specific customer requirements.
- In the same way Fraunhofer FOKUS and TU Berlin are interested in setting up joint R&D projects based on the OpenEPC platform.
- **In order to receive information on licensing and prices for the components, please send us an email to info@openepc.net**

Evolution of Telecommunication Platforms toward Future Internet



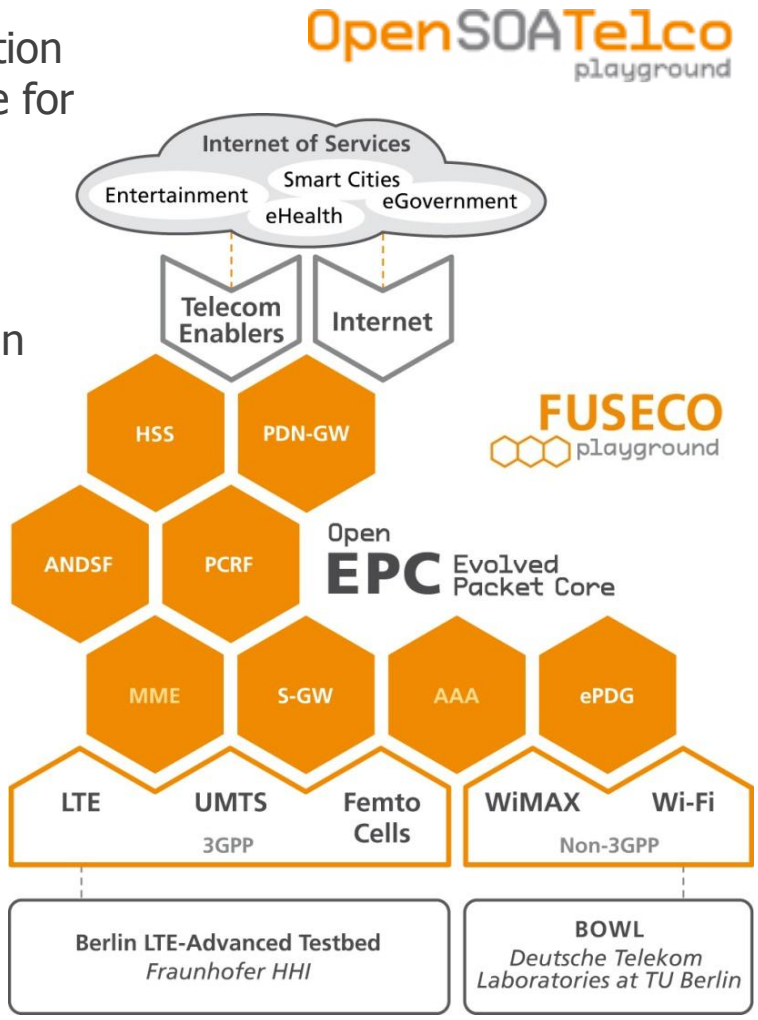
Related FOKUS Testbeds for Research and Development

NGN2FI
NGN to Future Internet Evolution



Getting Started: Future Seamless Communication (FUSECO) Playground

- State of the art testbed infrastructure as a cooperation of Berlin's future seamless communication expertise for
  - **EPC** from Fraunhofer FOKUS
  - **LTE-Advanced** at the Fraunhofer HHI
  - **WLAN** Networks at the Berlin Open Wireless Network from the Dt. Telekom Labs @ TU Berlin
- Enabling to prototype application support for
  - handover optimization across heterogeneous networks
  - support for Always Best Connected (ABC)
  - subscriber profile based service personalization
  - QoS provisioning and related charging
  - controlled access to IMS based services
  - controlled access to Internet/Mobile Clouds
- More information:
  - **www.FUSECO-Playground.org**

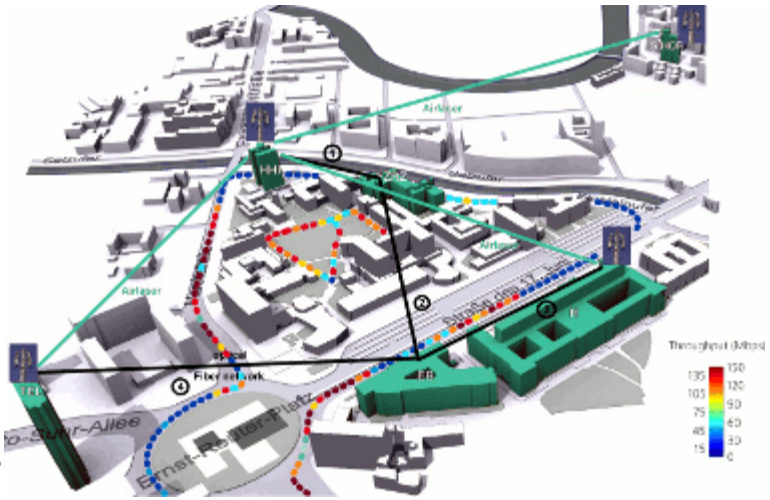


The FUSECO Playground – Partner Offering

- **Operators** can prepare for the upcoming all-IP NGN and Mobile Broadband Networks world in an open and vendor independent end-to-end test-bed infrastructure
- **Manufacturers** of individual EPC components can use the OpenEPC to test their products in concert with a standards aligned Next Generation Mobile Network environment
- **Application developers** can use the FUSECO Playground APIs to certify that their applications are tailored for mobile broadband communication
- **Research institutions and universities** can use the setup for practical research in an open lab environment
- General offers to all partners
  - **customized access** to parts or the whole infrastructure
  - **local distribution/deployment of parts of the EPC infrastructure** within the partner environment
  - customization of the infrastructure for **application trials**, **IOP testing** or for use within R&D projects
  - **product validation**
  - **tutorials and consultancy**

Berlin LTE-Advanced Testbed as Part of FUSECO

- Serves for the early evaluation of LTE-Advanced concepts in a realistic cellular environment
- For the demonstration of key technology features to increase spectral efficiency, range, throughput and quality-of-service
- Challenges
  - Reducing inter-cell interference
  - Cooperation between adjacent base stations (promises a higher performance in the cellular network)
  - Distributed cooperative signal processing
- operated from Fraunhofer HHI, Deutsche Telekom Laboratories and Technische Universität Berlin
- More information: **www.hhi.fraunhofer.de/bm**



Fraunhofer
Heinrich Hertz Institute

FUSECO playground

Demonstration Scenarios

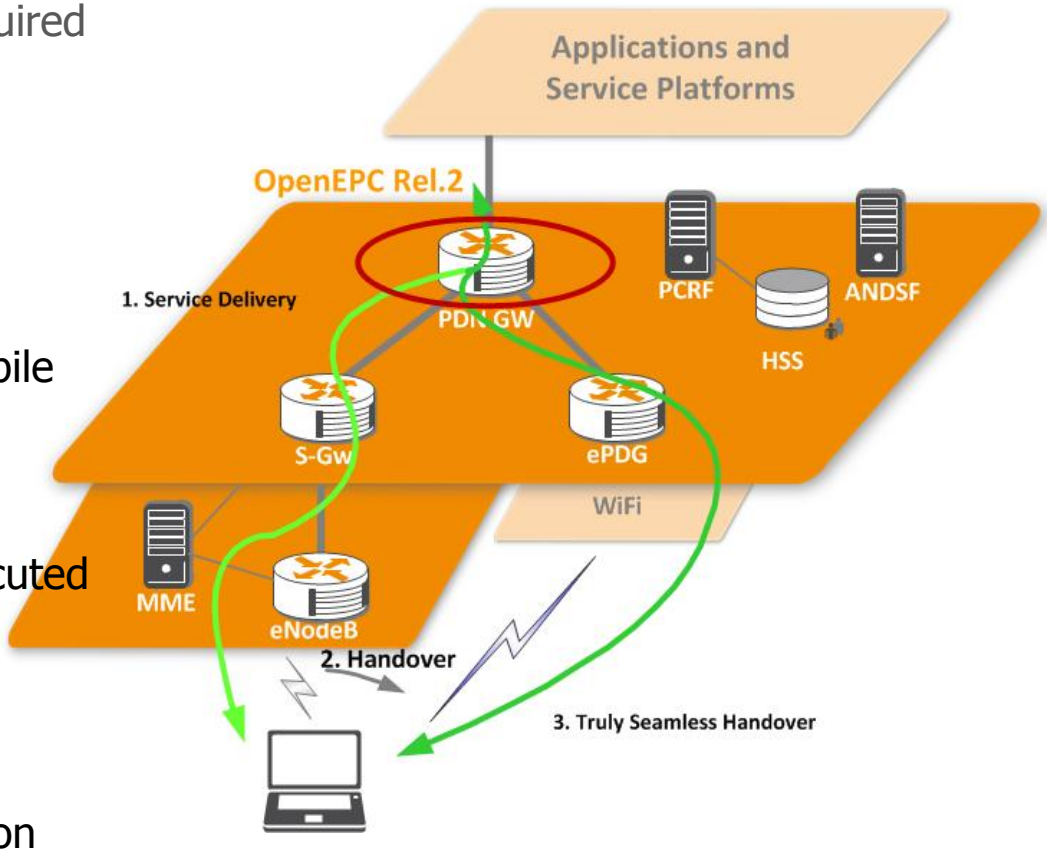
1. **Seamless Core Network Mobility** – Core network support for handovers in the heterogeneous wireless environment
2. **Core Network Support for LTE Access** – Using the LTE access network as the access network for communication
3. **Always Best Connected (ABC)** – Operator assisted access network discovery and selection
4. **More than IP bit-pipes** – Resource reservation based on subscription and application requirements
5. **Service Adaptation to Access Network Context –** OpenEPC supports the requirements for novel wireless applications
6. **OpenEPC and IMS –** Prioritized EPC support for IMS based services
7. **Over-The-Top (OTT) Services and OpenEPC –** Support for IP based service – i.e. Internet

Demo 1. Seamless Core Network Mobility

- Truly seamless vertical handover solution
  - Extension of the PDN GW
  - No buffering/No duplication required

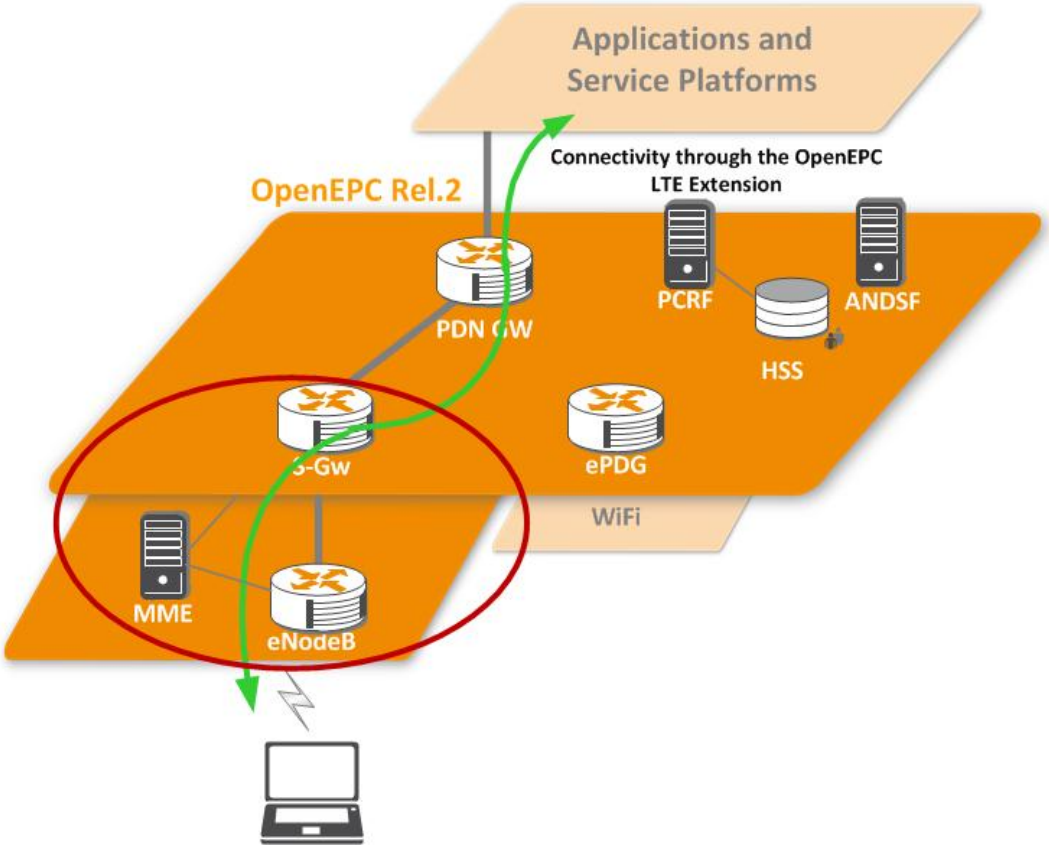
1. Service is initialized over one access network
2. A handover is performed by the mobile device to another access network
3. A seamless vertical handover is executed by the OpenEPC

- The effect of the scenario can be perceived on any real-time application on the mobile device



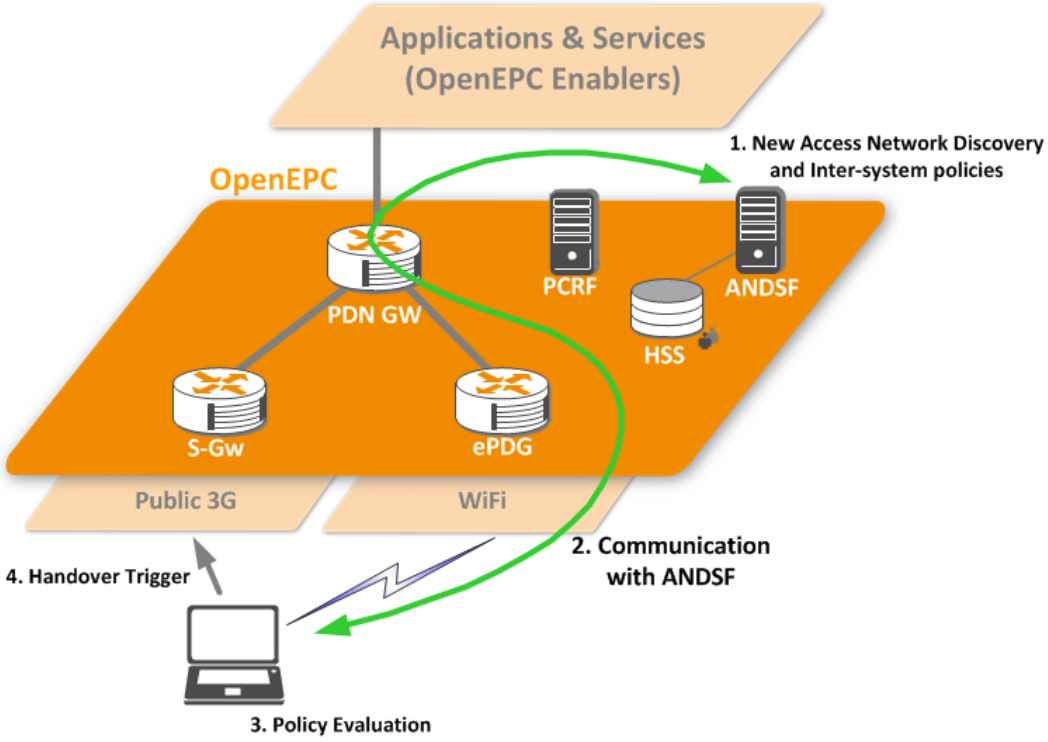
Demo 2. Core Network Support for LTE Access

- Demonstrating the functionality of the:
  - MME
  - eNodeB emulation
  - Interworking with S-GW
  - GTPv2 protocol stack
- The demonstration includes:
  - Attachment and detachment procedures from the LTE access
  - Default and dedicated bearer reservations
- The effect of the scenario can be perceived on any real-time application on the mobile device



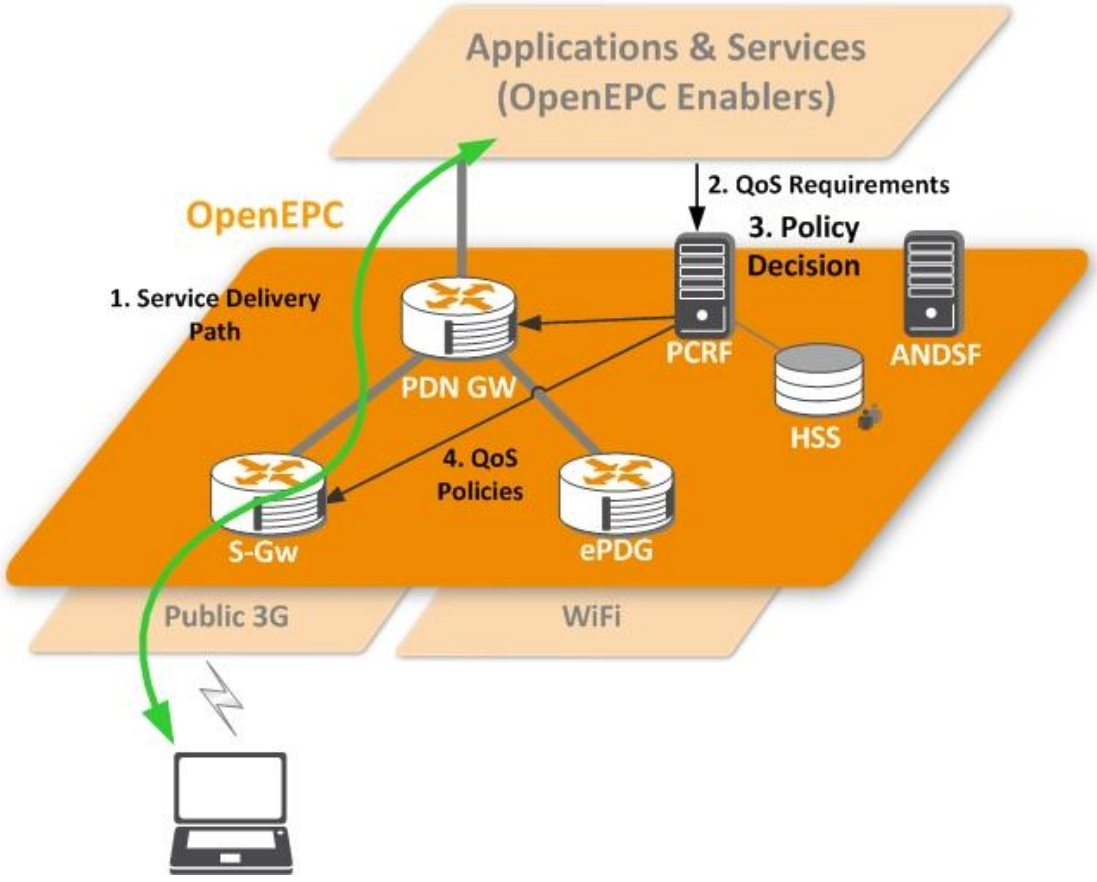
Demo 3. Always Best Connected (ABC)

- Operators are able to balance subscribers between access networks
- In dense wireless environment multiple wireless access networks overlap
- The best access network is selected for the current requirements of the mobile devices
  - Automatic decision from the core network
  - Automatic communication of the decision to the mobile device
  - Automatic handover execution



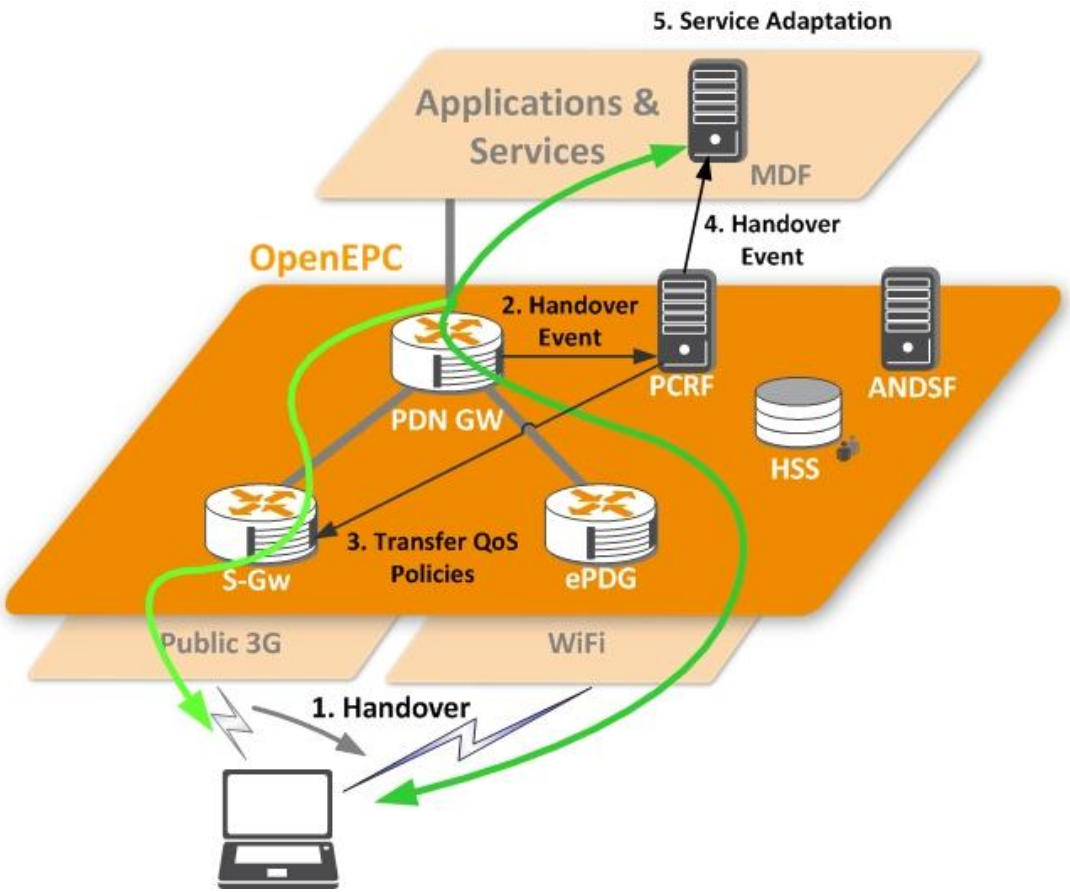
Demo 3. More than IP Bit-Pipes – Guaranteed Resources

- Guaranteed resources for each data flow:
  - Based on the requirements of the services
  - Policy decision in the PCRF
  - QoS enforcement on the data path



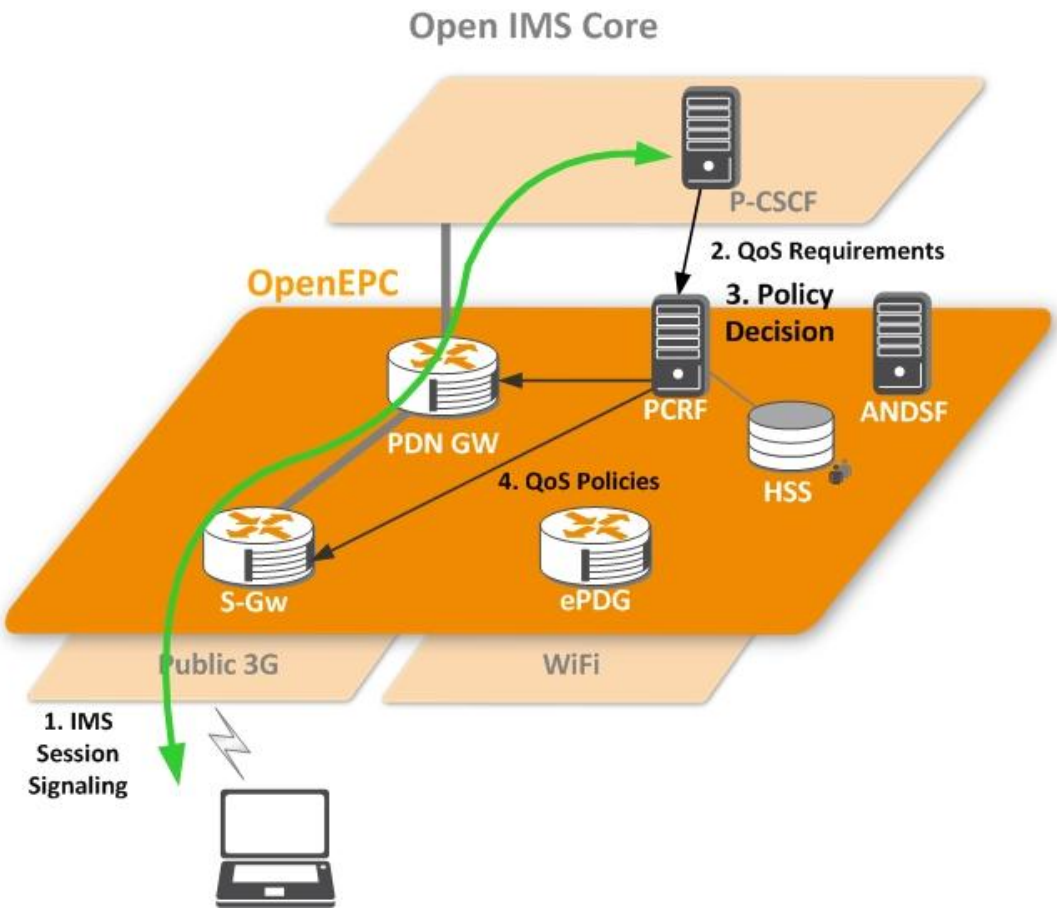
Demo 4. Service Adaptation to Access Network Context

- OpenEPC is prepared for the services adapted to the wireless environment
- On handovers, the event is forwarded by the PCRF to the services subscribed
- Services can immediately adapt to the new network conditions
  - No communication with the mobile device is required



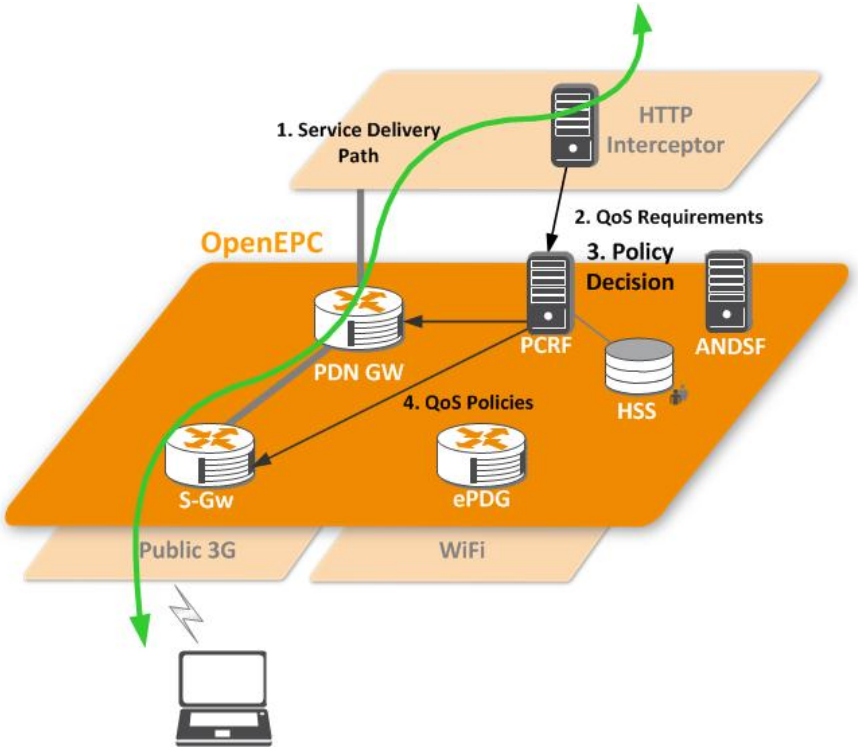
Demo 5. OpenEPC and IMS

- EPC extends IMS with Policy and Charging Control in all-IP environments
- IMS registered subscribers receive from EPC a default amount of resource for signaling
- Upon request, OpenEPC prioritizes resource reservations for IMS sessions



Demo 6. OpenEPC and Over-The-Top (OTT) Services

- Transparent identification of data flows for OTT Services
  - Deep Packet Inspection
- Policy based resource reservations for OTT Services
  - QoS reservations for HTTP data flows
- OpenEPC is prepared for mobile Internet services



OpenEPC
R&D Topics

- Goal is to **cover the entire technology spectrum for communication for vertically integrated research in the area of future mobile seamless communication** from mobile devices to applications

Network Support for Future Mobile Applications
- M2M communication / sensor network integration
- Mobile Cloud Computing
- Ambient Aware Applications
- Future Internet Network Enablers

Open EPC Evolved Packet Core

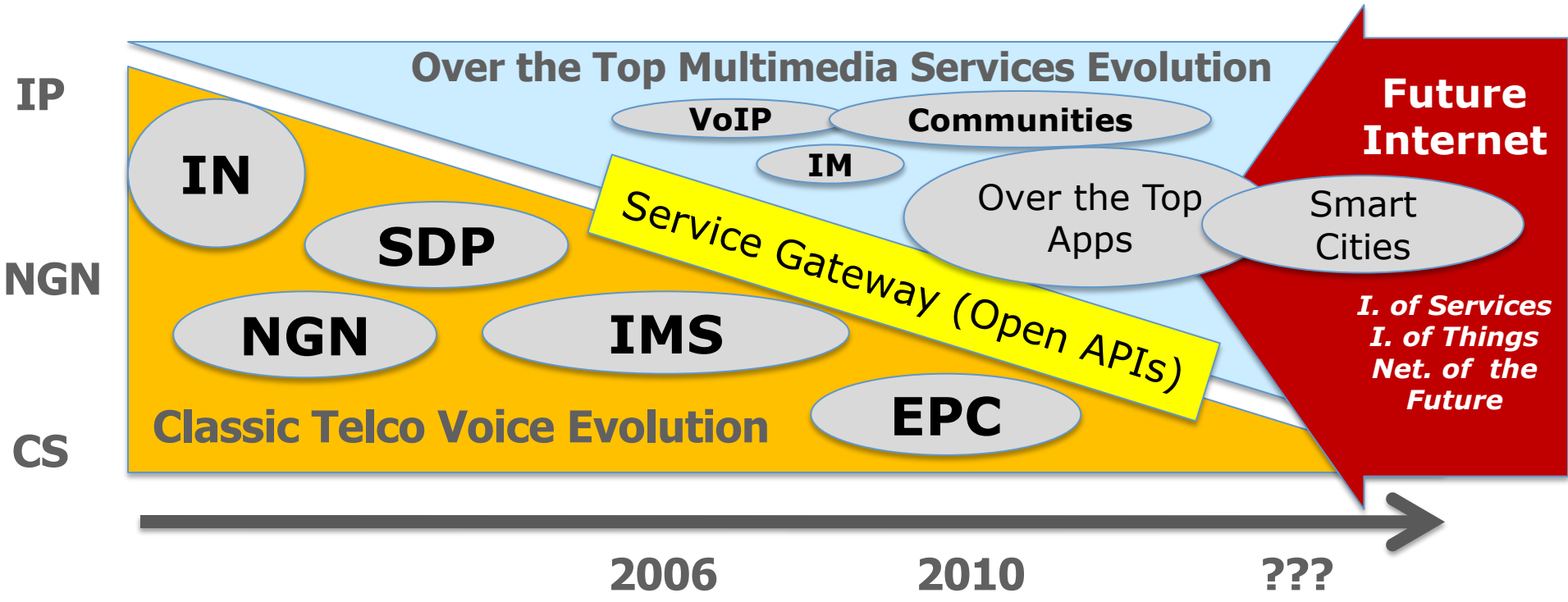
Mobility Management
- Self-organization in the core networks
- Harmonization of mobility layers
- Core network scalability and load balancing
- Multi-access and IP flow mobility
- Optimized Access Network Discovery and Selection
- Mobile device support for mobility

Resource Management & Security
- Convergence for fixed and mobile QoS and AAA topics
- Cognitive Radio Technologies
- Packet tracking and classification mechanisms
- Evolution of PCC & QoS support for all-IP data services
- Aspects of Femtocell integration to EPC

Summary

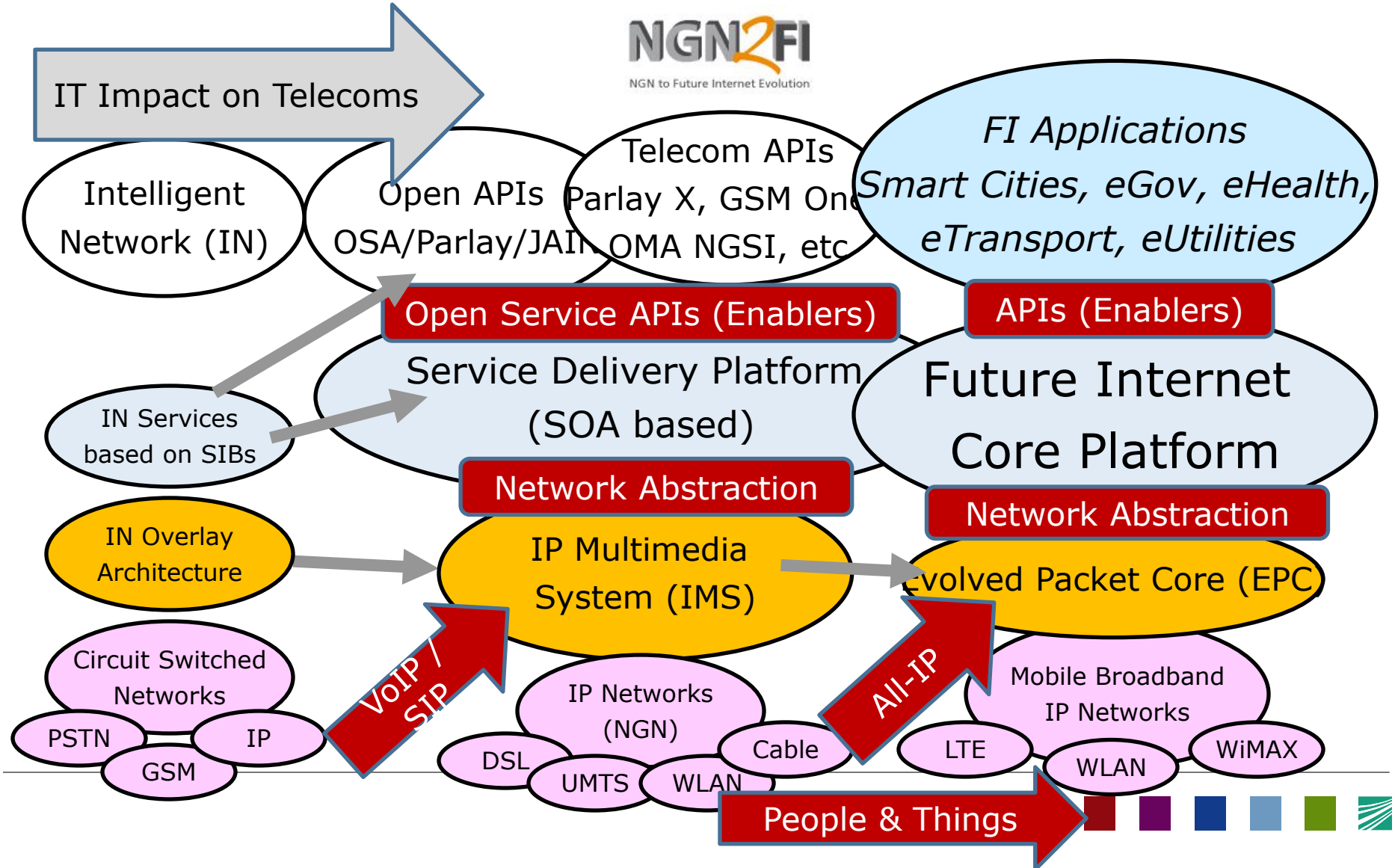
- Transition from current networks to fixed and mobile NGNs is challenging due to high complexity of the new eco system, services and involved technology migration
- IMS and EPC and SDPs based on Open APIs will be important key components
- Transition toward the Future Internet will be even more challenging due to unproved eco system and technologies
- Besides the network of the future mainly the internet of services and things will be of prime importance
- Service / functional composition across different domains and system federation are major research topics since many years
- Early testing at large will be crucial to idenify road blockers and validate new architectures, particulary for system migration and interworking
- Fraunhofer FOKUS and its related TU Berlin departments are working in this field since many years and have developed adequate tools and technology playgrounds which are used in major academic and industry projects

Different Layers for IP Application Enablement …

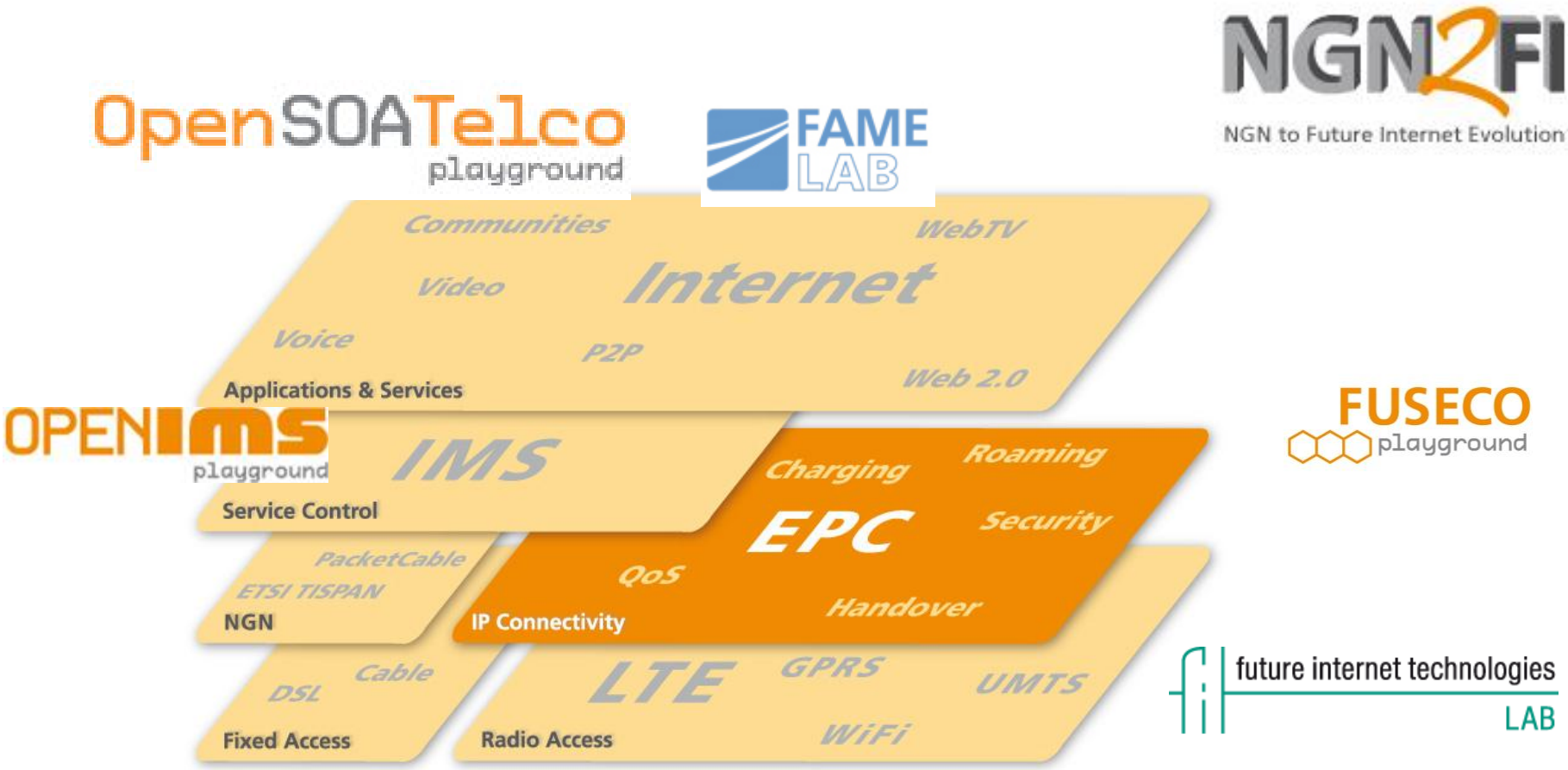


- ✓ All IP Networks will pave the road for Over the Top (OTT) Application
- ✓ Evolved telecom platforms will provide revenue potentials via Service Gateways (open APIs) and Smart Bit pipe approaches (EPC)

Evolution of Telecommunication Platforms toward Future Internet



Relating FOKUS Testbeds for Research and Development



Agenda

- Introduction
- IP Multimedia System (IMS) as Uniform All-IP Operator Service Platform
- Evolved Packet Core (EPC) Overview
- Future Internet (FI)
- Summary - Relating EPC, IMS, SDPs, and FI
- Q&A

Join us at the 3rd International IEEE Workshop on Open NGN and IMS Testbeds (ONIT 2011)

Munich, Germany, July 18, 2011

- Theme: "Next Generation Network Evolution Towards the Future Internet"
- Visit our Website: www.onit-ws.org/
- The full-day workshop covers 8 talks and a demo
  - Keynote Presentation: 'Mobile Service Evolution und Research Trends in Future Internet', Kurt Tutschku (University of Vienna)

Join us at the 2nd FOKUS Future Seamless Communication Forum (FFF)

Berlin, Germany, November 17-18, 2011

- Theme: "From FMC towards total Convergence: *New Applications and Platforms for Converging Mobile and Fixed Next Generation Networks and the emerging Future Internet"*
- Visit our Website: www.fuseco-forum.org/
- FFF will feature vendor exhibitions, and operator only talks
  - FFF is the successor of the famous FOKUS IMS Workshop series
  - FFF 2010 attracted 150 experts from 21 nations
  - See www.fuseco-forum.org/minutes for details and free download of presentations

FUSECO playground

Questions to be discussed with the audience

if time permits …

- *What will be the killer application on top of IP connectivity?*
- *Will network neutrality ruin the operator business case?*
- *Will LTE pave the way for Google services everywhere?*
- *Are operators ready to stand against Google Apps?*
- *What is the value of multi access network support?*
- *What are the requirements for new mobile devices?*
- *What are the impacts on future Service Delivery Platforms?*
- *What are the impacts of ongoing Future Internet Research?*

Julius.Mueller@tu-berlin.de

Questions ???

Join us at the 2nd FOKUS Future Seamless Communication Forum

Berlin, Germany, November 17-18, 2011

Visit our Website: www.fuseco-forum.org/

Recent OSTP Publications I

OpenSOATelco playground

- Blum, N.; Margaria, T.: An Open Service Environment for Service Exposure and Orchestration of Heterogeneous NGN Services, PIK-Praxis der Informationsverarbeitung und Kommunikation, Vol.33 (2010), 1, 16-20
- Blum, N.; Magedanz, T.; Stein, H.; Wolf, I.: A Platform For User Generated Multimedia Communication Services, Journal of mobile multimedia, Vol.6 (2010), 3, 185-206
- Blum, N.; Boldea, I.; Magedanz, T.; Margaria, T.: Service-oriented Access to Next Generation Networks - from Service Creation to Execution, Mobile networks and applications, Vol.15 (2010), 3, 356-365
- N. Blum, T. Magedanz, F. Schreiner, S. Wahle, "From IMS Management to SOA based NGN Management", in: Journal of Network and Systems Management, Springer New York, February 2009, ISSN 1064-7570 (Print) 1573-7705 (Online), DOI 10.1007/s10922-009-9118-4, www.springerlink.com/content/y662p11477364g5g
- N. Blum, T. Magedanz, T. Margaria, "Rapid Service Creation using eXtreme Model Driven Design for real-time Communications Services on top of Next Generation Networks", Proc. of International Conference on Intelligence in Networks (ICIN), Bordeaux, 26 - 29 October, 2009, www.icin.biz
- N. Blum, I. Boldea, T. Magedanz, U. Staiger, H. Stein, "A Service Broker providing Real-time Telecommunications Services for 3rd Party Services", Proc. of 33rd Annual IEEE International Computer Software and Applications Conference (COMPSAC), Seattle, July 2009, ISBN 978-0-7695-3726-9, DOI 10.1109/COMPSAC.2009.202
- N. Blum, S. Lampe, T. Magedanz, "Design of a Message Interworking Function for Converged IP Messaging in Next Generation Networks", Proc. of IEEE Symposium on Computers and Communications (ISCC'09), pp.80-86, Sousse, Tunisia, July 2009, ISBN 978-1-4244-4671-1
- N. Blum, T. Magedanz, F. Schreiner, "Management of SOA based NGN service exposure, service discovery and service composition", Proc. of the 11th IFIP/IEEE International Symposium on Integrated Network Management (IM 2009), Long Island, New York, USA, June 2009, accepted for publication at IEEE
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- Niklas Blum, Thomas Magedanz, Jan Kleeßen, Tiziana Margaria, "Enabling eXtreme Model Driven Design of Parlay X-based Communications Services for End-to-End Multiplatform Service Orchestrations", Proc. of 14th IEEE International Conference on Engineering of Complex Computer Systems (ICECCS), pp.240-247, 2009, ISBN 978-0-7695-3702-3

Recent OSTP Publications II

OpenSOATelco playground

- N. Blum, T. Magedanz, F. Schreiner, S. Wahle, "A Research Infrastructure for SOA-based Service Delivery Frameworks - The Open SOA Telco Playground at Fraunhofer FOKUS", in TRIDENTCOM 2009, 5th International Conference on Testbeds and Research Infrastructures for the Development of Networks and Communities, Washington DC, USA, April 2009, IEEE, ISBN: 978-1-4244-2847-2, IEEE Catalog Number: CFP09364, www.tridentcom.org
- N. Blum, T. Magedanz, F. Schreiner, "The Role of Service Brokers for Composed Services in an Open Service Environment", TELEKOMMUNIKATION AKTUELL 1-2/2008, Verlag für Wissenschaft und Leben Georg Heidecker GmbH, Erlangen, ISSN 1619-2036
- N. Blum, T. Magedanz, F. Schreiner, "Definition of a Service Delivery Platform for Service Exposure and Service Orchestration in Next Generation Networks", UbiCC Journal - Volume 3 Number 3, 2008, http://www.ubicc.org/journal_detail.aspx?id=17, ISSN: 1994-4608
- N. Blum, T. Magedanz, P. Weik, "The Integration of IMS into Service Delivery Platforms based on ServiceOriented Architectures" in IMS Handbook: Concepts, Technologies, and Services, Mohammad Ilyas and Syed Ahson, Taylor & Francis, New York, November 2008, pp. 307 - 328, ISBN 978-1420064599
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- N. Blum, T. Magedanz, F. Schreiner, "Services, Enablers and Architectures: Definition of a Connected Web 2.0 / Telco Service Broker to Enable New Flexible Service Exposure Models", Proc. of International Conference on Intelligence in Networks (ICIN), Bordeaux, 20 - 23 October 2008
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- S. Wahle, N. Blum, and T. Magedanz, "Evolution of the Open IMS Playground - Open Next Generation Network Testbeds in Face of Service Oriented Architectures, Web2.0 and European Testbed Federations" In Mobilfunk - Technologien und Anwendungen, ITG-Fachbericht 208, pages 49-54. VDE VERLAG GmbH, May 2008. ISBN:978-3-8007-3104-6, ISSN:0932-6022

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- M.Corici, A.Corici, D.Vingarzan, T.Magedanz, J.Mueller, 'Massive Deployment of Small Coverage Area Cells in the all-IP Wireless System', ITU WT11 2011 - Technical Symposium at ITU Telecom World 2011 (ITU WT11) Global Technical Symposium on Communications Technologies and Enablers, Geneva, Switzerland, 24-27 October 2011
- L.Lange, T.Magedanz, J.Mueller, D.Nehls, D.Vingarzan. 'Evolutionary Future Internet Service Platforms Enabling Seamless Cross Layer Interoperability', Baltic Congress on Future Internet and Communications BCFIC, to be published in IEEE Xplore, Riga, Latvia, Feb. 2011
- Corici, Marius; Gouveia, Fabricio; Magedanz, Thomas; Vingarzan, Dragos: OpenEPC: A technical Infrastructure for early prototyping of NGMN Testbeds, International Conference on Testbeds and Research Infrastructures for the Development of Networks and Communities (Tridentcom '10), 6, 2010, Berlin
- Corici, Marius; Magedanz, Thomas; Vingarzan, Dragos; Cornel, Pampu; Qing, Zhou: Proactive vertical handover optimizations in the 3GPP Evolved Packet Core, International ICST Conference on Mobile Networks and Management (MONAMI 2010), 2, 2010, Santander
- Corici M., Gouveia F., Magedanz T., Vingarzan D., "OpenEPC: A Technical Infrastructure for Early Prototyping of Next Generation Mobile Network Testbeds", in Proceedings of TRIDENTCOM 2010, 6th International Conference on Testbeds and Research Infrastructures for the Development of Networks and Communities, Berlin, Germany, accepted for publication
- Diez, A., Gouveia, F., Corici, M., Magedanz, T., "Evolution of QoS control in Next Generation Mobile Networks", chapter 26 in S. Adibi (Ed.), "Quality of Service Architectures for Wireless Networks: Performance Metrics and Management", published by Information Science Reference, ISBN: 978-1-61520-680-3, release date January 2010
- M. Corici, D. Vingarzan, A. Diez, T. Magedanz, C. Pampu, Q. Zhou. "Enhanced Access Network Discovery and Selection in 3GPP Evolved Packet Core", IEEE LCN, October 2009
- Fabricio Gouveia, Sebastian Wahle, Niklas Blum, Thomas Magedanz, "Cloud Computing and EPC / IMS Integration: New Value-added Services on Demand", in MobiMedia 2009, 5th International Mobile Multimedia Communications Conference Proceedings. ACM/ICST, 2009, accepted for publication in 2009

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- Corici M., Magedanz T., Vingarzan D., „ 3GPP Evolved Packet Core – the Next Generation Mobile Networks all-IP architecture", World Telecommunications Congress 2010, Vienna, Austria, accepted for publication
- Corici M., Magedanz T., Vingarzan D., Next Generation Mobile Networks Protocols Overview", book chapter accepted to be published in "Advanced Communication Protocol Technologies: Solutions, Methods and Applications" , edited by Katalin Tarnay, Gusztav Adamis and Tibor Dulai, to be published Information Science Reference (formerly Idea Group Reference) (an imprint of IGI Global) in 2010.
- Corici M., Fiedler J., Magedanz T., Vingarzan D., „ Access Network Discovery and Selection in the Next Generation Mobile Networks Environment", in Proceedings of Mobilware 2010, The Third International ICST Conference on MOBILe Wireless
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- M. Corici, D. Vingarzan, A. Diez, T. Magedanz, C. Pampu, Q. Zhou. "Enhanced Access Network Discovery and Selection in 3GPP Evolved Packet Core", IEEE LCN, October 2009

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- Fabricio Gouveia, Sebastian Wahle, Niklas Blum, Thomas Magedanz, "Cloud Computing and EPC / IMS Integration: New Value-added Services on Demand", in MobiMedia 2009, 5th International Mobile Multimedia Communications Conference Proceedings. ACM/ICST, 2009, accepted for publication in 2009
- Good, Richard; Gouveia, Fabricio; Magedanz, Thomas; Ventura, Neco, "Policy-Based Middleware for QoS Management and Signaling in the Evolved Packet System" In: Bonnin, Jean-Marie (Hrsg.) u.a.: Mobile Wireless Middleware, Operating Systems, and Applications : Second International Conference, Mobilware 2009, Berlin, Germany, April 28-29, 2009 Proceedings. Berlin [u.a.]: Springer, 2009, S. 115-128 (Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering 7)
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- M. Corici, F. Gouveia, T. Magedanz, "A Network Controlled QoS Model over the 3GPP Evolved Packet Core", Chapter 12, pp. 255-275 in "Advances in Broadband Communication and Networks", Editors: J.I. Agbinya, et.al., River Publishers Series in Communications; ISBN: 978-87-92329-00-4 (c) 2008 River Publishers, Denmark, September 2008
- Corici, M. I.; Gouveia, F. C.; Magedanz, T., "A Network Controlled QoS Model over the 3GPP System Architecture Evolution", Second Australian Conference on Wireless Broadband and Ultra Wideband Communications - AusWireless 2007, Crowne Plaza Hotel, S H

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NGN2FI
NGN to Future Internet Evolution

- J.Mueller, M.Kleis, A.Siddiqui, M.Becke, 'Evaluating a Future Internet Cross-Layer Composition Prototype', 7th International ICST Conference on Testbeds and Research Infrastructures for the Development of Networks and Communities, TridentCom, Shanghai, China, April 2011
- Julius Mueller, Abbas Siddiqui and Dirk Hoffstadt. 'Cross-Layer Security Demonstrator for Future Internet", "Security in NGNs and the Future Internet', Part of Future Internet Symposium FIS 2010, Berlin, Germany, September 20, 2010
- Julius Müller et al. 'Addressing Security in a Cross-Layer Composition Architecture', 10th Würzburg Workshop on IP: Joint ITG, ITC, and Euro-NF Workshop "Visions of Future Generation Networks"EuroView, Würzburg, Germany, August 2, 2010
- Sebastian Wahle, Anastasius Gavras, Fabricio Gouveia, Halid Hrasnica, and Thomas Magedanz. Network Domain Federation - Infrastructure for Federated Testbeds. In *2008 NEM Summit - Towards Future Media Internet*, pages 179 - 184, Saint-Malo, France, October 2008. Eurescom GmbH. ISBN 978-3-00-025978-4.
- Sebastian Wahle and Thomas Magedanz. Network Domain Federation - An Architectural View on How to Federate Testbeds. In *Fireworks Strategy Workshop - Position Statements*, Paris, France, September 2008.
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- Sebastian Wahle, Niklas Blum, and Thomas Magedanz. Evolution of the Open IMS Playground - Open Next Generation Network Testbeds in Face of Service Oriented Architectures, Web2.0 and European Testbed Federations. In *Mobilfunk - Technologien und Anwendungen, ITG-Fachbericht 208*, pages 49 - 54. VDE VERLAG GmbH, May 2008. ISBN: 978-3-8007-3104-6, ISSN: 0932-6022.
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- Thomas Magedanz, Florian Schreiner, and Sebastian Wahle. Service-Oriented Testbed Infrastructures and Cross-Domain Federation for Future Internet Research. In *2009 IFIP/IEEE International Symposium on Integrated Network Management Proceedings*, New York, USA, June 2009. IEEE.
- Anastasius Gavras, Halid Hrasnica, Sebastian Wahle, David Lozano, Denis Mischler, and Spyros Denazis. *Towards the Future Internet - A European Research Perspective*, chapter Control of Resources in Pan-European Testbed Federation, pages 67 - 78. IOS Press, May 2009. ISBN 978-1-60750-007-0.
- Sebastian Wahle, Thomas Magedanz, Anastasius Gavras, Halid Hrasnica, and Spyros Denazis. Technical Infrastructure for a Pan-European Federation of Testbeds. In *Testbeds and Research Infrastructures for the Development of Networks & Communities and Workshops, 2009. TridentCom 2009. 5th International Conference on*, pages 1-8, Washington DC, USA, April 2009. IEEE. ISBN: 978-1-4244-2846-5.

Fraunhofer
FOKUS

Fraunhofer Institute for Open
Communication Systems

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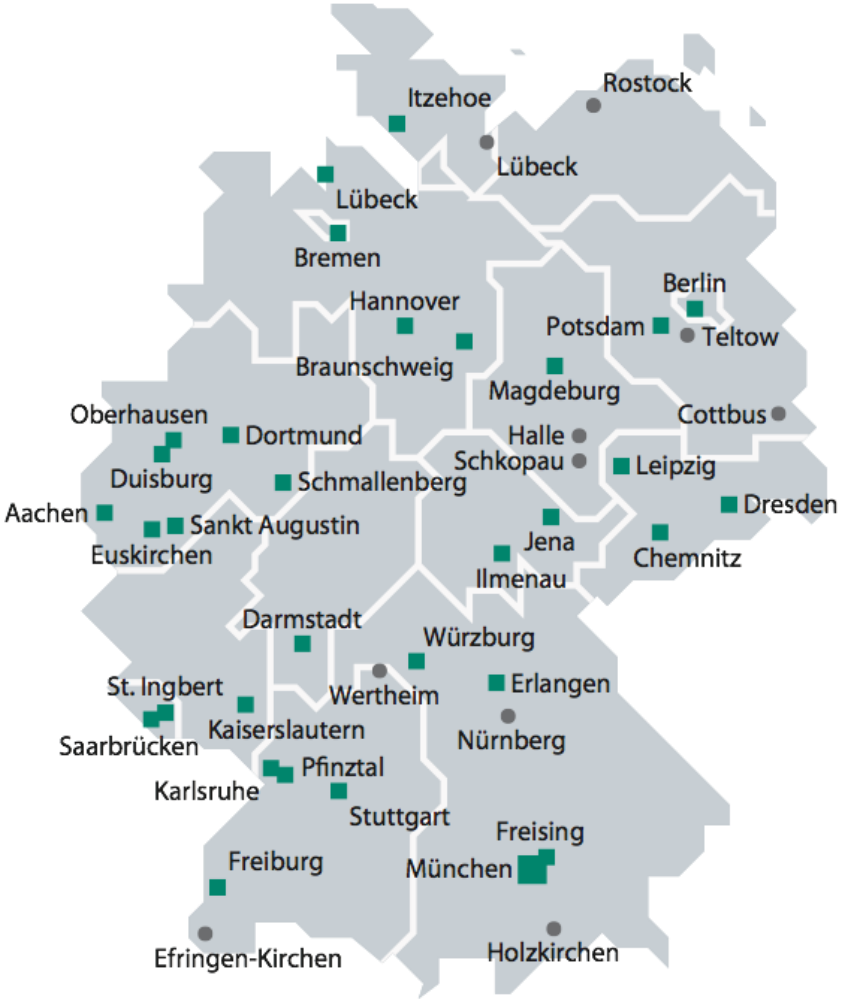
Fraunhofer in Germany

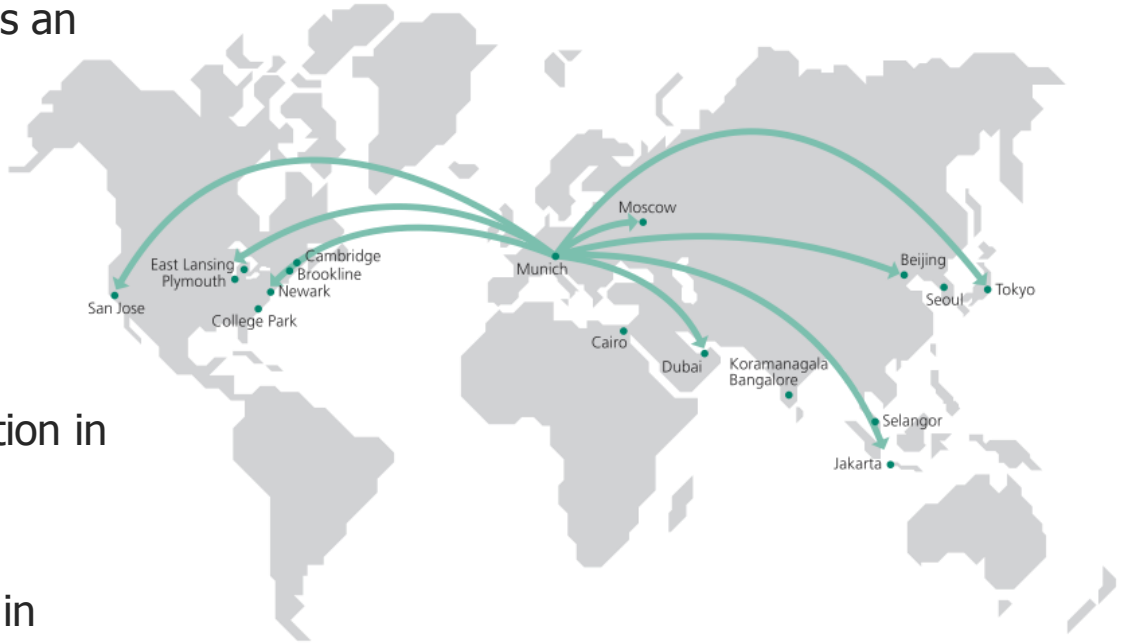
At present Fraunhofer maintains

- 80 research units
- including 57 Fraunhofer institutes
- at over 40 different locations
- with a staff of 15.000 scientists & engineers
- 1.3 billion € annual budget

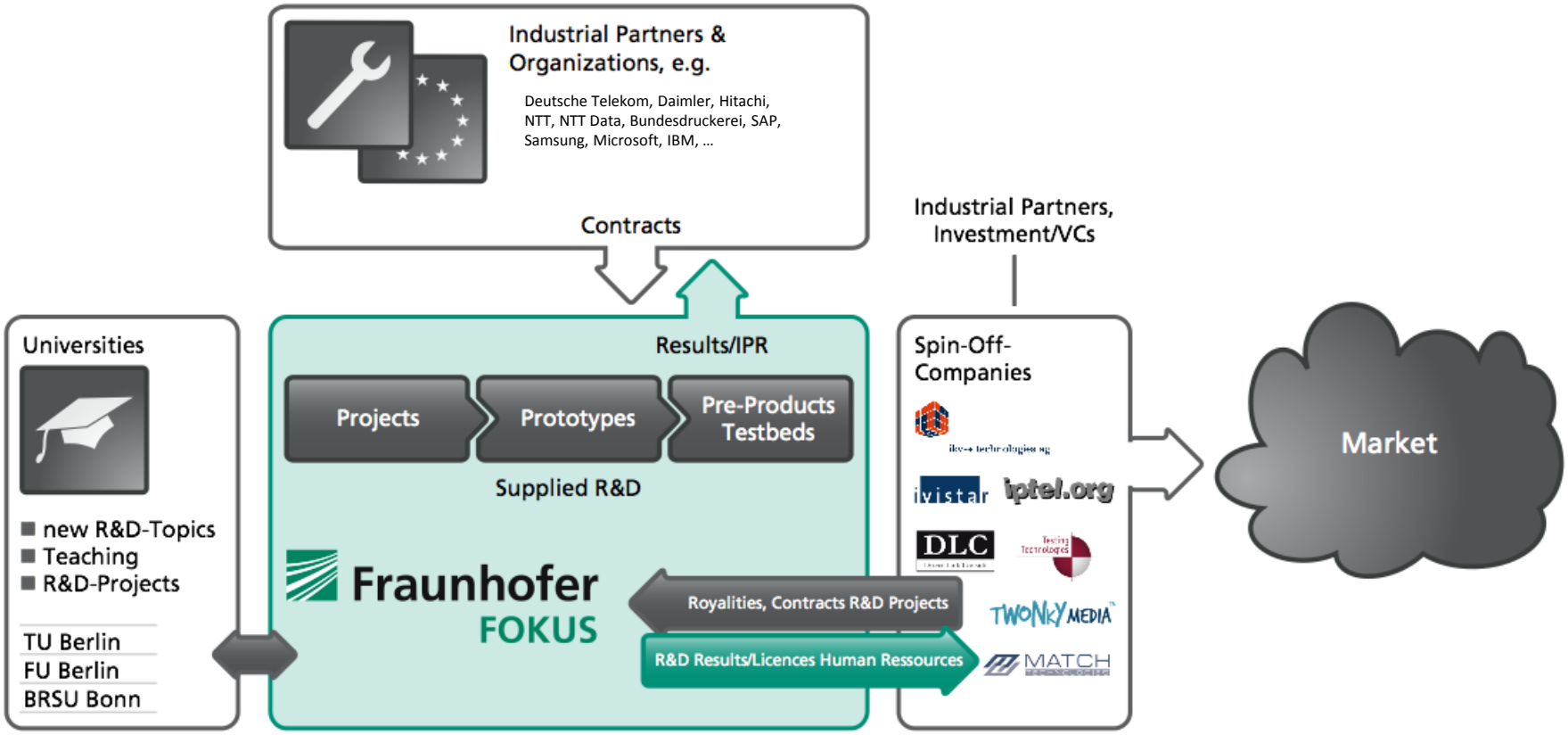


Fraunhofer International Locations

- In Europe, the Fraunhofer Brussels office was set up in 2001 to act as an interface between the European institutions and the Fraunhofer-Gesellschaft
- The Fraunhofer Representative Office Moscow exists since 2005
- 2009: Fraunhofer is a founding member of the eCAESAR Association in Romania
- Fraunhofer USA, Inc. maintains 7 centers next to the headquarters in Plymouth, MI
- In Asia, Fraunhofer offices are located in China, Indonesia, Korea and Japan



FOKUS: A virtual organization - from idea to market



FOKUS stands for

- IP Telephony: FOKUS invented SIP
- Web2.0 / Web / Telco Convergence
- I-Centric communication
- IPTV & Rich Media
- Future internet & autonomic communication
- Car-2-X Communication
- eGovernment: One stop shopping
- Open source provider: BerliOS – Second largest OS-Center
- Test automation: Invention of TTCN-3
- Testbeds / FOKUS labs: Proof of concepts

The FOKUS R&D Domains in Applications, Service & Platforms and Communication

- eGovernment
- Future Applications & Media
- Automotive Services & Communication Technologies
- Next Generation Networks & Service Platforms
- Model-Driven Engineering of Software-Intensive Systems
- Future Internet Technologies
- Communicating Sensor Systems

FOKUS Organizational structure - corresponding to R&D domains

FOKUS Directorate

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Radu Popescu-Zeletin
Director

Dipl.-Ing. Berthold Butscher
Vice Director

Resources & Management
Dipl.-Ing. Werner Pöpplau

Corporate Communications
Dipl.-Inform. Ilona Schubert
Dipl.-Geogr. Eva Sittig

Infrastructure/Communication
Dipl.-Phys. Stephan Waßerroth

COMPETENCE CENTER

ELAN	Electronic Government and Applications / BerliOS Dipl.-Inform. Gerd Schürmann
FAME	Future Applications and Media Dr. Stefan Arbanowski, Dr. Stephan Steglich
ASCT	Automotive Services and Communication Technologies Dr. Ilja Radusch
NGNI	Next Generation Network Infrastructures Prof. Dr. Thomas Magedanz
MOTION	Modelling and Testing for System and Service Solutions Dr. Eckhard Moeller, Prof. Dr. Ina Schieferdecker
NET	Future Internet Technologies Dr. Tanja Zseby, Prof. Dr. Karl Jonas
SANE	Sensor Applications and Networks Dr. Thomas Luckenbach

NGNI – Next Generation Network Infrastructures

Evolution from Next Generation Networks to the Future Internet

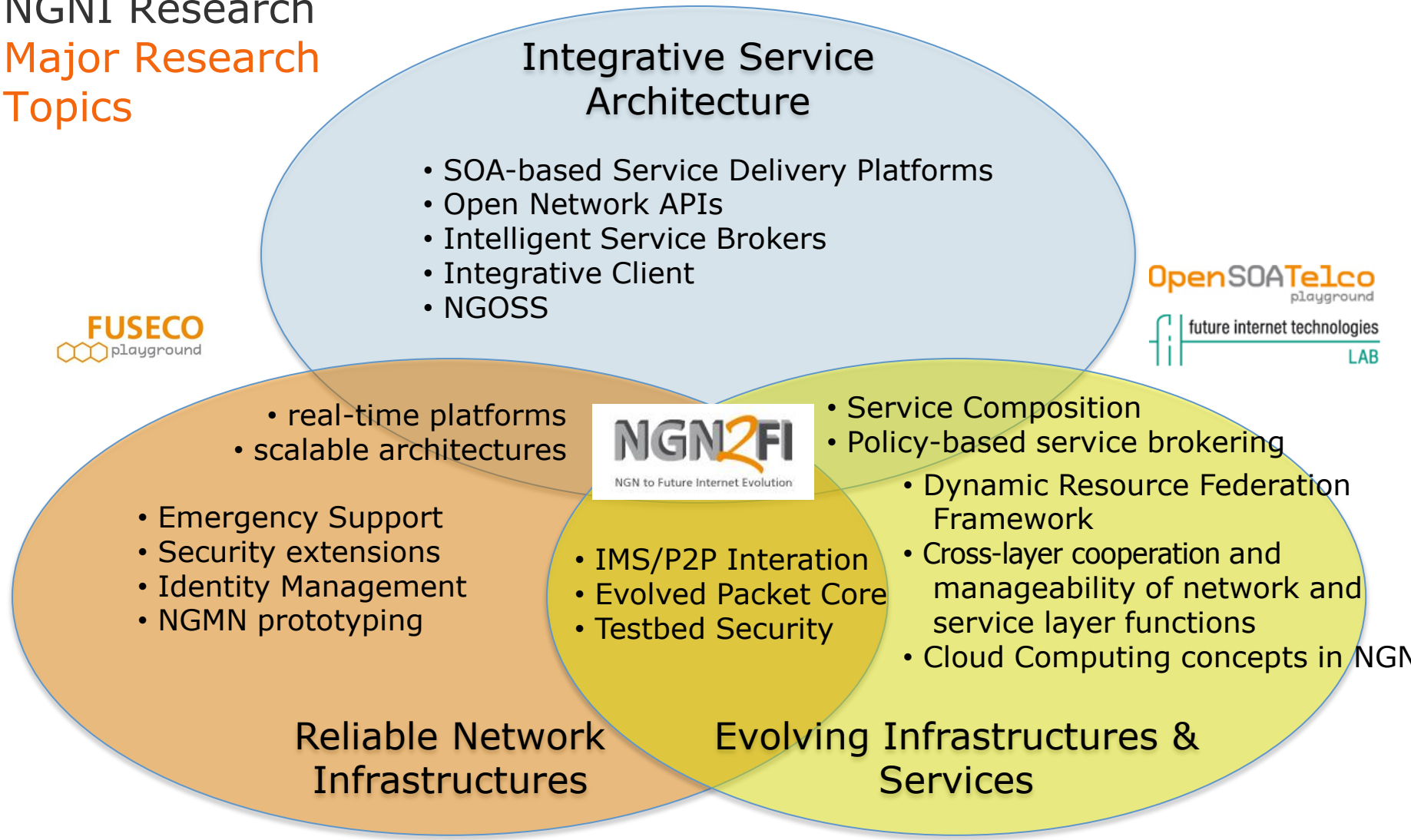
- R&D on advanced network and service control protocols and related components for multimedia services, with special focus on:
  - Reusability, efficiency, reliability, security, manageability
- R&D on middleware and Service Delivery Platform (SDP) implementation options above converging networks and Next Generation Networks (NGNs)
- R&D on NGN to Future Internet Evolution (NGN2FI)
- Evolution towards mobile and fixe Next Generation Networks
- Provision of reliable network and service platforms and related tools, including integration with legacy networks
- Prototyping of converged multimedia applications, e.g. FMC, 4Play & Telco 2.0 applications
- Development of Open Evolved Packet Core (OpenEPC)
- Strong cooperation with TUB Chair AV

NGN2FI
NGN to Future Internet Evolution

TU berlin

AV
Next Generation Networks

NGNI Research Major Research Topics



NGNI – Next Generation Network Infrastructures

Enabling rich multimedia communications over converging networks

Key Technologies

- Open IMS Core
- Converged Open Messaging Server (COMS)
- Anubis Gate – a Telco 2.0 gateway
- Service Broker – cross-domain/cross-layer servier interactions
- myMonster – the Convergent Client Framework
- OpenEPC
- Teagle – Testbed search tool

Key Laboratories

- Open SOA Telco Playground
- FI Technologies Lab
- FUSECO Playground

Key Projects

- Deutsche Telekom Service Broker and Integrated Service Architecture
- BMBF MAMSplus – Service composition and management for NGN/IMS
- EU Panlab II (PII) – Federation and management of distributed NGN/Future internet testbeds
- BMBF Project G-Lab_Deep
- EU PEACE – Emergency support extensions for IMS-based network
- Multimedia session continuity & policy-based QoS control for NGN and LTE
- Various industry NGN testbed deployments with operators