Toolkits and Testbeds for
NGN 2 Future Internet Evolution Research:

Into the FIRE – SER sparked OpenIMS,
OpenIMS sparked OpenEPC, what´s next?

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FOKUS Center Next Generation Network Infrastructures (NGNI)
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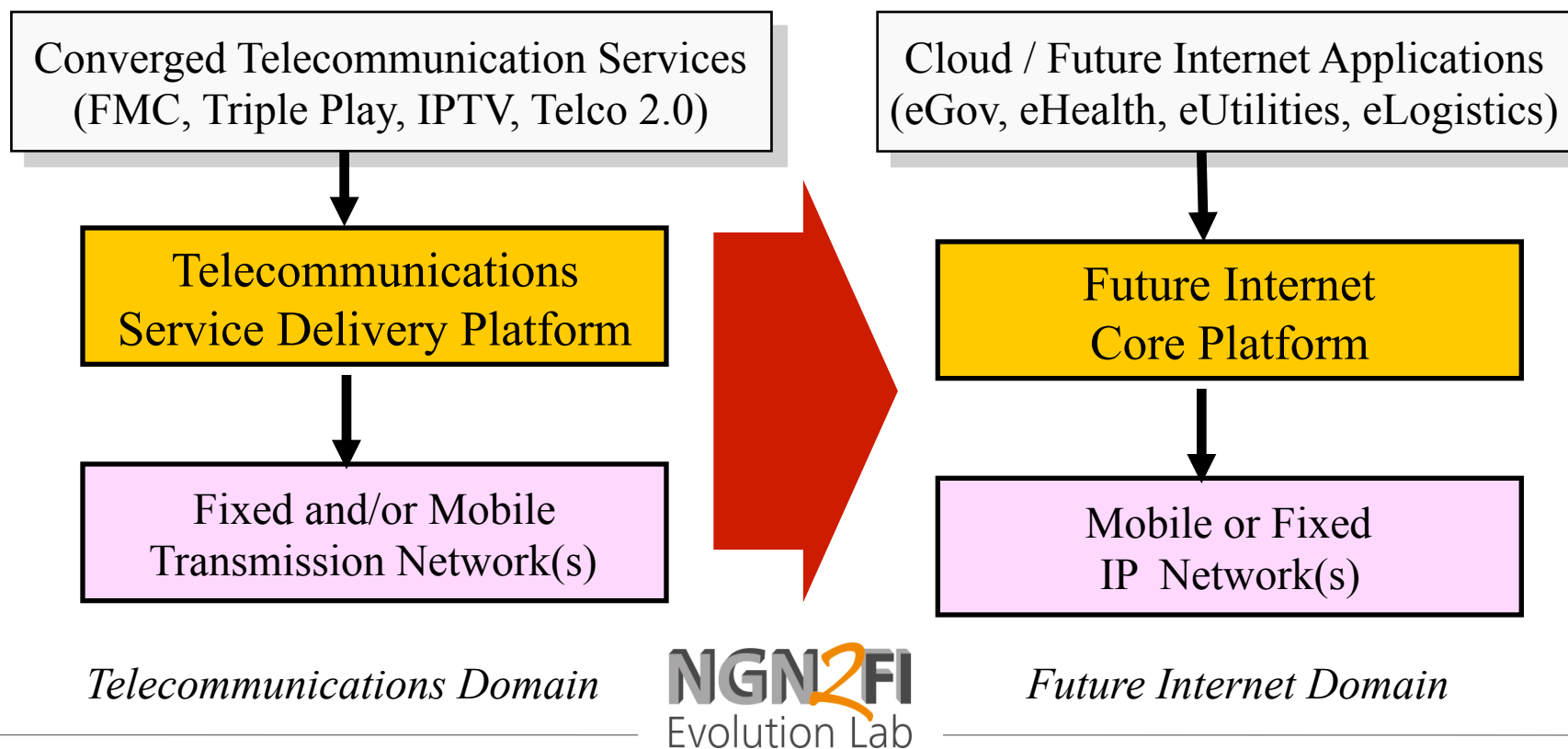TU Berlin Chair for Next Generation Networks (AV)
thomas.magedanz@tu-berlin.de

Introduction / Motivation

- FOKUS Competence Center NGNI under leadership of Prof Dr. Thomas Magedanz from Technische Universität Berlin represents a distinguished team of leading experts in the field of telecommunications and internet technologies convergence and open seamless service delivery platforms

- NGNI has become the globally leading research team in the context of **fixed and mobile Next Generation Network** prototyping by its unique technology testbeds and toolkits
  - OpenIMS, Open IMS Playground
  - FOKUS Broker, Open SOA Telco Playground
  - OpenEPC, Future Seamless Communication (FUSECO) Playground

- A key aspects of research are business, service and infrastructure transition driven by ICT innovation

- After the transition from legacy networks to NGNs in the last decade the next transition is underway: the **Future Internet** will result in total convergence of applications and communication technologies in regard to the emerging seamless interconnection of humans and devices

- The new testbeds and toolkits are addressing these challenges
 - OPenMTC, NGN2FI Evolution Lab

From Telecommunications toward the Future Internet

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


| Converged Telecommunication Services (FMC, Triple Play, IPTV, Telco 2.0) | Cloud / Future Internet Applications (eGov, eHealth, eUtilities, eLogistics) |

Telecommunications Service Delivery Platform

Future Internet Core Platform

Fixed and/or Mobile Transmission Network(s)

Mobile or Fixed IP Network(s)

Telecommunications Domain

NGN2FI Evolution Lab

Future Internet Domain

The control of Telcos is getting smaller – IMS/EPC as last resort??
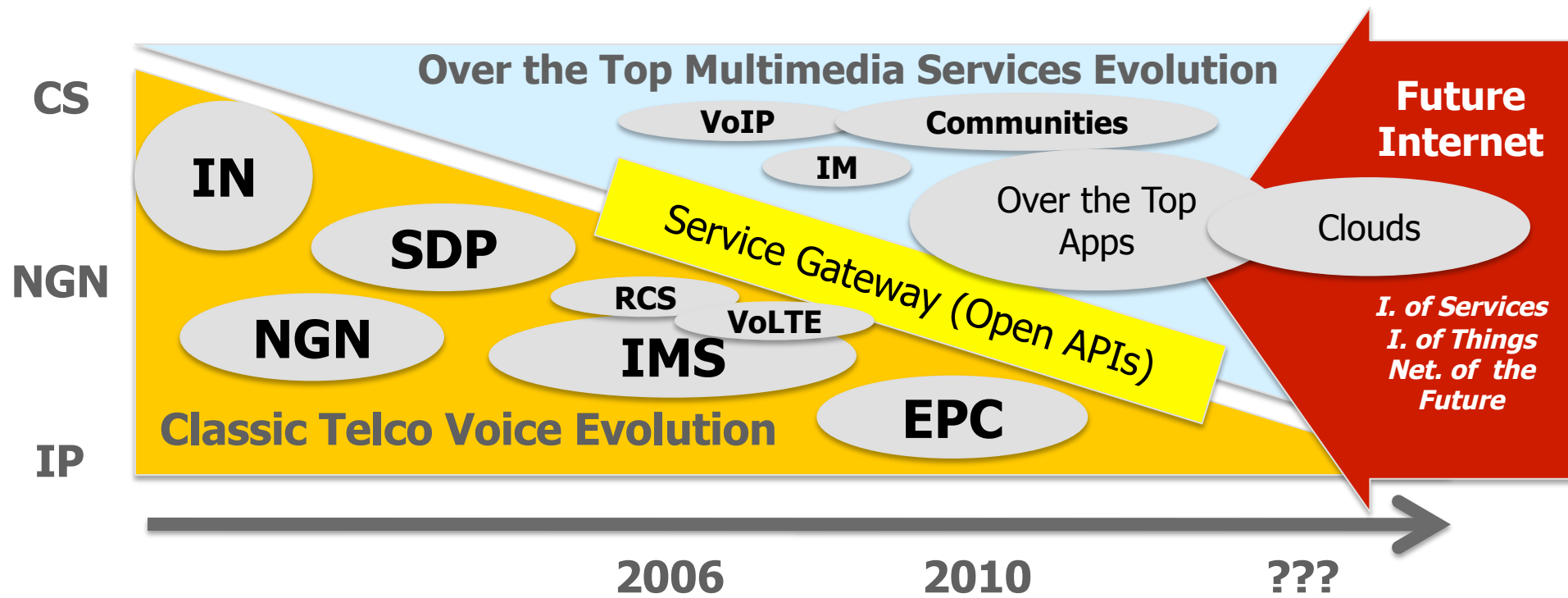
✓ All IP Networks will pave the road for Over the Top (OTT) Application
✓ Evolved telecom platforms will provide revenue potentials via Service Gateways (open APIs), VoIP (IMS) and Smart Bit pipe approaches (EPC)

Evolution of Telecommunication Platforms toward Future Internet
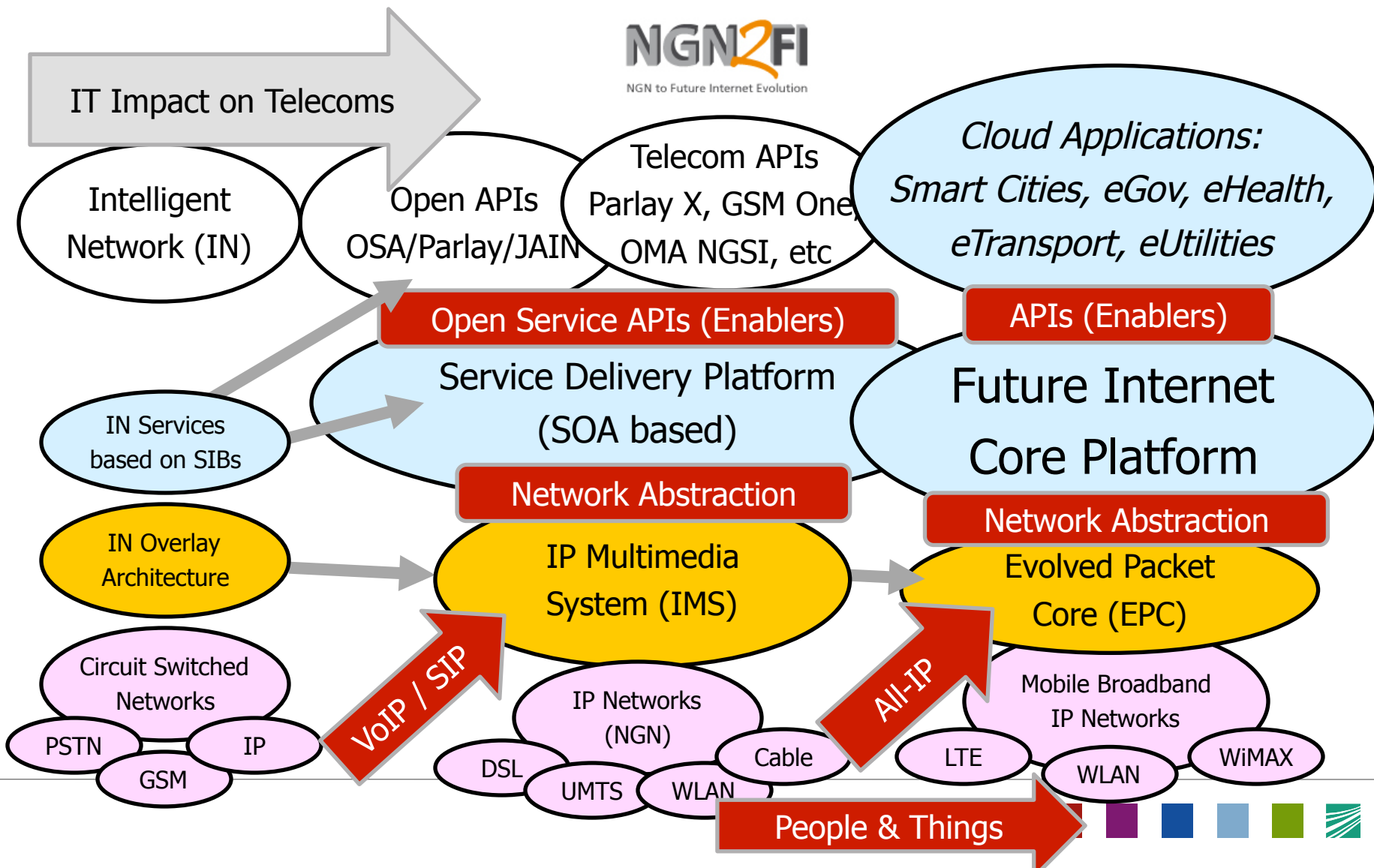
Related FOKUS Testbed Evolution
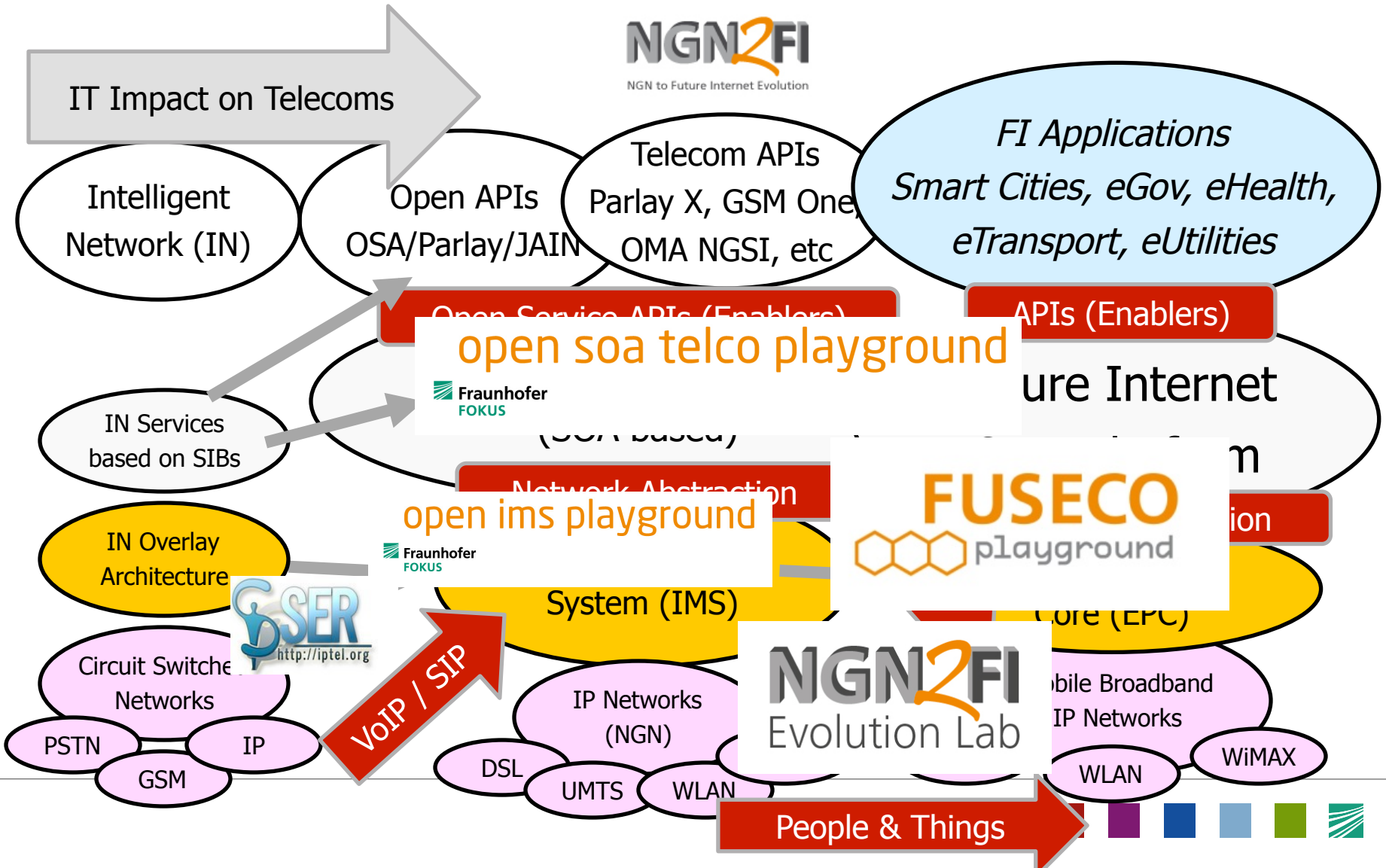
NGNI Research Domains and Tools & Testbeds

Integrated Service Architecture (ISA)

NGN2FI
NGN to Future Internet Evolution

- SOA-based Service Delivery Platforms
- Open Network APIs
- Agile Service Brokerage
- Open Client Platforms
- Telco Service Prototyping

open soa telco playground
Fraunhofer FOKUS

mymonster tcs
Fraunhofer FOKUS

fokus broker
Fraunhofer FOKUS

AV
Next Generation Networks

open mtc
Fraunhofer FOKUS

osims
Fraunhofer FOKUS

open epc
Fraunhofer FOKUS

open ims playground
Fraunhofer FOKUS

FUSECO playground

NGN2FI Evolution Lab

packet tracking

teagle

- NGN Services
- IP Multimedia System
- Evolved Packet Core
- Security and Network Monitoring
- M2M Communication
- Coginitive Networking

- IMS/P2P Integration
- Monitoring & Security
- Internet of Things
- IPv6 testbed

- Cross-domain resource federation
- FI Crosslayer network, infrastructure and service monitoring & management composition
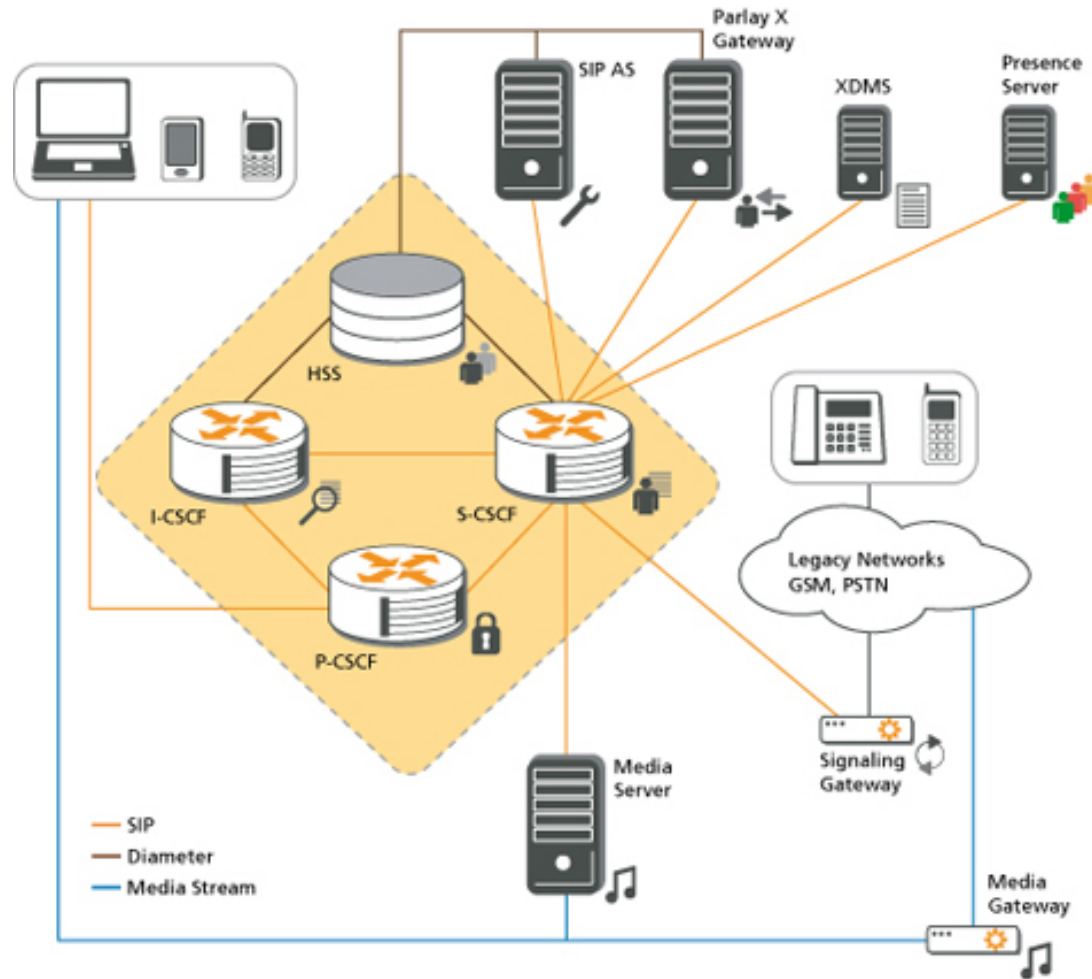- Mobile Cloud Applications
- Smart City Applications

Reliable Network Infrastructures (RNI)

Emerging Infrastructures & Services (EIS)

FOKUS Open IMS Playground

open ims playground

# 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 officially 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
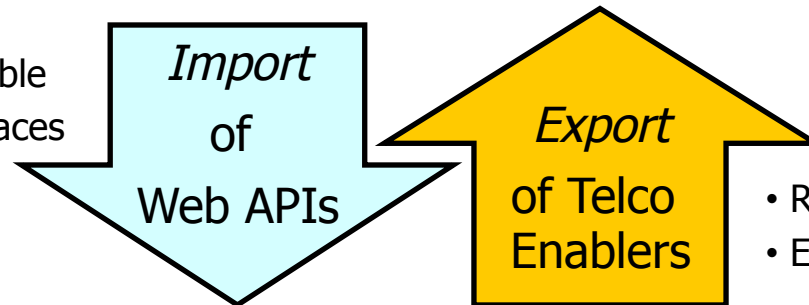
- See also www.open-ims.org
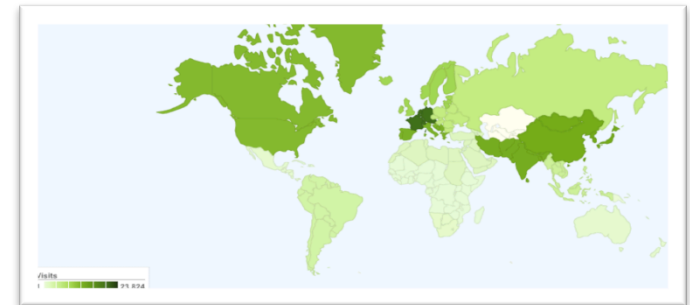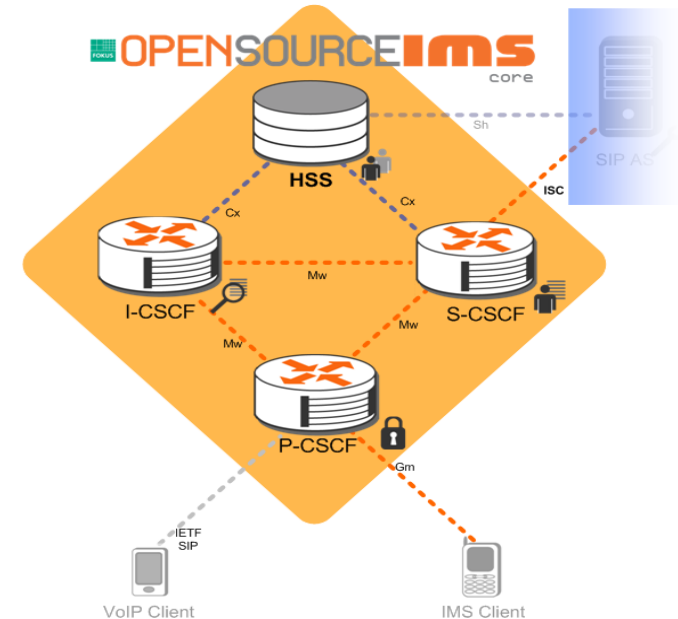
Open Network APIs: Import and Export of „Services Enablers"

Web 2.0 World Players and Services

(Google Maps, YouTube, RSS Feeds, etc.)

• Re-use what is publicly available
• Create recognised user interfaces

Import
of
Web APIs

Export
of Telco
Enablers

• Resell available capabilities
• Enable value added services

Service Brokering

Telco Enablers provided by SDPs

(Calls, Messaging, QoS, Charging, Identity Mgt., Security)
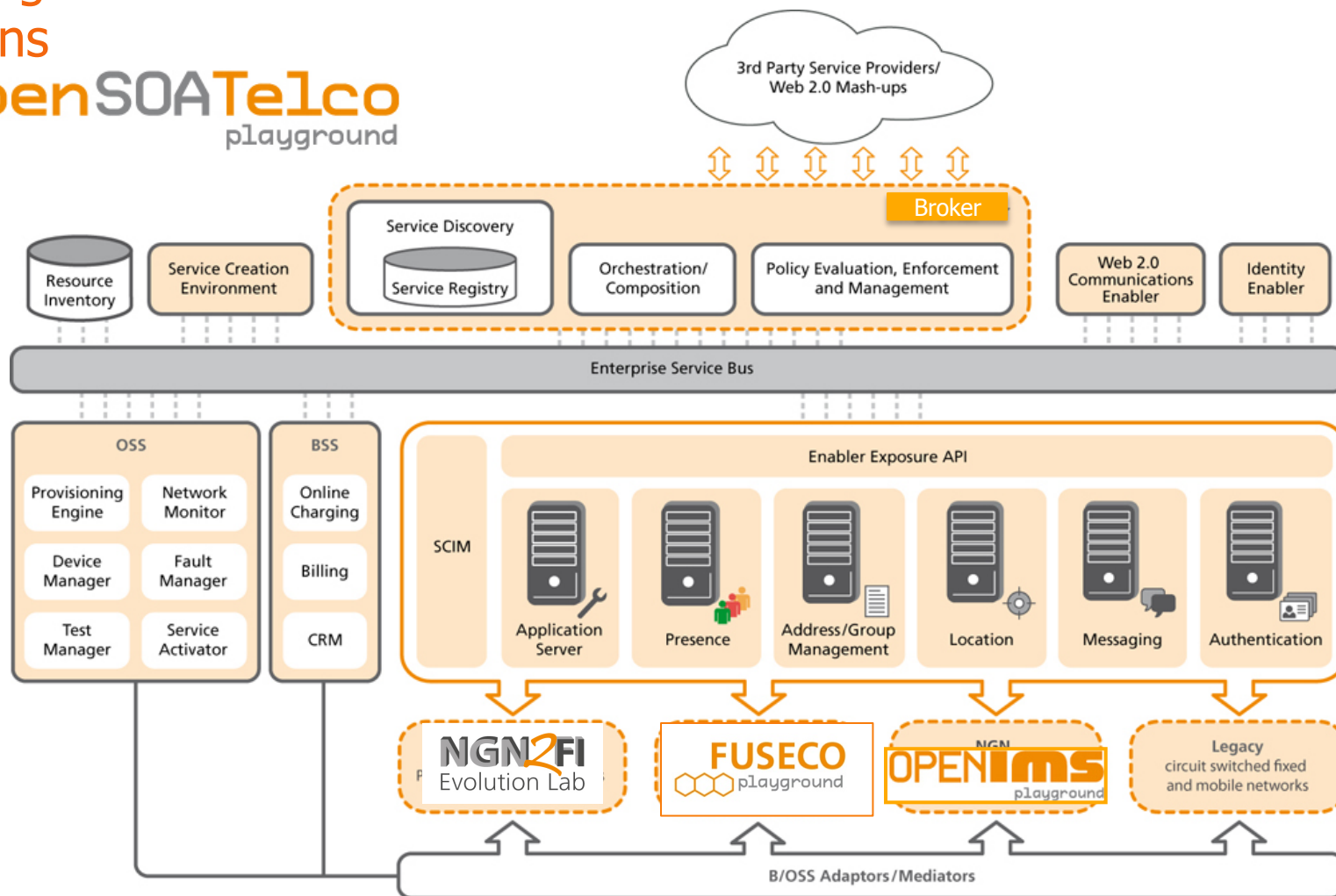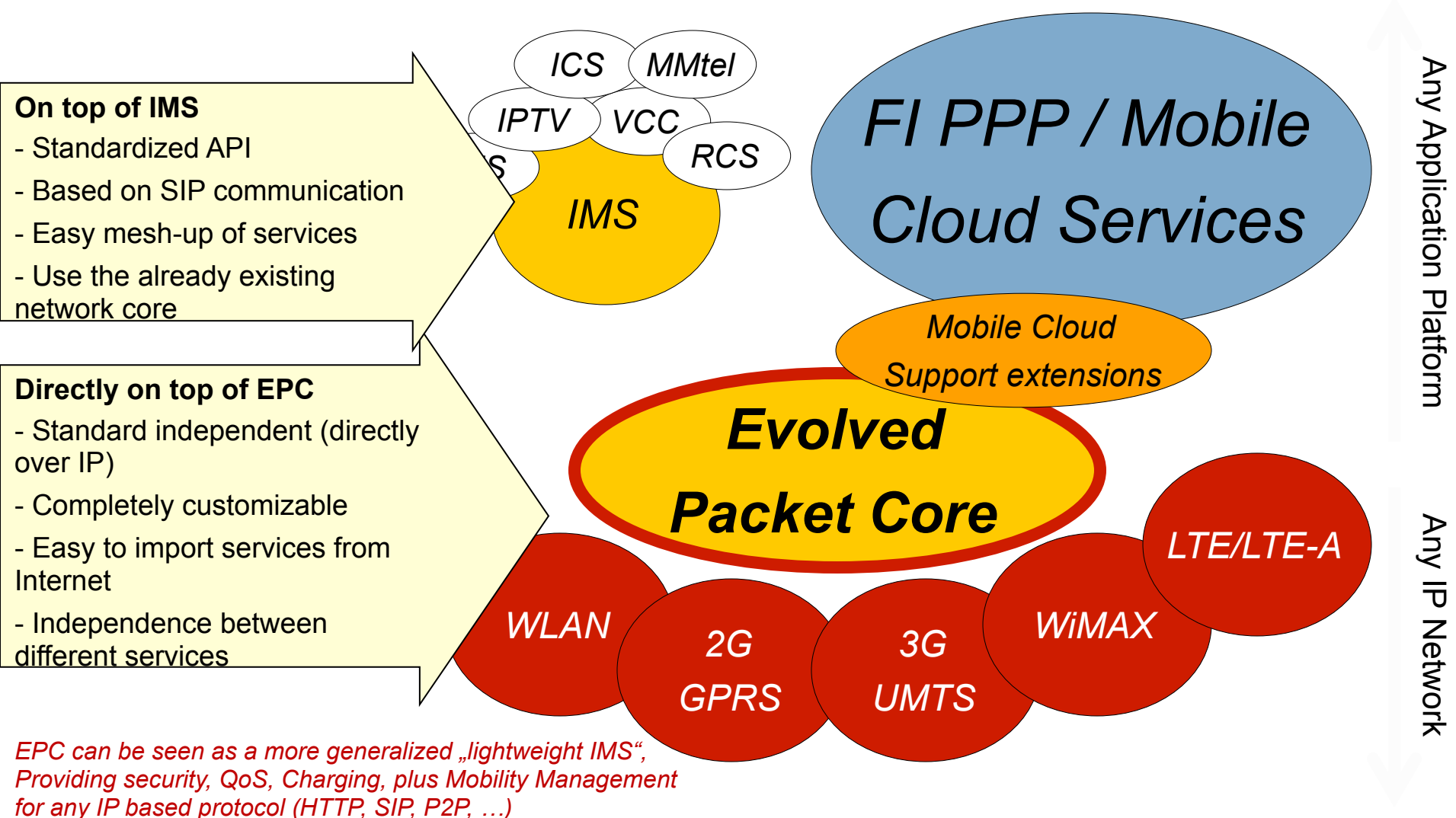
Network Abstraction

Fixed Network

Mobile Network

NGN

OpenSOATelco playground

Exploring Services Composition - Open SOA Telco Playground
Enabling seamless Services across different Networks and Service Domains

Services Deployment in an IMS+EPC Environment

On top of IMS

- Standardized API

- Based on SIP communication

- Easy mesh-up of services

- Use the already existing network core

Directly on top of EPC

- Standard independent (directly over IP)

- Completely customizable

- Easy to import services from Internet

- Independence between different services

*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, …)*

ICS   MMtel

IPTV   VCC

RCS

IMS

FI PPP / Mobile Cloud Services

Mobile Cloud Support extensions

Evolved Packet Core

WLAN

2G GPRS

3G UMTS

WiMAX

LTE/LTE-A

Any Application Platform

Any IP Network

Future Seamless Communication (FUSECO) Playground

- State of the art testbed infrastructure as a cooperation of Berlin's Next Generation Mobile Network expertise for

  - **OpenEPC** 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:

  FUSECO–playground.org
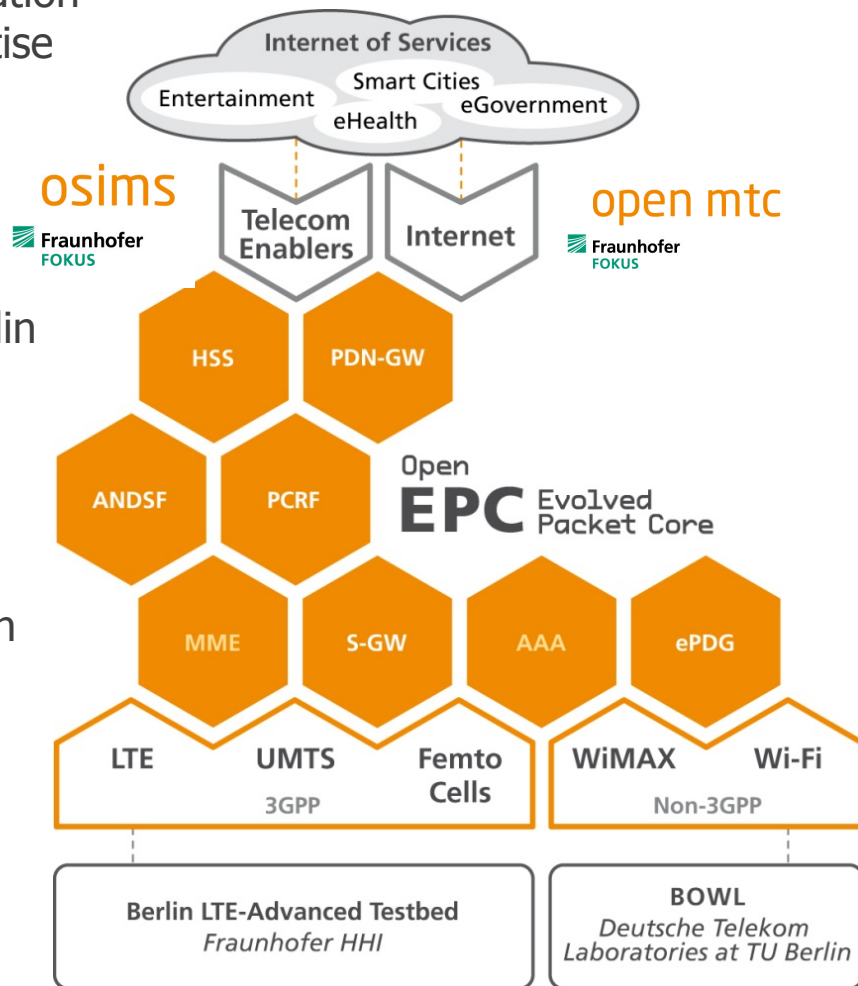
OpenEPC as key enabler of the FUSECO Playground

- 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
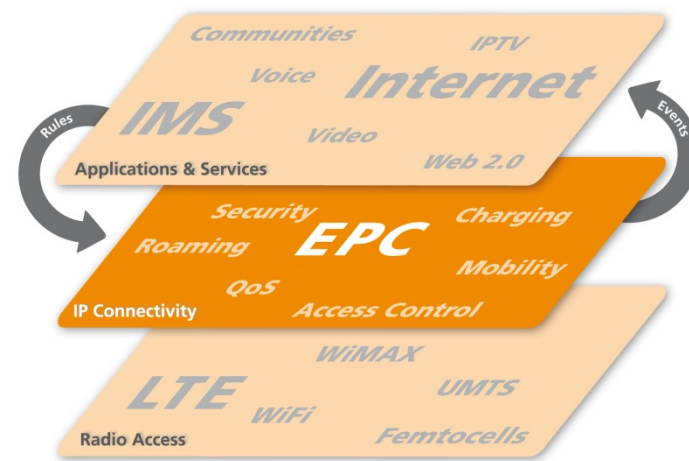
EPC Capabilities = Seamless IP Connectivity (= ABC) for FI PPP Apps

- 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

FI PPP Apps / Mobile Clouds

Internet

E-UTRAN

HTTP / HTML5 ....

EPC = IP Connectivity

EPC = IP Connectivity

WiMAX

**SIP**

WLAN

Packet GW

Packet GW

IMS

User Equipment
may be connected to several IP service domains in parallel
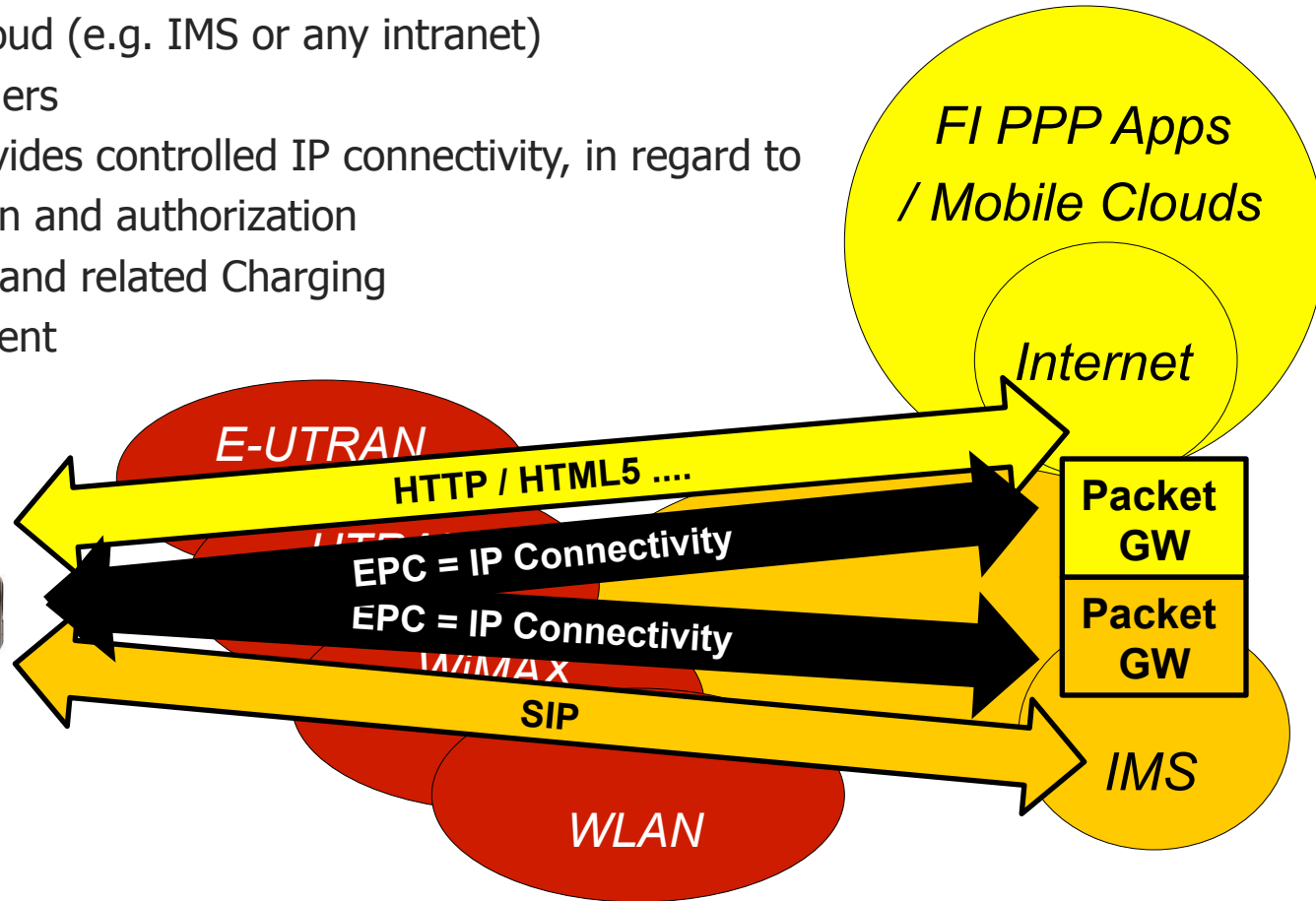
Network Control for the Service Layer (to Mobile Clouds)
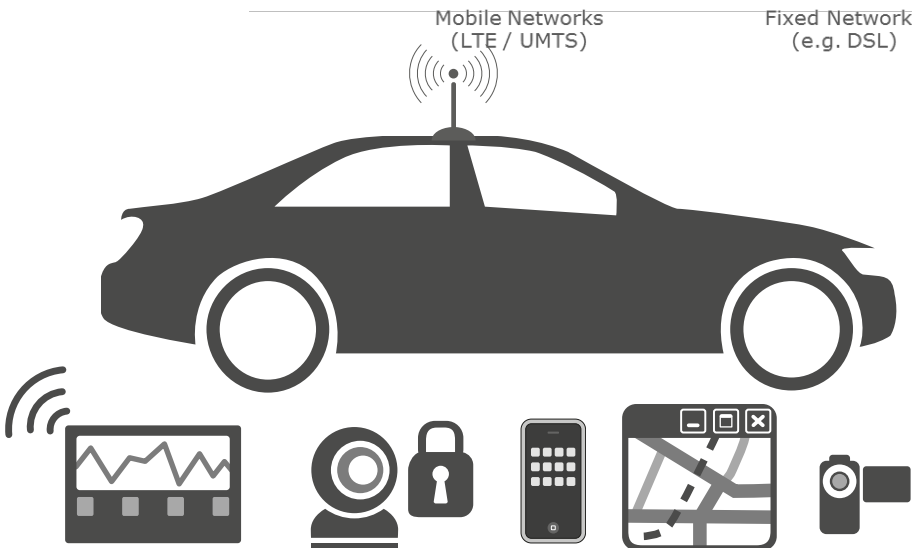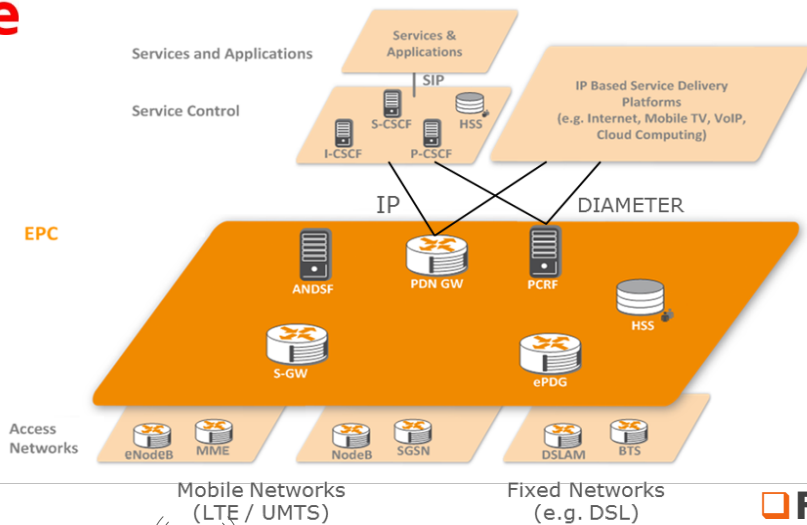## QoS Control through EPC/PCC Rx interface

- 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).
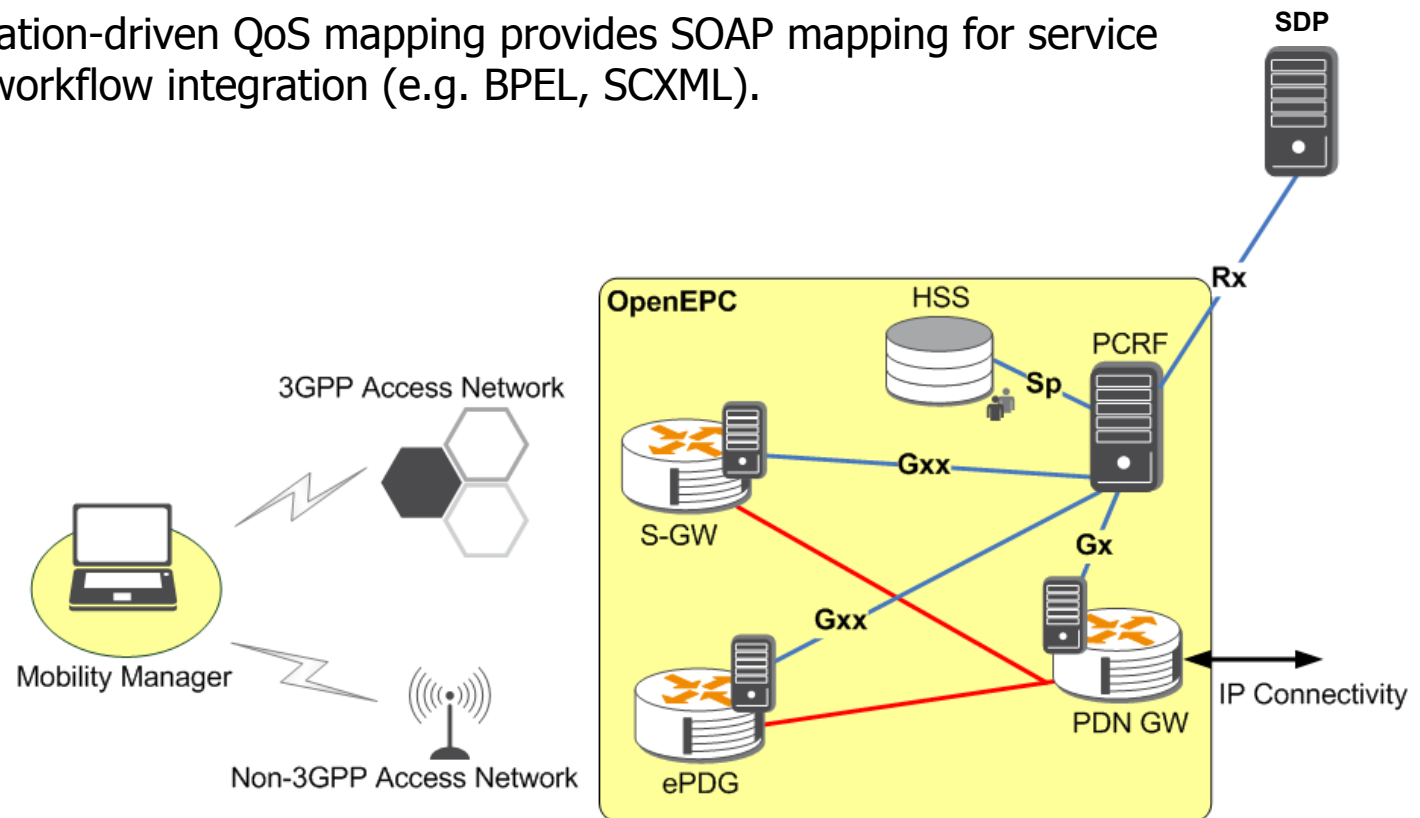
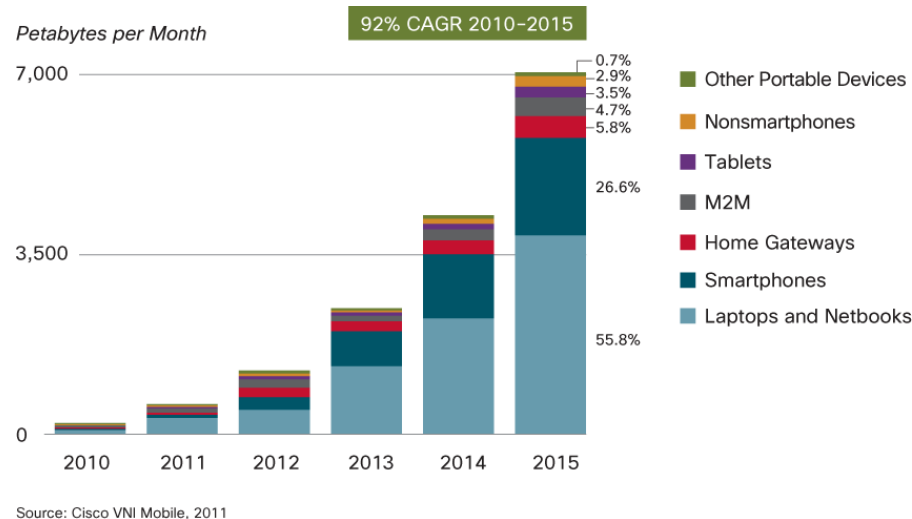# Starting Point: An Automotive Testbed Trial for M2M

- ☐ **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

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

Petabytes per Month

92% CAGR 2010–2015

Other Portable Devices
Nonsmartphones
Tablets
M2M
Home Gateways
Smartphones
Laptops and Netbooks

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}

IMS/EPC and Plain IP vs. M2M Platform

open epc
Fraunhofer FOKUS

	IMS/EPC (one model fits all)	**M2M Platform** (dynamic model)	**Plain IP** (best effort delivery)
Session Management	Everything is a session	Everything is a session	IP Packets Only
Session Signaling	Synchronous with the session	Once at the service deployment / once for all devices	*
Bearer Management	Based on Session Signaling =subscriber based=	Based on pre-shared info. in the core network =class based=	*
Device Signaling	Only for active devices	For all deployed devices	*
Communication Management	No communication management	Dynamic communication management	CoRE does include the parameters mgmt
Mobility Management	Anchoring based seamless mobility for all devices	Customized support (seamless, reachability, none)	*
Identity Management	1 Identity/Subscriber	1/1-to-n Identity/ Subscribers	Identity at service level
IP Connectivity	Yes	Yes	Yes

M2M Platform for Mobile Machine Type Communication (OpenMTC)
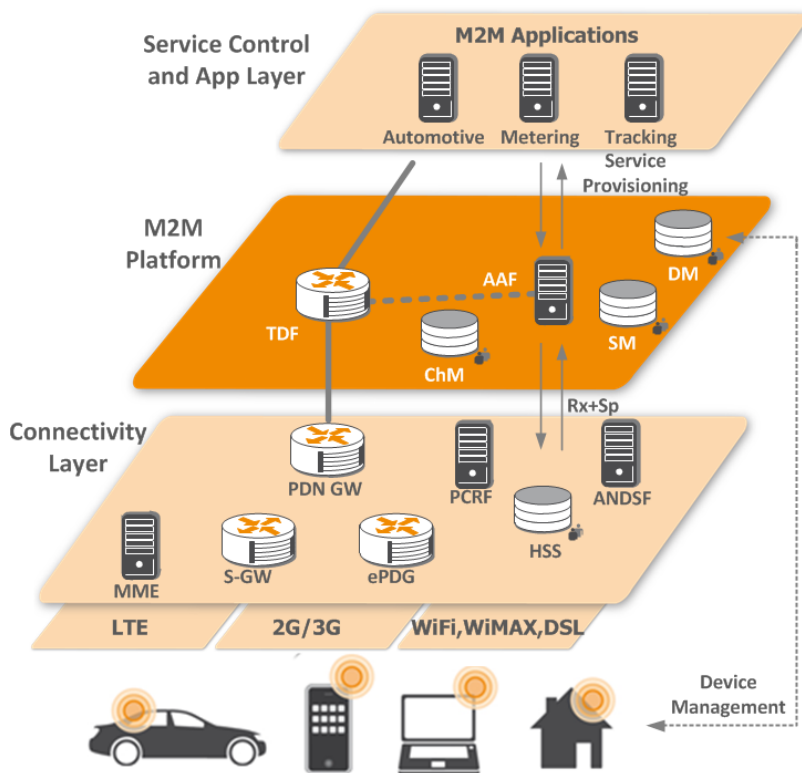
Defining an intermediary M2M Platform which handles the:

– 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
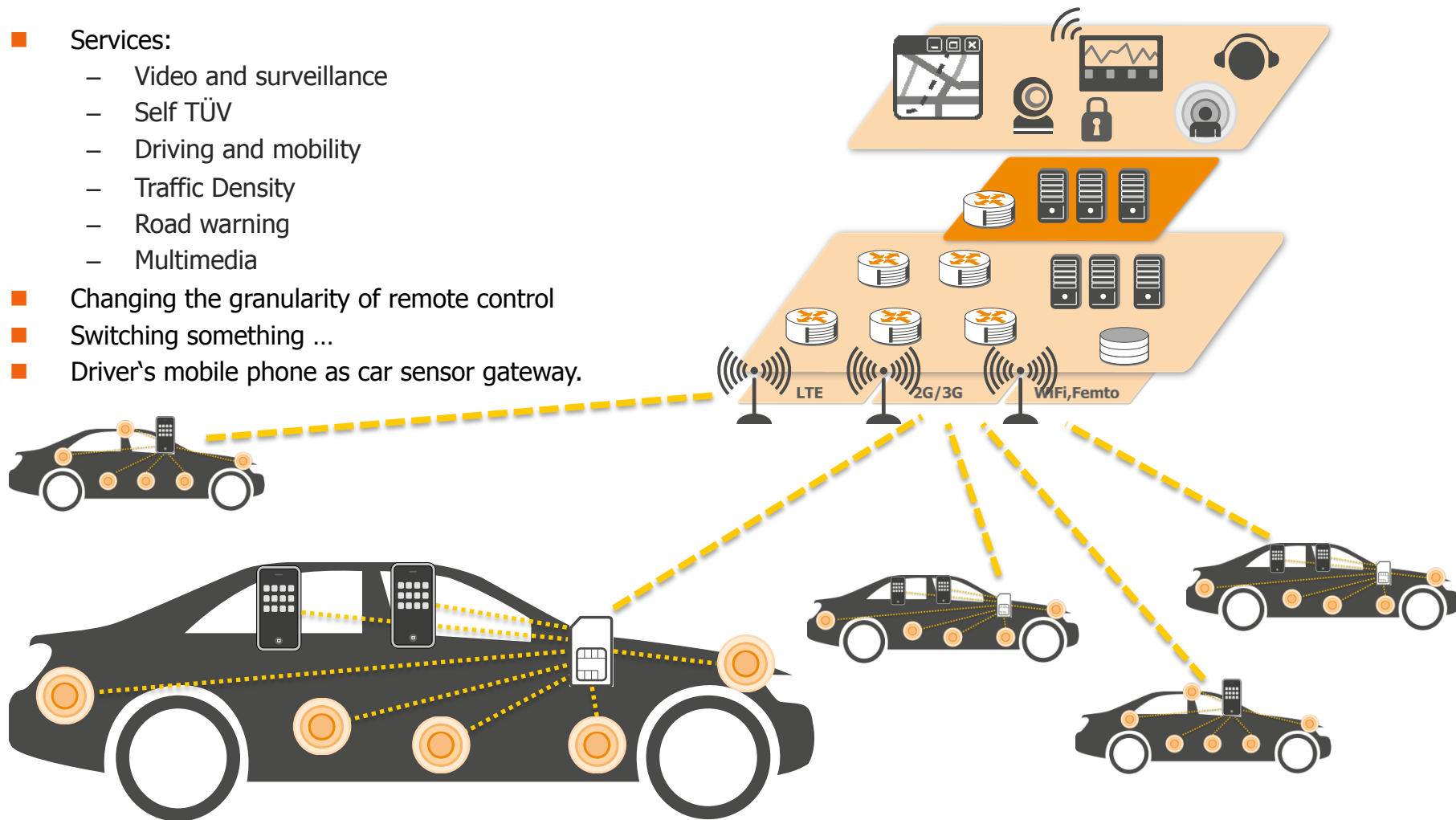
Automotive – Remote Control

open mtc

- 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.

LTE   2G/3G   WiFi,Femto

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

open mtc

Fraunhofer FOKUS

LTE   2G/3G   WiFi,Femto
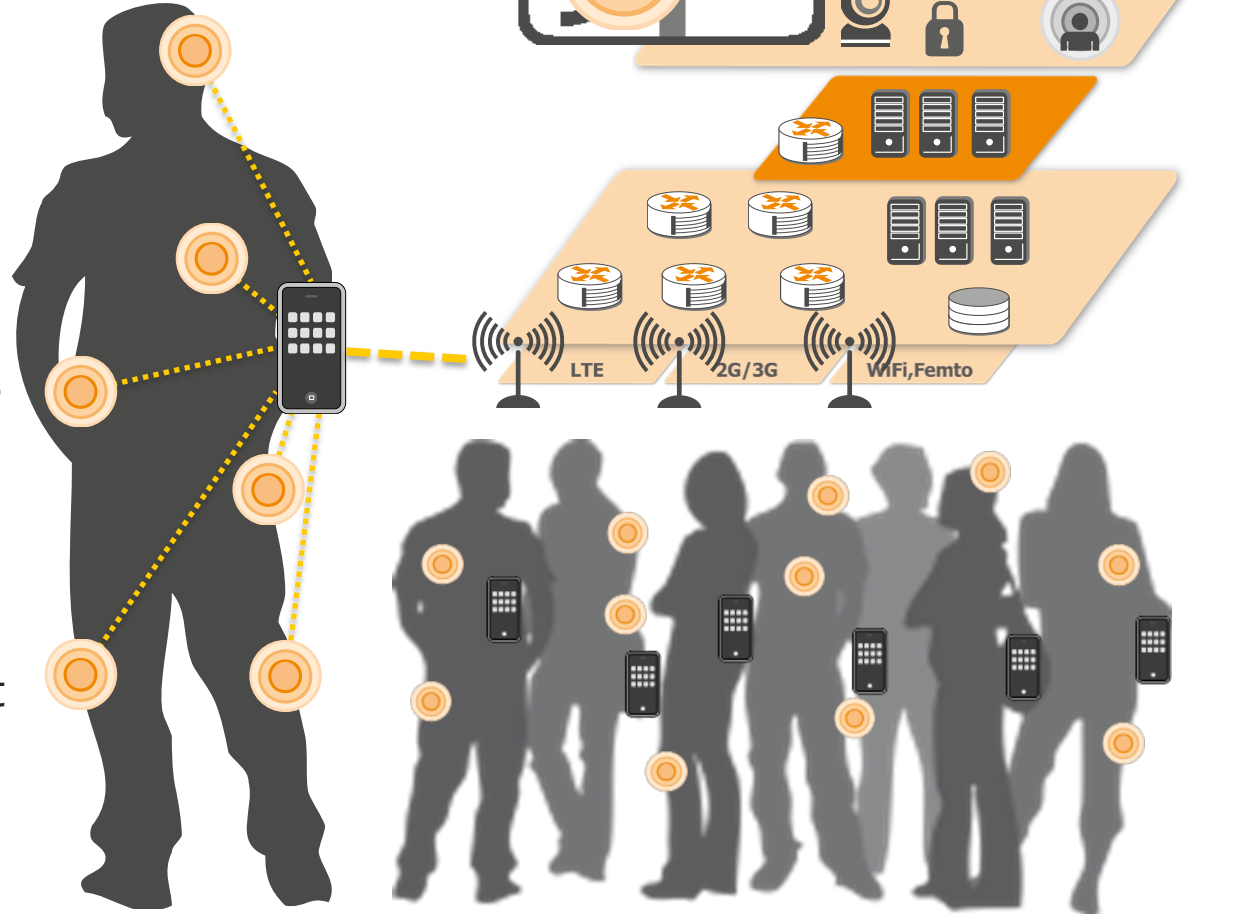
Infrastructure Integration – M2M Scalability
Automatic control of the many devices

open mtc

■ Video service to show:

– Scalability

– Low mobility

– Time back off and concurrent functioning

– QoS and real-time

– M2M trick functions
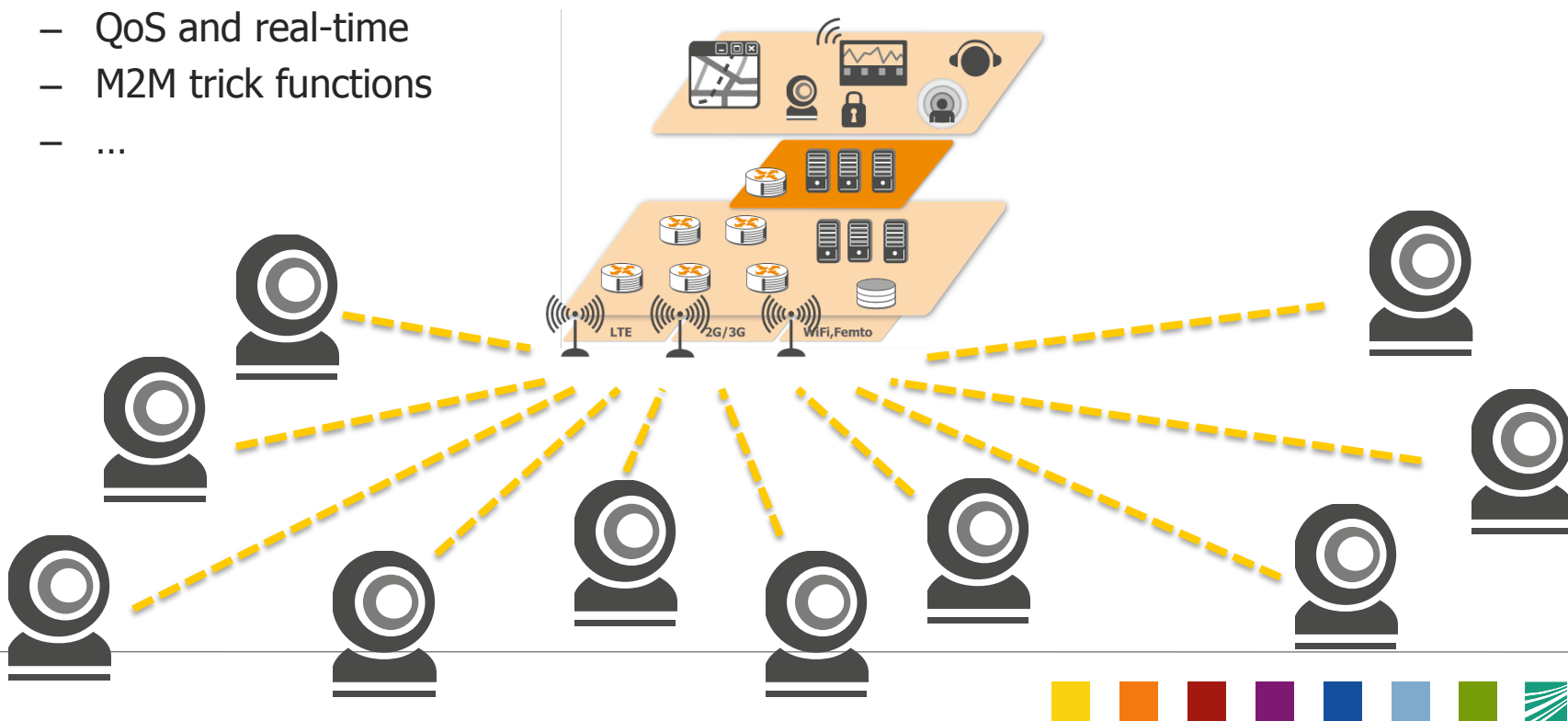
– ...

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
  - Internet by and for people
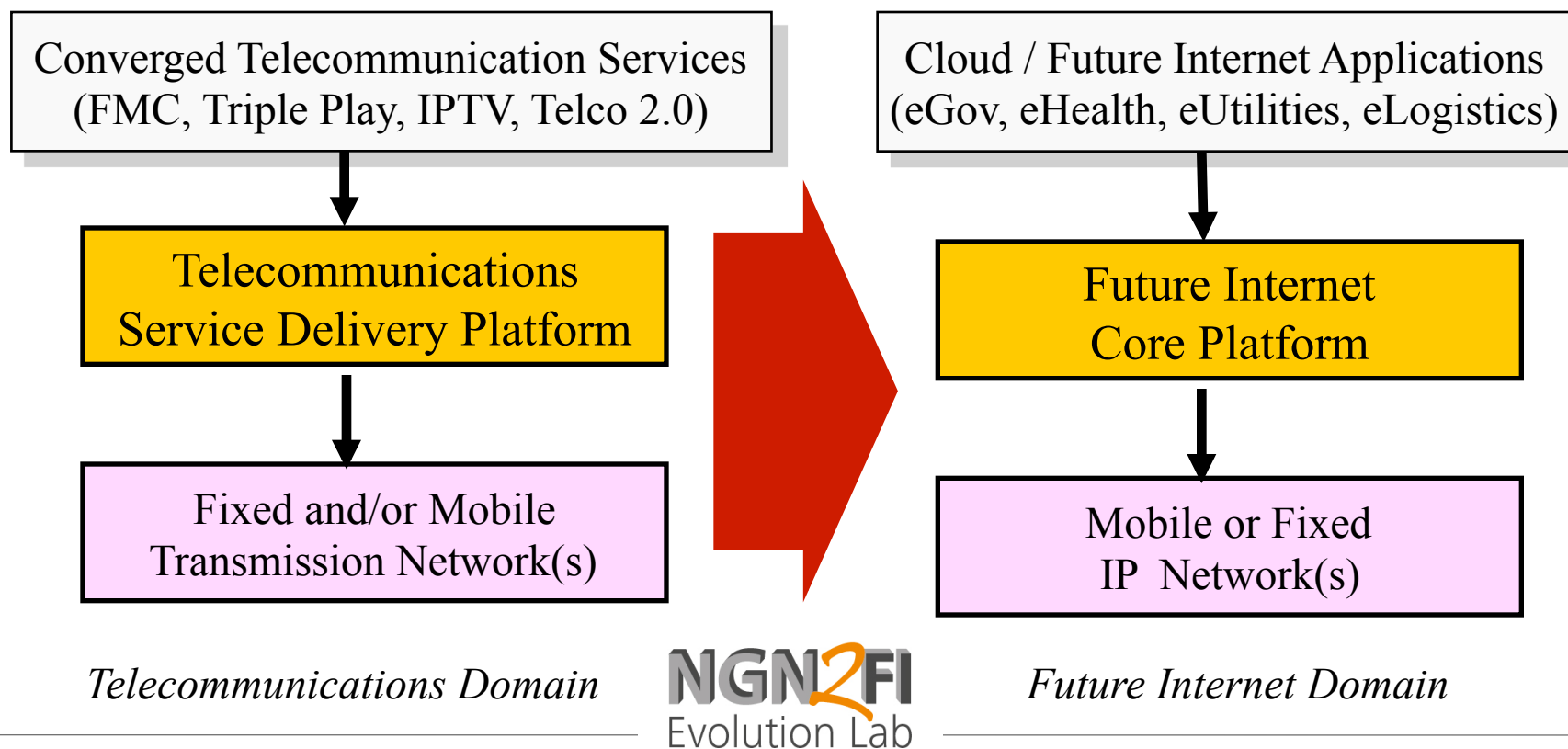 - Internet of Content
  - **Internet of Things**
  - Internet of Services
- Infrastructure Foundation:
  - Network infrastructure / substrate that supports the pillars
  - Shall support capacity requirements of Future Internet

Future Internet, The Cross-ETP Vision Document, Version 1.0, 2009
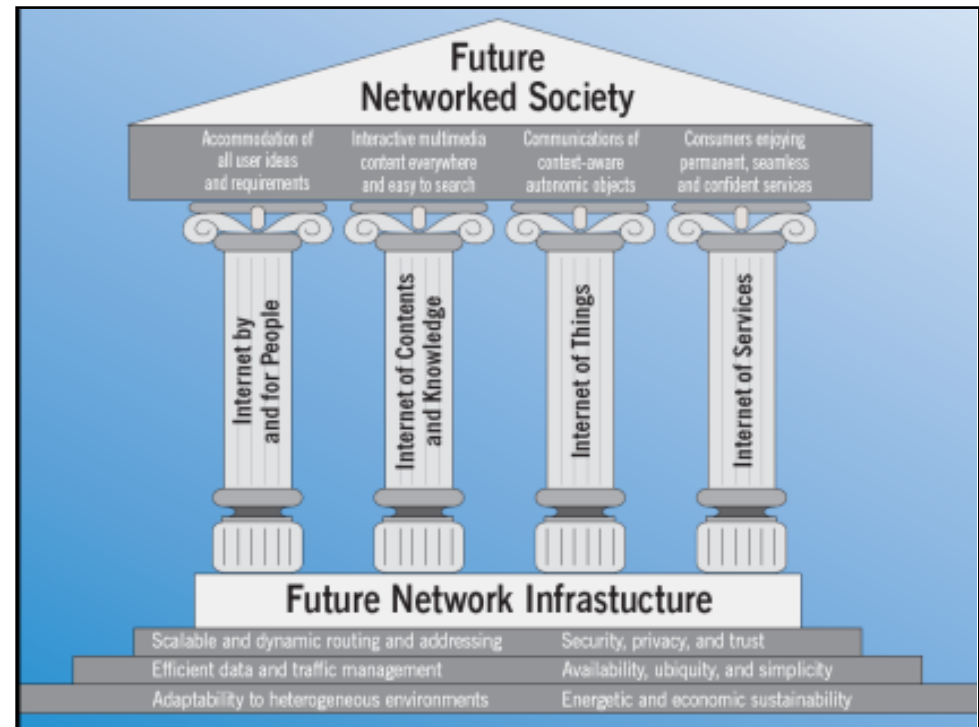
NGN2FI Evolution is a Challenge

Information Technologies
(Service Oriented Architectures & Cloud Comuting)

Service Architectures

Telecommunications

Internet

VoIP and Instant Messaging

Fixed and Mobile Telecommunications

Cable Networks

PES
RCS
FMC
3/4 Play
IPTV

Next Generation Network

eHealth
eGovernment
Smart Cities
Smart ***

OTT
SDP
IMS
MTC
EPC

Future Internet

Clouds

Internet of Services

Internet of Things

Network Virtualization

Self Organising Networks

Evolution

NGN2FI
NGN to Future Internet Evolution

Revolution

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

packet tracking

open epc
Fraunhofer FOKUS

teagle
A Pan-European Laboratory Project

INFINITY
INfrastructures for the
Future Internet commuNITY

G-Lab DEEP

- 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

fi-ware

One Lab

PLANETLAB

- Development of FI Monitoring

→ www.onelab.eu

NGN2FI
Evolution Lab

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

→ www.fi-ware.eu

Panlab
Pan European Laboratory Infrastructure Implementation

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

→ www.panlab.net

BonFIRE

nvi TEFIS

- Call 5 projects
- Building the FIRE facility

OpenLab

- Integration of Panlab and Onelab
- Federation of Testbeds

→ www.ict-openlabs.eu

NGN2FI
NGN to Future Internet Evolution

APIs / Enablers in the FI Context ...

FI Application Providers and Services

(Smart Cities, eLogistics, eUtilities, eEnergy, eHealth)

- Re-use what is publicly available
- Create recognised user interfaces

Import of FI APIs

Export of FI Enablers

- Resell available capabilities
- Enable value added services

fokus broker

≥ Fraunhofer FOKUS

Service Brokering

teagle

FI Enablers provided by FI Core Platform

(Communications, information access, QoS, Charging, Identity Mgt., Security)

osims

≥ Fraunhofer FOKUS

Network Abstraction

open mtc

≥ Fraunhofer FOKUS

open epc

≥ Fraunhofer FOKUS

Evolved Packet Core

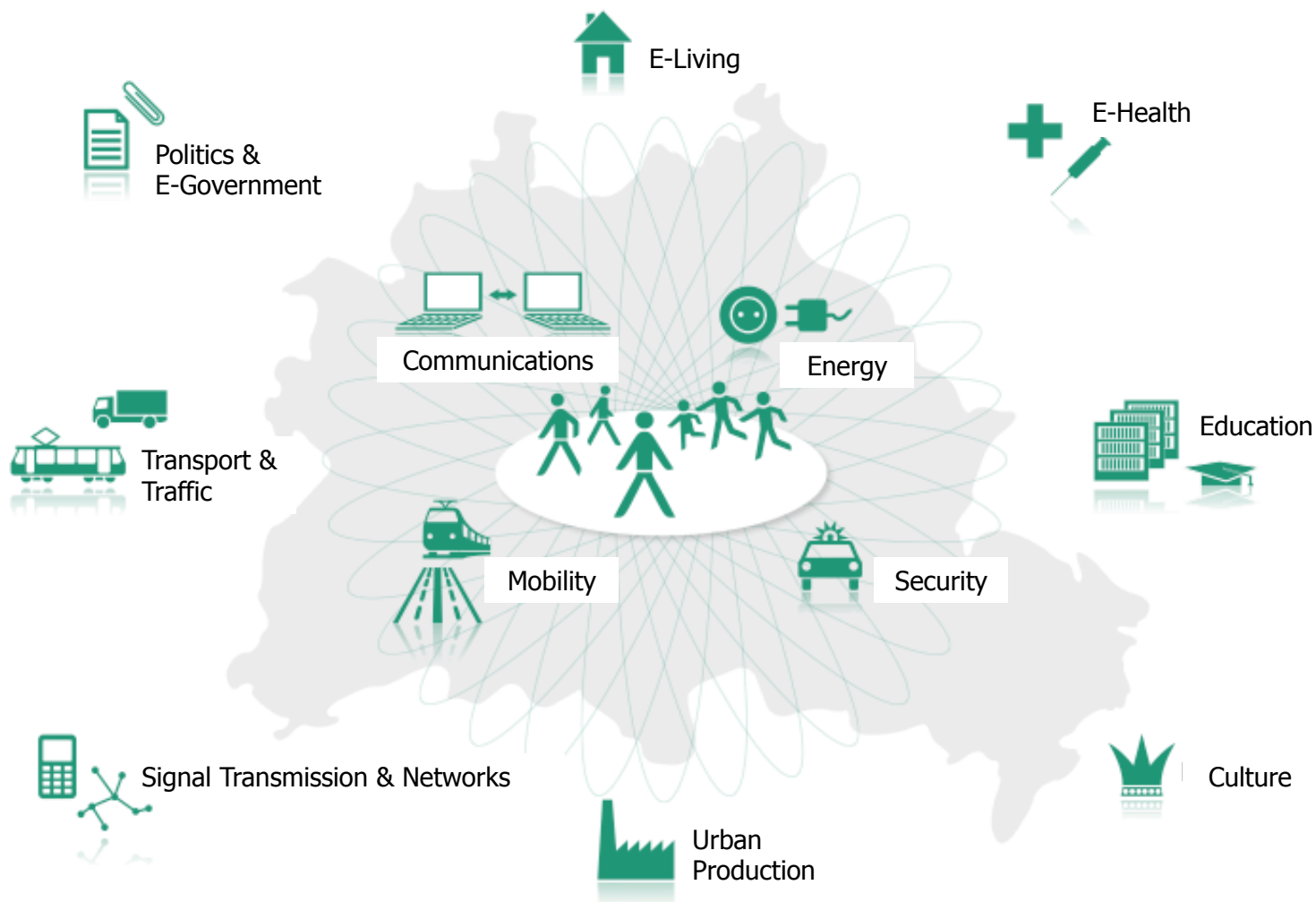Sensor Networks

Mobile IP Network

Fixed IP Network

NGN2FI Evolution Lab

Future Internet … to make our cities smart
A Smart City is a huge Future Internet Show Case

Fraunhofer
SMART CITIES

E-Living

E-Health

Politics &
E-Government

Communications

Energy

Education

Transport &
Traffic

Mobility

Security

Signal Transmission & Networks

Culture

Urban
Production

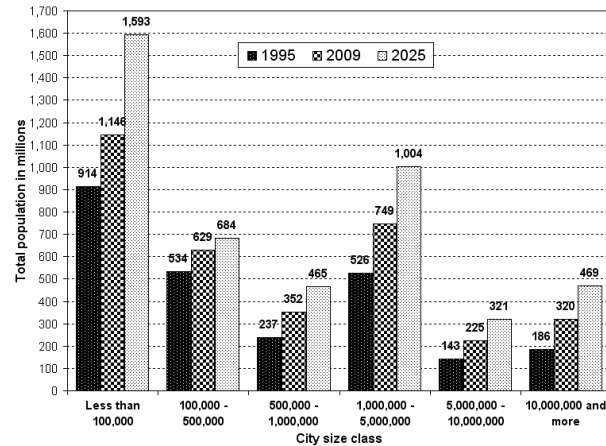NGN2FI
NGN to Future Internet Evolution

World Urbanization Prospects, the 2009 Revision
United Nations, Department of Economic and Social Affairs, Population Division
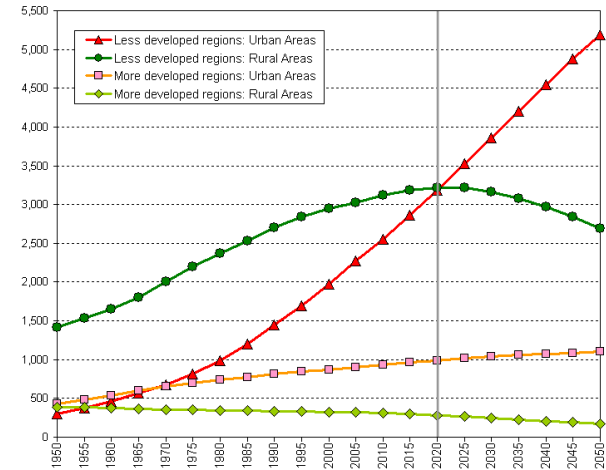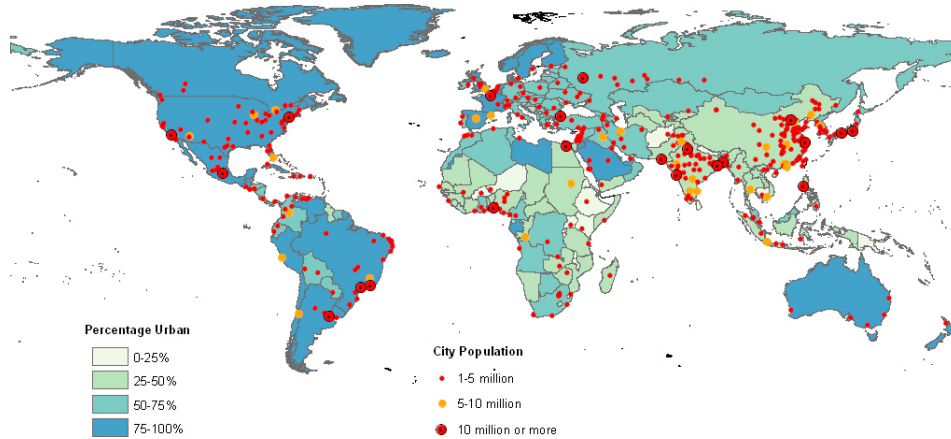
Urban Agglomerations in 2009 (proportion urban of the world: 50.1%)
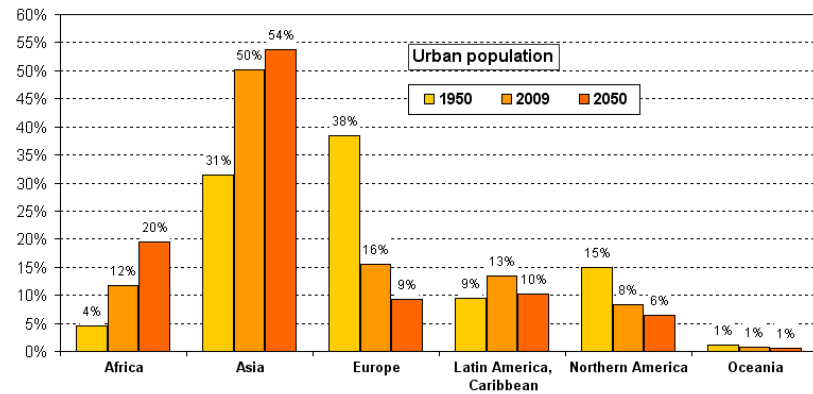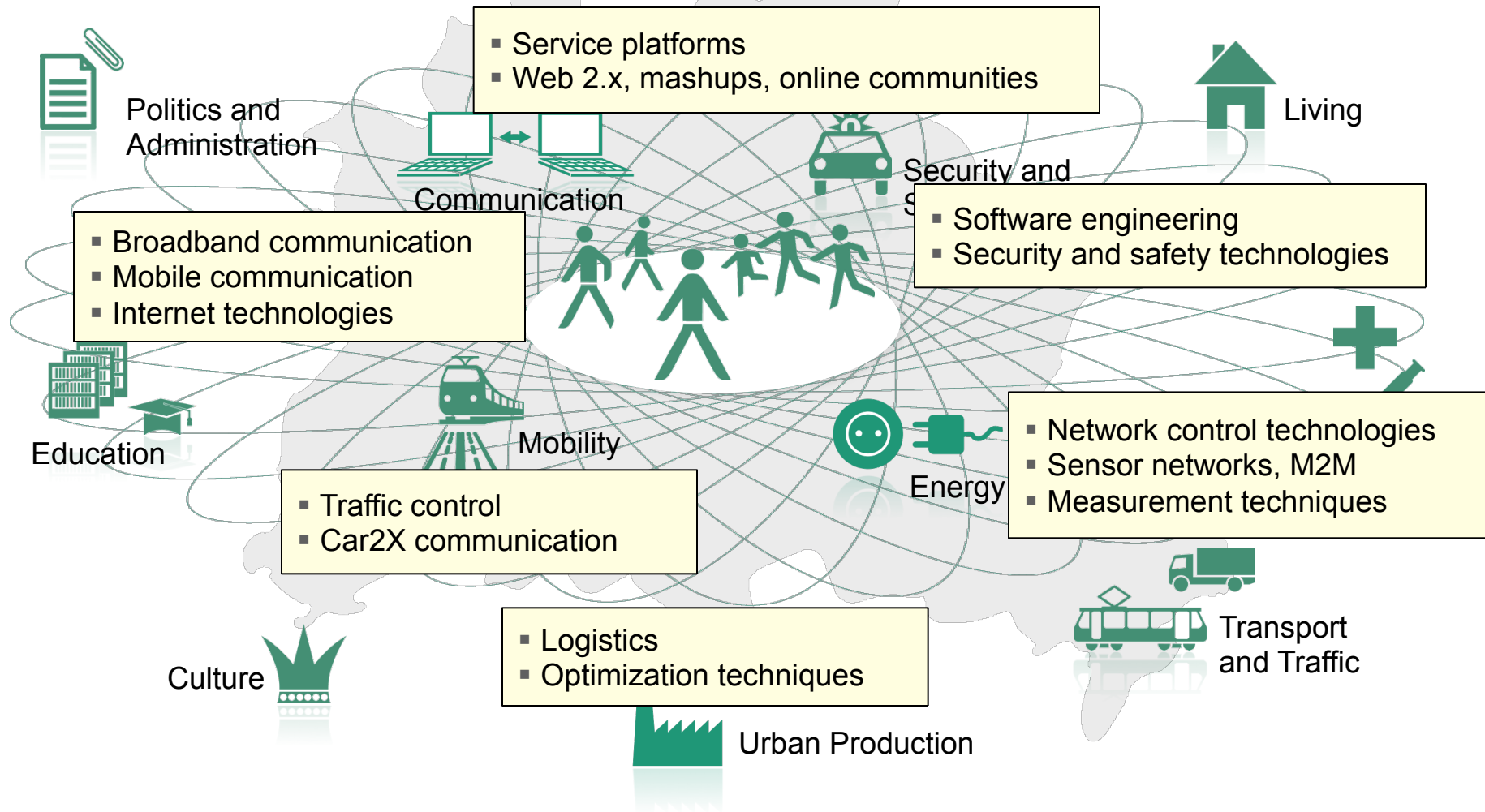

Urban and rural population by development regions (in mill.)

Total population by city size class (in millions)

Distribution of the world urban and rural population by major area

Fraunhofer
FOKUS

Our Expertise for ICT for Smart Cities

Politics and Administration

Communication

- Service platforms
- Web 2.x, mashups, online communities

Living

Security and S...

- Broadband communication
- Mobile communication
- Internet technologies

- Software engineering
- Security and safety technologies

Education

Mobility

- Network control technologies
- Sensor networks, M2M
- Measurement techniques

Energy

- Traffic control
- Car2X communication
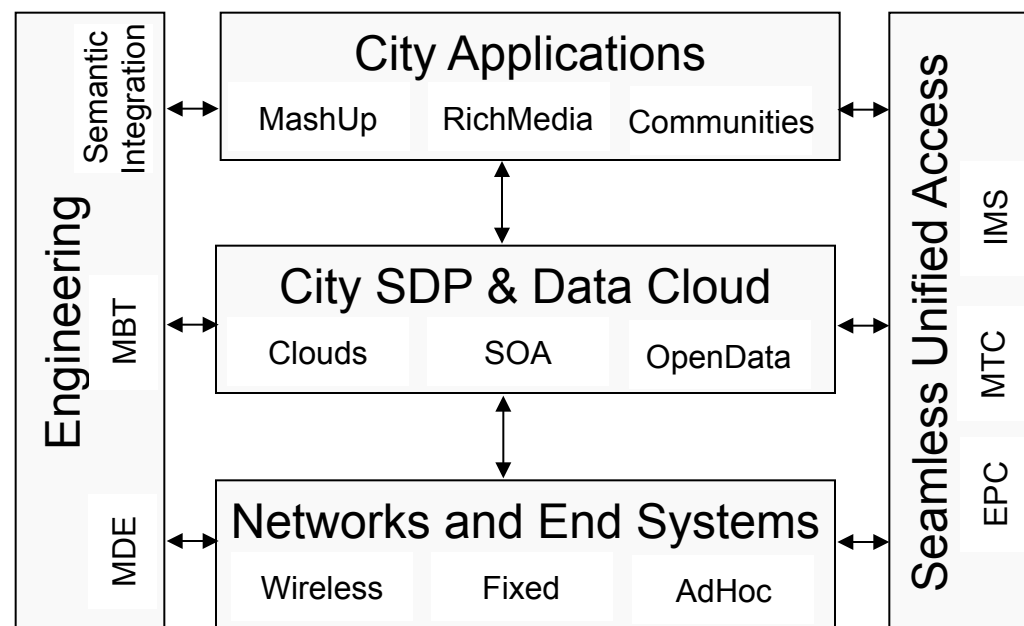
- Logistics
- Optimization techniques
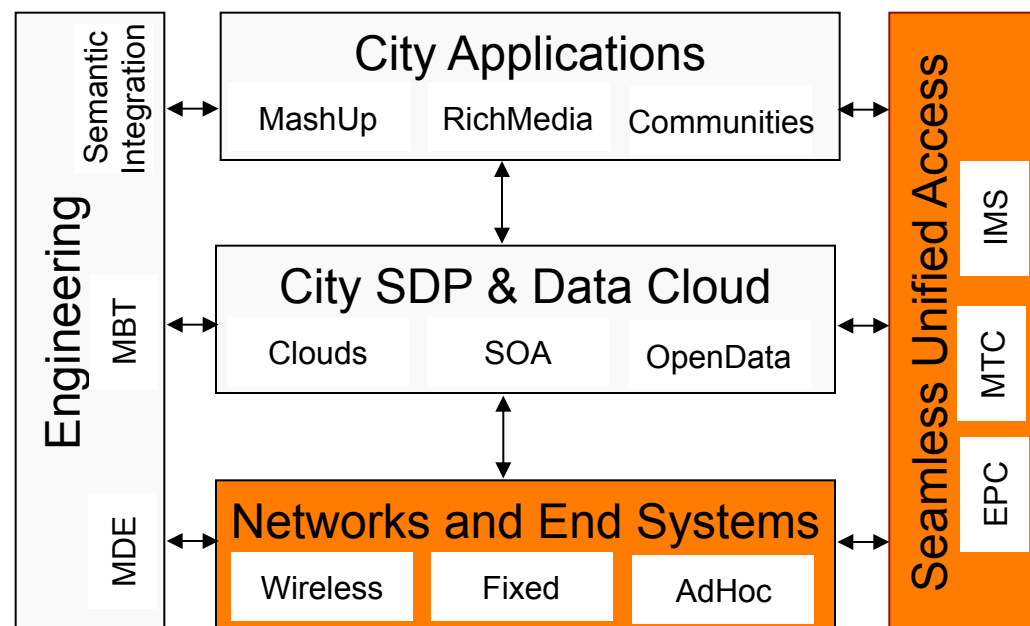
Culture

Transport and Traffic

Urban Production

Our View on ICT for Smart Cities

- City application platform for advanced apps by city stakeholders and communities
- City SDP and data cloud of secured, distributed, and interconnected data for managed information access
- Various types of fixed, mobile, adhoc, sensor networks connecting devices and sensors
- Seamless and unified access to raw, aggregated and consumer data and meta-data for fixed and mobile services
- Efficient engineering (design, development and maintenance) of validated secure, robust and reliable systems
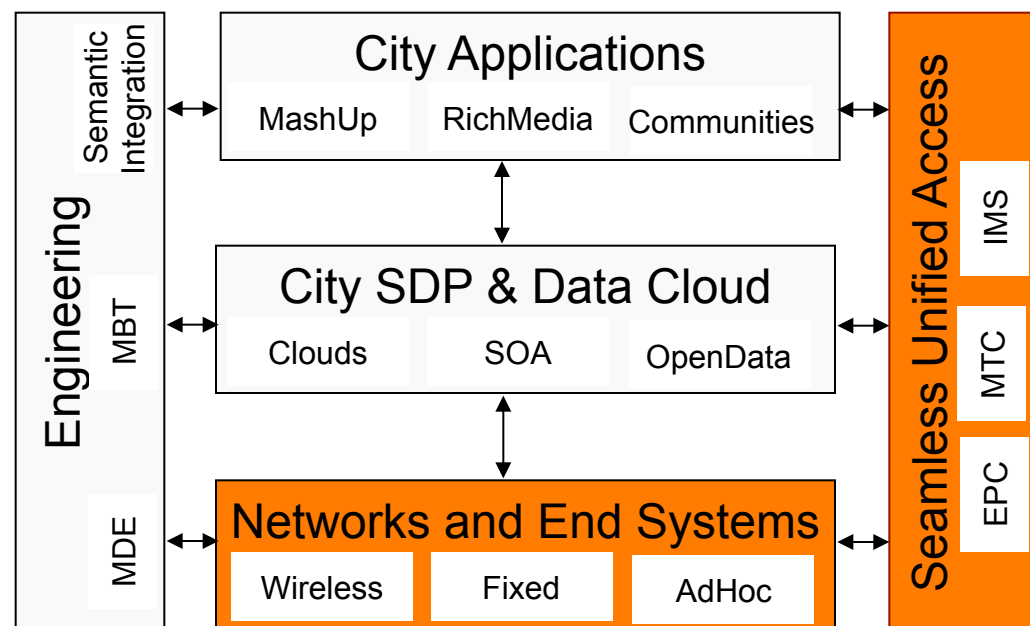
Engineering

Semantic Integration

MBT

MDE

City Applications

MashUp   RichMedia   Communities

City SDP & Data Cloud

Clouds   SOA   OpenData

Networks and End Systems

Wireless   Fixed   AdHoc

Seamless Unified Access

IMS

MTC

EPC

Towards a Smart City Communications Platform

- After Fixed Mobile Convergence and Voice Data Convergence we will witness *total communications convergence*
- Key value preposition of Smart Cities is seamless network, data and application integration
- ***Seamless and unfied communications support*** is a prerequisite for this!
- Various communication patterns need to be supported
  - Human – human(s)
  - Maschine – maschine(s)
  - Maschine – Human(s)
- Various business models and value chains need to be supported
- Various heterogeneous systems, devices, and networks need to be interconnected / federated

Engineering

Semantic Integration

MBT

MDE

City Applications
MashUp | RichMedia | Communities

City SDP & Data Cloud
Clouds | SOA | OpenData

Networks and End Systems
Wireless | Fixed | AdHoc

Seamless Unified Access
IMS | MTC | EPC

Towards a Smart City Communications Platform

- Applications should be able to express their communication needs (QoS) via communication APIs provided by the SC Communications Platform
- The platform integrates all existing and emerging communication networks by providing appropriate overlay networks / virtual networks
- Key platforms to be considered
  - IP Multimedia System (IMS) – Rich multimedia communications
  - Evolved Packet Core (EPC) – seamless mobility / mobile (and fixed) access network integration
  - Maschine Type Communications (MTC) – emerging plattform tuned for M2M communication

Engineering

Semantic Integration

MBT

MDE

City Applications

| MashUp | RichMedia | Communities |

City SDP & Data Cloud

| Clouds | SOA | OpenData |

Networks and End Systems

| Wireless | Fixed | AdHoc |

Seamless Unified Access

IMS

MTC

EPC

# Our toolkits for ICT for Smart Cities *(the NGNI view)*

- **Open SOA Telco Playground** provides a SOA based NGN Service Delivery Platform (SDP) for hosting an open number of service enablers to be used by SC applications

- **FOKUS Broker** allows for controlled exposure of service enablers for dynamic policy based service and data composition

- **OpenIMS Core** is a proven NGN platform for rich communication services

- **OpenEPC** is a globally recognised QoS and seamless mobility platform for all mobile networks, incl. LTE

- **OpenMTC** is an upcoming platform optimized for new types of M2M communications
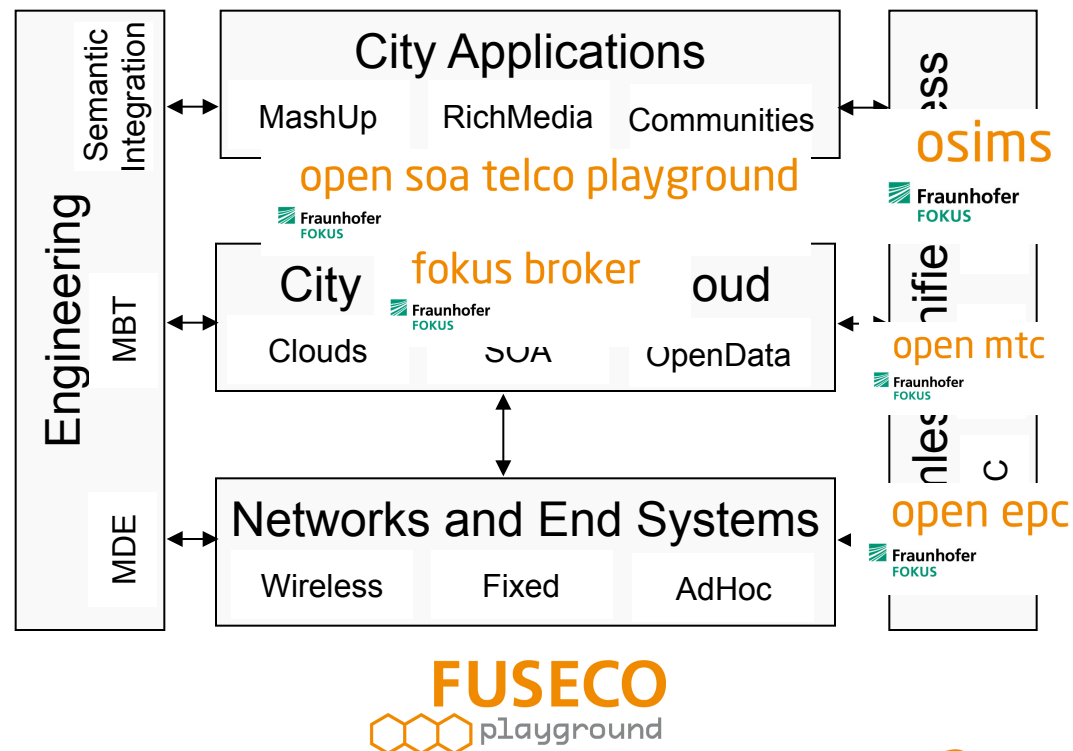
The Federation Challenge
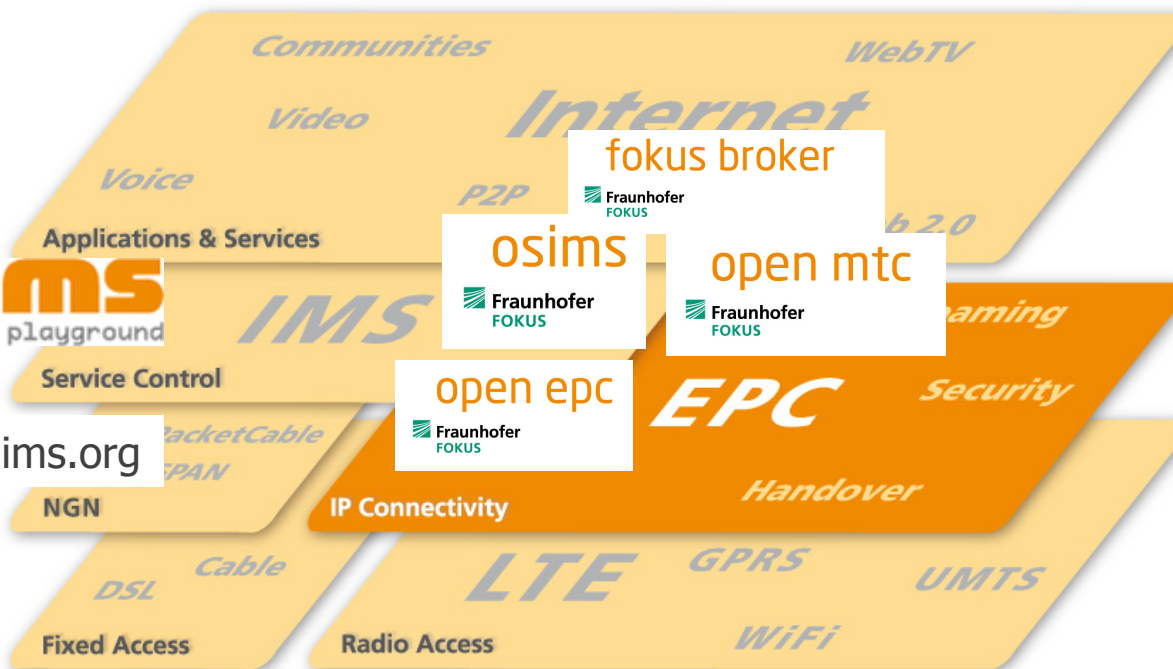## Different Application and Testbed Scopes

- 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
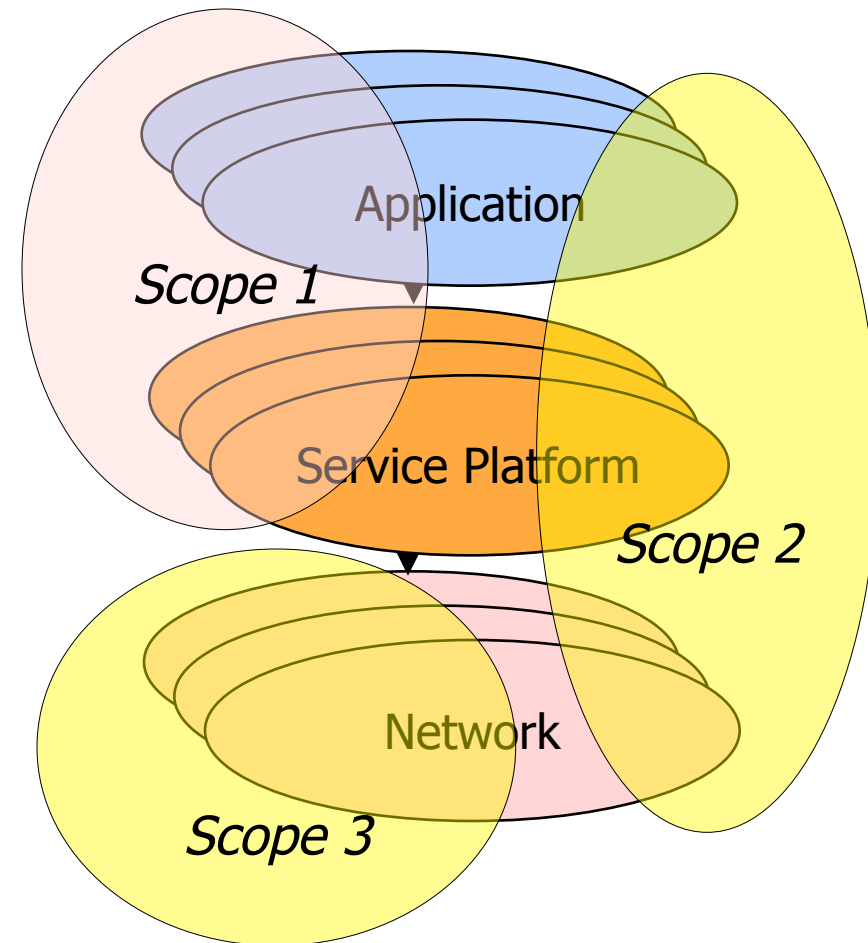
Related FOKUS Testbeds and Toolkits for Research and Development

NGNI provides Testbeds to Academia and Industry
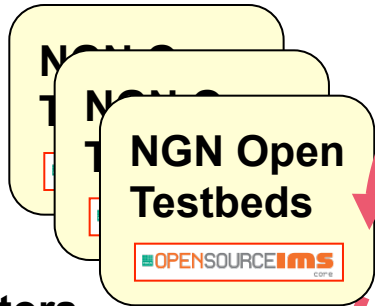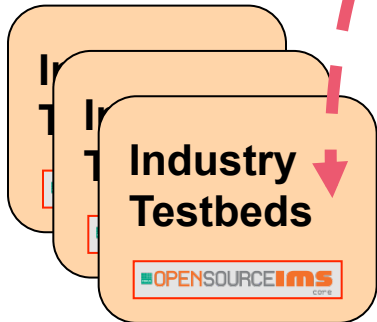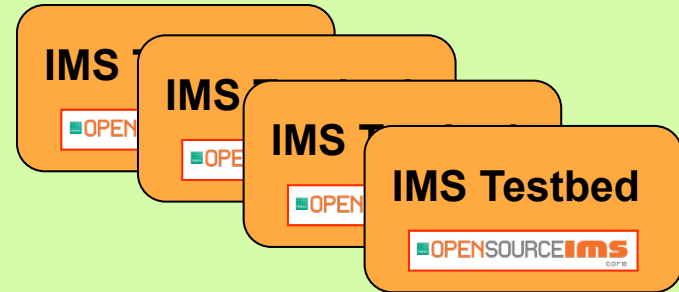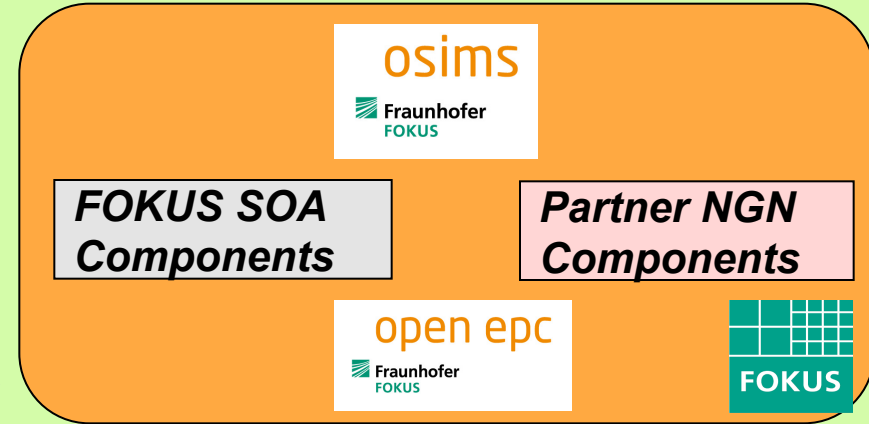
Commercial FOKUS NGN/SOA Testbed Deployments around the world

osims

open epc
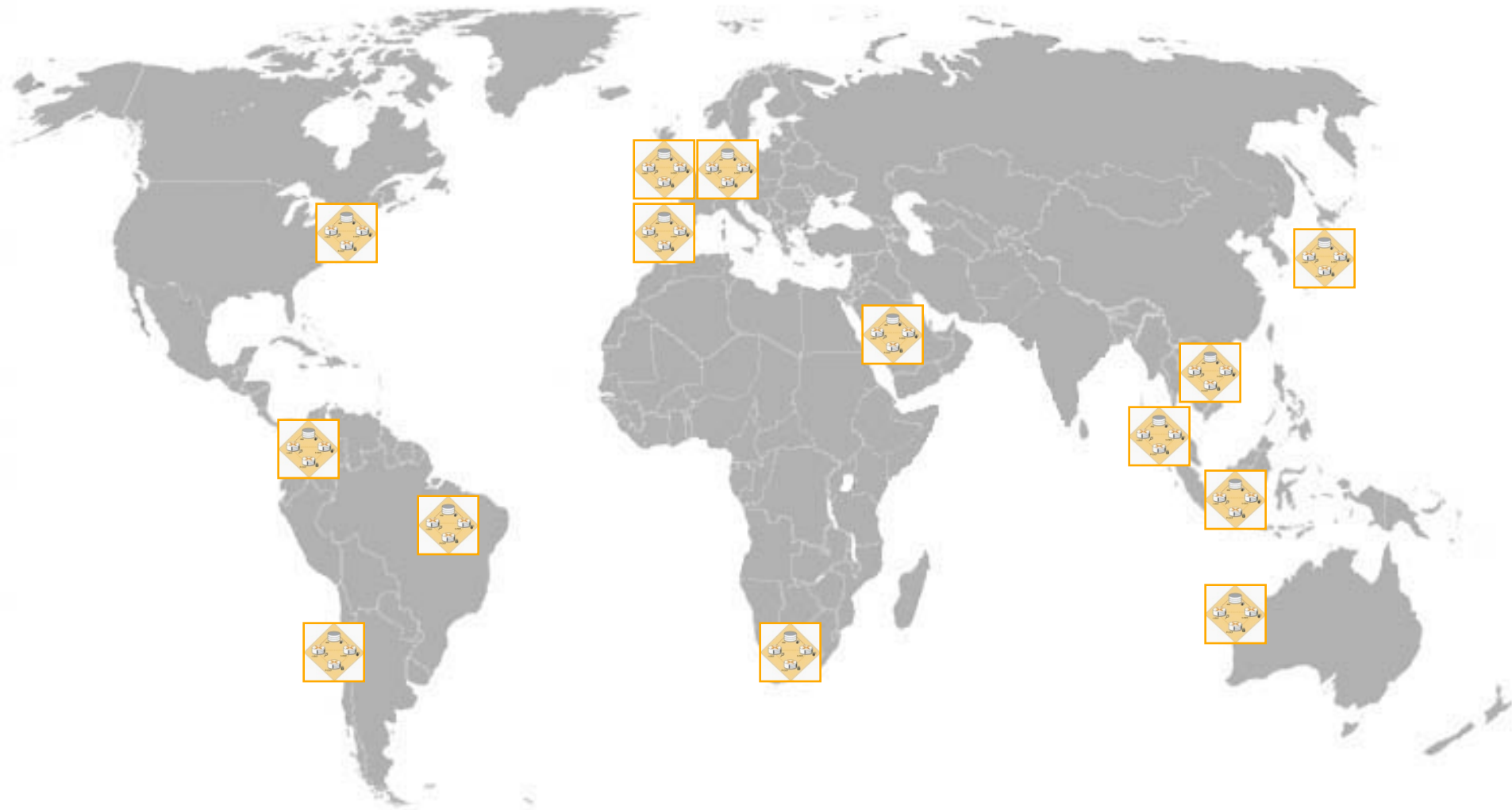
Join us at the 2nd FOKUS Future Seamless Communication Forum (FFF)
Berlin, Germany, November 17-18, 2011

- 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/2011 for Speaker and Sponsoring options

- 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

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Standardization involvements of TUB and FOKUS with IMS/EPC

- Specialist Task Force (TC INT) STF 414 on
  - "Update of IMS NNI Test Specifications for 3GPP R9, RCS 3.0 and IMS&EPC"
- TC INT has identified a need for specific tests for:
  - Interoperability for 3GPP Release 9 on NNI
  - ***IMS and EPC Interworking***
  - RCS Release 3.0
- Project goals in two phases:
  - Creating Test specifications (IMS&EPC Interoperability Testing):
    - Use case creation
    - Identification of relevant interfaces
    - Writing test descriptions
  - Validation of the tests/scenarios during 5th ETSI IMS Plugtests in 2012 using ***OpenEPC*** and ***OpenIMSCore*** as reference software tools.
- Fraunhofer FOKUS Interoperability lab and ETSI/INT website:
- http://www.etsi.org/WebSite/technologies/IMSTesting.aspx

Plugtests of ETSI/INT

- ETSI/INT develops common global IMS specifications for mobile, fixed and convergence based on the existing 3GPP IMS
- ETSI Plugtests organized by Technical Committee for IMS Network Testing (TC INT)
- Plugtests provide a base for operators and vendors to perform pairwise interoperability tests between two participating parties on:
  - Complete IMS testbeds
  - Single IMS components
- Test results under NDA
- The (next) 4th ETSI Plugtest for IMS NNI for 3GPP R8 by TC INT targets:
  - Interoperability for 3GPP Release 9 on NNI
  - Emergency Call
  - IMS and EPC Interworking
  - RCS Release 3.0
- STF Steering: Telecom Italia, Telekom Austria, Conformiq, Testing Tech, **FOKUS**
- http://www.etsi.org/WebSite/NewsandEvents/events.aspx

Fraunhofer FOKUS IMS Components used for IOP

Open IMS Playground features the following IMS related services, toolkits and frameworks for testing interoperability between single components or against full architectures.

- NGN myMONSTER Telco Communicator Suite (TCS) supports 3GPP IMS, GSMA RCS and Open Mobile Alliance (OMA) services
- Generic Event Enabler a generic framework for the SIP event subscription
- OSIMS - The FOKUS Open Source IMS Core
- Parlay X Gateway a SOAP-based Network Abstraction API providing industry-standard APIs, now defined by the Open Mobile Alliance (OMA)
- OpenEPC – IMS on top of EPC enables QoS controlled voice-over-LTE and other SIP-based data services
- Etc.

OPENIMS playground

http://www.fokus.fraunhofer.de/en/fokus_testbeds/open_ims_playground/index.html

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Useful Links

- Fraunhofer FOKUS NGNI Competence Center: www.fokus.fraunhofer.de/go/ngni
- TU Berlin Chair for Next Generation Networks: www.av.tu-berlin.de
- Open IMS Core Project: www.openimscore.org
- Open IMS Playground: www.open-ims.org
- Open SOA Telco Playgorund: www.opensoaplayground.org
- Open EPC Project: www.openEPC.net
- Future Seamless Communication Playground: www.fuseco-playground.org
- NGN to Future Internet evolution Lab: www.ngn2fi.org
- Future Internet testbed tool Teagle: www.fire-teagle.org

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- 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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- T. Magedanz, N. Blum, S. Dutkowski, "Evolution of SOA Concepts in Telecommunications - A Déjà vu?", Special Issue on Service Oriented Architectures, IEEE Computer, November 2007, ISSN 0018-9162

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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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