Towards Smart City Service Delivery and Control Platforms - Putting SDP, IMS, MTC, and EPC into a single context

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Agenda

- Smart Cities as Future Internet Show Case
- Smart City communication infrastructures requirements
- The Role of IP Multimedia Subsystem, Machine Type Communication, Evolved Packet Core and related Open APIs within emerging Smart City SDPs
- FOKUS Toolkits and practical examples
- Summary
- Q&A
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)

Telecommunications Service Delivery Platform

Fixed and/or Mobile Transmission Network(s)

Future Internet / SC Applications (eGov, eHealth, eUtilities, eLogistics)

Future Internet / Smart Cities Core Platform

Mobile or Fixed IP Network(s)

Telecommunications / NGN Domain

Future Internet Domain
From specific to unified next generation Multi-Service networks

*Individual networks = individual services vs. Multi service networks*

NOTE: This slide is more than 15 Years old!
For quality and efficiency reasons, the network architecture moves from “stovepipes” to a unified production ...

- From “stovepipes” per service ...
- ...to an open layered architecture

**Technology**
- Circuit-switched
- Copper
- GSM/UMTS

**Architecture**
- Vertical “stovepipes”/silos
- Duplicated elements per silo

**Integration**
- Multiple production platforms

**Services**
- Network centered around voice services

- Packet-switched (IP- and Ethernet-based)
- Optical \(^1\)
- OFDM \(^2\)

\(^1\) Optical and copper in last mile
\(^2\) OFDM = Orthogonal Frequency Division Multiplexing

Source DTAG
Connectivity vs. Content – Where will be the Money in Mobile Broadband?

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

IP-based Core Network (IMS or EPC)

Access Systems

Common Applications and Services

IMS Apps

Common Applications and Services
From Simple Voice to Innovative Service Platforms

Goal for Everybody
- Customer Care and service quality
- Rapid, efficient customer-centric services
- Value curve understood to maximize revenue
- Lean operation with Business Agility

How to provide “Carrier grade” quality?
How to foster a “leap change in innovation”?

Service Proliferation
- High
- Low

Service Revenues
- Low
- High

Communications Services Domain
Goal: Leverage Existing Revenue Relationship

Internet Services Domain

How to provide “Carrier grade” quality?
How to foster a “leap change in innovation”?
New Eco System demands Federation and Open APIs
OTT vs. Telco Networks & Platforms – APIs/IMS/EPC/MTC as last resort??

- All IP Networks will pave the road for Over the Top (OTT) Application
- Evolved telecom platforms may provide revenue potentials via Service Gateways (APIs) on top VoIP/RCS (IMS), Maschine Type Communication (MTC) and Smart Bit pipe approaches (EPC)
- RCS will have to compete with Unified Communications (UIC) in OTT area
NGN2FI Evolution is a Challenge

Information Technologies
(Service Oriented Architectures
& Cloud Computing)

VoIP and Instant Messaging

Fixed and Mobile Telecommunications

Cable Networks

Evolution

Revolution

Next Generation Network

Smart Cities

Future Internet

Telecommunications

Internet

NGN Evolution

Future Internet

Fixed and Mobile Telecommunications

Cable Networks

VoIP and Instant Messaging

Next Generation Network

Smart Cities

Future Internet

Evolution

Revolution
Evolution of Telecommunication Platforms toward Smart Communications

IT Impact on Telecoms

Open APIs
OSA/Parlay/JAIN

Intelligent Network (IN)

IN Services based on SIBs

IN Overlay Architecture

Circuit Switched Networks
PSTN
GSM

IP Multimedia System (IMS)
IP Networks (NGN)
DSL
UMTS
WLAN
Cable

Open Service APIs (Enablers)

Service Delivery Platform (SOA based)

Network Abstraction

SC Cloud Applications:
RCS, UC, eGov, eHealth, eTransport, eUtilities

APIs (Enablers)

Smart City /
Future Internet

Core Platform

Network Abstraction

IP Networks
Mobile Broadband
LTE
WLAN
WiMAX

Evolved Packet Core (EPC)

MTC

Telecom APIs
Parlay X, GSM One, OMA NGSI, etc

Telecom APIs

All-IP

All-IP

VoIP / SIP
Evolution of Telecommunication Platforms toward Smart Communications

IT Impact on Telecoms
- Intelligent Network (IN)
- Circuit Switched Networks
- PSTN
- GSM

Open APIs
- OSA/Parlay/JAIN
- Telecom APIs
- Parlay X, GSM One, OMA NGSI, etc

Service Delivery Platform (SOA based)
- Open Service APIs (Enablers)
- Network Abstraction

IP Multimedia System (IMS)
- IP Networks (NGN)
- VoIP / SIP
- All-IP
- DSL
- UMTS
- WLAN
- LTE
- Cable

Future Internet Research
- SC Cloud Applications: RCS, UC, eGov, eHealth, eTransport, etc

Internet of Services
- APIs for Smart Services
- Future Internet

Internet of Things
- Network of the Future
- MTC
- Mobile
- Core
- eHealth
- eTransport
- eUtilities
- eGov

IT Impact on Telecoms
- PSTN
- GSM
- IP
- DSL
- UMTS
- WLAN
- LTE
- Cable
- Cloud
- Mobile
- Core
- eHealth
- eTransport
- eUtilities
- eGov
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
FI = Towards a Thinner Protocol Stack

Application
Overlay & Mediation
Presentation
Session
Transport
Network
Data Link
Physical

Application
Mediation
Connectivity
Decoupling Networks from Infrastructure

- Management of virtual networks
- Provisioning of virtual networks
- Virtualisation of resources

Independent, isolated VNs, running different protocols, packet formats, management tools, etc.
Collection of virtual resources, aggregated to build virtual networks
Infrastructure made of virtualizable network resources

Source: EURESCOM Project P1956
M2M World of Connected Services
The Internet of Things
M2M Services & Applications

**Today**
- SMS based.
- Vertical isolated systems.
- INTRAnet of Things

**Future**
- Global horizontal approach.
- INTERnet of Things.
Towards a European Future Internet Platform

Making the world ‘smarter’ and accelerate sustainable innovation

ICT applications research

Application Pull

FI Platform holistic/system perspective/market impact

Technology push

ICT technology research

ICT Programme Challenge 1

Making Europe a world leader in Future Internet technologies

Trade-offs:
- Private/Public
- Infrastructure
- Openness
- Regulation

Competitiveness & Innovation Programme ICT-PSP

+ user-driven
+ social benefit
- time to market
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
A Smart City is a huge Future Internet Show Case

- E-Living
- Energy
- Communications
- Mobility
- Security
- Transport & Traffic
- Politics & E-Government
- Signal Transmission & Networks
- Urban Production
- Education
- Culture
- E-Health

www.fokus.fraunhofer.de/go/ngn2fi
Future Internet is “a socio-technical system comprising Internet-accessible information and services, coupled to the physical environment and human behavior, and supporting smart applications of societal importance”

FI can transform a Smart City into an open innovation platform supporting vertical domain of business applications built upon horizontal enabling technologies.

FI pillars for a Smart City environment:

- The Internet of Things (IoS): defined as a global network infrastructure based on standard and interoperable communication protocols where physical and virtual “things” are seamlessly integrated into the information network.
- The Internet of Services (IoS): flexible, open and standardized enablers that facilitate the harmonization of various applications into interoperable services as well as the use of semantics for the understanding, combination and processing of data and information from different service provides, sources and formats.
- The Internet of People (IoP): envisaged as people becoming part of ubiquitous intelligent networks having the potential to seamlessly connect, interact and exchange information about themselves and their social context and environment.
Smart Cities: The Facts

- 50% of the world’s population already lives in cities and trends suggest that over 60% will live in cities by 2030
- 50% of global GDP is generated in the largest 600 cities
- There are 484 cities worldwide with populations in excess of one million
- There are 780,000 municipalities and states that are charged with the same functions as cities
- A UN report suggests that 40,000 new cities will need to be built worldwide by 2050
- The global private & public ICT market is $1580bn per annum; public sector market $423bn with $179bn of that local & regional government
- The global ICT market is 15% software and around 85% services and hardware
- Total estimated global budget for improving city ICT- $35-55bn
- Total ICT public sector city market circa $5bn software, $30bn services/hardware
- USA largest market +$12bn, Europe +$5bn, China +$3bn, Japan +$3bn, India +$1bn
Smart Cities

- The Smart City can be defined as the integration of technology into a strategic approach to sustainability, citizen well-being, and economic development. Any adequate model for the smart city must be multidimensional, encompassing different aspects of “smartness” and stressing the importance of integration and interaction across multiple domains.

- “Smart Cities” are environments of open and user-driven innovation for experimenting and validating Future Internet-enabled services.

- Smart Cities Technology links to FI, the Internet of Things, and M2M.

As cities are defined as ‘systems of systems’, there is no one Smart Cities market: 
- There are Smart Cities segments, ecosystems, and subsystems
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Smart City Vision – Information and Communication is Key

- City as **service provider**
  
  for citizens, enterprises, institutions, and tourists

- Smartness via

  **Always Best Informed and Inter-Connected Urban Actors** (Machines, Systems and People)

  Information at any need, at any place, at any device, at any time, at any preference
Smart Cities require a common service and network Infrastructure

City is a system of systems

- Set of separate technical systems → Integrated systems

Effectivity and efficiency results from optimized integration / federation of separated systems

- Measure, Aggregate and Filter
- Analyse and Decide
- Optimize

as Enabler and Integrator for ICT-based Solutions

- FOKUS Smart Cities Portal, Sept. 2011
- Münchener Kreis Smart Cities Conference in Berlin, July 2010
The Smart Cities Value Chain

Source: Accenture
A Multi-Dimensional Smart City Model

Environmental Sustainability
- Energy efficiency
- Pollution
- Resources

Citizen Well-Being
- Public safety
- Education
- Healthcare
- Social care

Economic Viability
- Investment
- Jobs
- Innovation

Smart Policies & Objectives

Smart Utilities

Smart Buildings

Smart Transport

Smart Government

Smart City Operating System
- Sensor networks
- Data analytics
- Intelligent devices
- Control systems
- Communications platforms
- Web services

Smart Industries & Services

Smart Infrastructure

(Source: Pike Research)
General Smart City Communication Requirements

- We see different communication patterns
- Generic platform needs to support multiple use cases and application scenarios
  - Human to human (H2H) communication, typically session based, as we know from NGNs and Telco 2.0 needs to be supported
    - 1-1, multicast, broadcast, group communication (n-m)
    - Typically downlink communication
  - Machine to Machine (M2M) communication:
    - Communication link between sensors/actuators and data centers, typically uplink data
    - Thousands of devices transporting small information regularly
General Smart City Communication Requirements (cont.)

- We see network convergence across multiple networks
  - Need to support mobile, wireless, fixed, and cable networks
  - Efficient communication
  - Mobility support
  - Network selection and Quality of Service

- Automatic behavior
  - Combination of information
  - Handling of large amounts of data
  - Policy-based behavior of services
Future Internet ... to make our cities smart
A Smart City is a huge Future Internet Show Case

Politics & E-Government
Transport & Traffic
Signal Transmission & Networks
Communications
Energy
Mobility
Security
Urban Production
Education
Culture
E-Living
E-Health

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A Smart City relies on Integration & Federation of Systems

Enablement of "Smarter Applications" by allowing these to make use of common / open data and common service capabilities provided by a Smart City service platform

Federation & Integration of different fixed and mobile Network Technologies to interconnect different machines (sensors, actuators) and people and for providing applications seamless
Smart Cities – Total Convergence of Communications

Smart Cities require the convergence of services from the telecommunication industry and other business branches into a common mediation layer possibly around the operator core networks.
General Smart City Communication Requirements

- Different communication patterns need to be supported for different service domains:
  - session-based human-to-human & M2M communication
  - one-to-one, multicast, broadcast and group communication
  - resource-based pull/push communication between sensors & actuators

- Generic Smart City platform needs to support many service verticals and application scenarios

- Smart City communication platform acts as central convergence & orchestration point for networks, services and data

- Different principles for OTT & Telecom core networks need to be supported

- A set of common requirements as QoS, security, charging, device & entity management needs to be shared to across many service domains.
Assessment of Platform Requirements

- Separation of communication-centric services and enablers into three categories:
  1. Machine-to-Machine (M2M) Communication
  2. Human-to-Human (H2H) Communication
  3. Overarching Services and Enablers

- Mapping of service and enablers towards different service domains where applicable

- Exemplary refinement for one specific service vertical (facility management)
# Smart Communication Enablers & Sectors

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# Example Use Case: In-Depth Analysis for Facility Management

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<th>Automation (light, air conditioning, etc.)</th>
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Smart Cities ... making it tangible

Example sector

Application fields

Facility Management

Devices, Infrastructure, and Communication Platforms

Example sector

Facility Management

Devices, Infrastructure, and Communication Platforms

Alarm system monitoring

Utility Metering

Video surveillance

Condition monitoring

Automation
Smart Cities ... making it tangible

Facility Management Application fields

- Alarm system monitoring
- Utility Metering
- Video surveillance
- Condition monitoring
- Automation

Demos that we have build @ FOKUS

Utility Metering
Condition monitoring
Automation

Communication requirements

- Retrieve data
- Control devices
- Send data
- A/V Call
- A/V conference
- Messaging / File transfer
- Presence
- Location
- Address Book
- QoS
- Device/entity mgmt
- Security

Demo video
http://www.open-mtc.org/_videos/OpenMTC_Demo_video.mp4
Communication & Control Infrastructures for enabling Smart Cities

- Smart Cities is a heterogeneous field to enable many service verticals by ONE platform:
  - Voice/video/text/binary communication
  - Entertainment
  - Water management,
  - Public safety,
  - Traffic,
  - Buildings,
  - Energy,
  - Security,
  - Utility, etc.

- Combination of services is needed and may be achieved on two layers:
  - Service layer (SDP)
  - Control layer (IMS or MTC)
Session-Based vs. Ressource-Based Communication

- Session-based (e.g. IMS)
  - PRO
    - Good for longer sessions such as multimedia streaming
    - E.g. video surveillance
  - CONTRA
    - Has been designed for H2H communication
    - Not so well suited for regular transmission of small amounts of data
    - Signaling overhead

- Resource-based M2M Platform (e.g. ETSI)
  - PRO
    - Good for small amounts of data
    - Good for asynchronous communication
    - Easy replay of stored data (store and forward concept)
    - No signaling
  - CONTRA
    - Model does not find well with continues streams of data
    - Voice services not already integrated
Platforms for Smart Cities – the SDP approach

- SDP may provide abstraction over multiple control platforms and expose APIs to developers and services.

- Combination of communication APIs as:
  - OMA NGSI
  - GSMA OneAPI
  - RCS APIs for H2H communications

- M2M APIs for
  - data access
  - device control
  - connectivity control
Smart City H2H Communication APIs: OMA NGSI, GSMA OneAPI & RCS-e

- OMA NGSI provides abstract APIs suited for OMA enablers
  - defines services for GSMA
  - NGSI extension for payment, data connection & device capability
  - Zonal presence for location

- GSMA OneAPI profiles NGSI
  - NGSI extension for payment, data connection & device capability
  - Zonal presence for location

- RCS-e Network APIs
  - Defines services for GSMA OneAPI & NGSI
  - New API requirements:
    - Chat & capability discovery
    - Oauth for user/service authentication

Figure 2: RCS-e API architecture
Smart City M2M Communication APIs

- API is divided into the following three categories:
  - Network,
  - Device, and
  - Data APIs.

- Network APIs deal with the roles related to the network applications and its session control with the M2M core.

- Device APIs find appropriate devices and gateway resources to fetch information from them.

- Data APIs handle functionalities related to accessing/manipulating data collected from devices/sensors.
Smart Communication Infrastructures
Generic Enablers & Service Clouds for Smart Cities

Diverse Communication req.

Heterogeneous Infrastructures

City entities

power plant

mobile users

gov agency

water

factory

PC / IT

transportation

Generic Enablers

Unified access

APIs, SDKs & tools

M2M comm.

human-to-human comm.

access to data

control

device & entity mgmt.

federation between infrastructures

orchestration of services

orchestration of services

Fraunhofer FOKUS
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Evolution of Telecommunication Platforms toward Smart Cities

IT Impact on Telecoms

- Intelligent Network (IN)
- Open APIs
- Telecom APIs
- OSA/Parlay/JAIN
- OMA NGSI, etc.

IT Services:
- Open APIs
- Parlay X, GSM One
- OSA/Parlay/JAIN
- OMA NGSI, etc.

Open Service APIs (Enablers)

Service Delivery Platform (SOA based)

- IN Services based on SIBs
- IN Overlay Architecture
- Circuit Switched Networks
- PSTN
- GSM
- IP
- VoIP / SIP

Cloud Applications:
- RCS, UC, eGov, eHealth, eTransport, eUtilities

APIS (Enablers)

Smart City Core Platform

- Network Abstraction
- IP Multimedia System (IMS)
- IMS
- IMS

Mobile Broadband IP Networks
- LTE
- WLAN
- WiMAX

Network Abstraction

- People & Things
- MTC
- VoIP / SIP
- All-IP

- IP Networks (NGN)
- DSL
- UMTS
- Cable
- WLAN

- Evolved Packet Core (EPC)
- Mobile Broadband IP Networks
- LTE
- WLAN
- WiMAX

- VoIP / SIP
- All-IP
- People & Things
IN provides a uniform platform for providing an open set of telecommunication services, while abstracting from underlying network technologies.
Please compare: Intelligent Network Principle

Unified IN service logic and data for all switching nodes provided by:

- **Intelligent Node** contains service logic and data accessible for switching nodes (Note: Intelligent node is a non-switching node!)
- **Hooks** are required within the switching nodes to access the remote Intelligent Node
- **SS7 network** enables real-time signaling interconnection of nodes

---

**Diagram**

- **Service Program**
- **Data Logic**
- **Central Service Control Point (SCP)**
- **Signalling Network**
- **Enhanced Switches (SSPs)**
IN - the first Open Telecommunication Service Platform

IN platform provides service and network independence

- Service decomposition
- Separation of switching and service control network elements

IN can be considered as an additional (network) layer on top of any bearer network, e.g. PSTN, ISDN, B-ISDN
Next Generation Network = 3 Tier Architecture

- Enhanced services for the next generation network will be enabled by a tiered architecture where “Application Servers” will provide an independent service layer for the execution of enhanced services and content.

- Session / Call Control based on advanced signaling protocols (i.e. SIP) is performed in Softswitches, or “Session Servers”.

- Transport of signaling and content (incl. Voice) data will be done by Routers in the classical IP fashion. Dedicated nodes, i.e. “Media Gateways” and “Media Servers” are in charge for processing content data controlled by the Call Servers.
NGMN Over the Top (OTT) vs. Standardised IMS Service Platform

**Proprietary Service Platform**

- **LTE IP Pipe**
  - Clients
  - Standalone Solution
  - Fast one-off deployment
  - Optimised one-off CAPEX (but repeated)
  - OPEX for each standalone solution
  - Fragmented end-user experience

**IMS based Solution**

- **LTE IP Pipe**
  - Clients
  - IMS based Solution
  - Faster integration of subsequent apps
  - Re-use deployed infrastructure
  - OPEX shared across whole solution
  - Integrated end-user experience
IMS Architecture Principles

- IMS does NOT standardise specific services, but enablers
- BUT supports inherently multimedia over IP, VoIP, IM, presence (SIP)
- IMS enables the flexibility in providing IP-based applications!!

- 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 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
IMS – Flexible & Controlled Service Provision on IP Networks

- IMS Core provides session signalling based on SIP and AAA capabilities based on Diameter
- IMS control and content Application Servers can be dynamically connected to IMS Core for signalling
- Transport is based on RTP

**IMS Core**

**Group Server**

**Presence Server**

**Call Control**

**Content**

**SIP Server**

**Packet Core Network**

**Transport (RTP)**

**Access Networks (WLAN, UMTS, LTE, DSL)**

**Access Networks (WLAN, UMTS, LTE, DSL)**

**IMS Applications**

**Signalling (SIP)**
3GPP IMS Architecture: IMS Core and Application Layer

IMS Service Framework

- **P-CSCF**
  - PCC (PCRF)

IMS Core System

- **HSS (AAA)**
- **Application Server**
- **I-CSCF**
- **S-CSCF**
- **Media Server**

Access Networks (WLAN, UMTS, LTE, DSL)

Interworking with Legacy Networks (GSM, ISDN, DVB)

IP Core Network

Interworking with Legacy Networks (GSM, ISDN, DVB)

SIP ➔ Diameter ➔ RTP
IMS integrates different Communication Services

Pre-IMS Communication ("Service Islands")
- Voice
- SMS
- Instant Messaging
- MMS

From the usage of specific individual communication services...

IMS Communication ("Combinational Services")
- Voice / Video
- TV
- SMS
- Instant Messaging
- MMS
- Presence
- PoC

... to the integrated usage of different communication services centered around presence information and within groups (communities)
IMS / SDP Standardisation – Roadmap

- AIN / Intelligent Networks Capability Sets 1 - 4
- Wireless IN
- CAMEL Phases 1-4
- SIP / Diameter / XCAP / RTP

- JAIN SLEE
- Parlay API
- Parlay X
- PacketCable 1.0 + 1.5
- PacketCable 2.0
- IMS Enabler + OSE
- IMS R5
- IMS R6
- IMS R7
- IMS R8

- Initial NGN
- TISPAN NGN
- MMD
- Common IMS - Rel 8

Timeline:
- 1996
- 1998
- 2000
- 2002
- 2004
- 2006
- 2008
- 2010
IMS Standardisation Scopes
Multimedia Telephony (MMTel) Overview

- Conventional telephony communicates using the voice medium only, and connecting only two telephones per user over circuits of fixed bit rates. In contrast, modern communication services depart from the conventional telephony service in three essential aspects: multimedia, multi-point, and multi-rate.
Rich Communications Services (RCS) - based on IMS

- 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
RCS Evolution

- **Release 1 (December 2008)**
  - Enhanced Address Book
  - Enhanced Messaging
  - Content Sharing
  - File Transfer

- **Release 2 (June 2009)**
  - Release 1 features plus
  - Broadband Access to RCS features from PC and Laptops
  - Network Address Book
  - Provisioning and configuration of RCS devices/clients
  - MMTel Endorsement
  - OMA IM Endorsement

- **Release 3 (December 2009)**
  - Broadband access enhancement
  - Content sharing enhancement
  - Social presence information enhancement
  - Messaging enhancement
  - Network value added services

- **RCSe (e=enhanced)**
  - Light weight version
  - Branded as „Join“

- See also [www.gsma.com/rcs](http://www.gsma.com/rcs)
RCS and VoLTE Interoperability Testing

- RCS VoLTE IOT builds on previous IOT Events
  - MSF LTE/EPC IOT in March 2010 & VoLTE IOT in September 2011
  - ETSI IMS Plugtests

- MSF partnered with ETSI & GSMA to jointly organise this event
  - Reflects the common focus of all 3 partners in VoLTE & RCS
  - Endorses a number of GSMA PRDs
  - Joint Task Force, comprising members from the partner organizations, formed to oversee all aspects of the event

- Event web site at: http://www.msforum.org/interoperability/RCSVoLTE.shtml
IMS Road Map

<table>
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<tbody>
<tr>
<td>IMS Reaches Trial Stage</td>
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<tr>
<td>The bulk of HSS, CSCF, BGCF, PSTN gateways, and application sever (mainly voice app server) equipment move from lab testing to field trials, some moving to services by the end of 2007</td>
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<tr>
<td>IMS Networks Emerge</td>
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<tr>
<td>IMS deployments consist of an HSS and a CSCF to support fixed-line VoIP services deployed by both large incumbents expanding out of their home turf, and mobile operators jumping into the fixed line business</td>
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<tr>
<td>IMS Deployments Ramp Up</td>
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<tr>
<td>Large fixed-line incumbents continue to migrate their infrastructure from PSTN to TISPAN. Mobile operators begin to deploy IMS with the adoption of RCS in 2010 and the migration of their mobile infrastructure to LTE, with massive IMS deployments expected in 2012.</td>
<td></td>
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Source: Infonetics

Industry expects IMS deployment to ramp up, driven by PSTN migration from fixed line operators and migration to LTE together with RCS adoption from operators.
IMS is the common control platform within the NGN for many Application Domains

- **VoLTE**: P/ISDN Emulation
- **RCS**: VOIP, Videoconf., IM, FMC, Presence
- **IPTV**: Emulation Subsystem
- **IP Multimedia Subsystem**: Streaming/IPTV Subsystem

IMS supports all

**Converged NGN (all-IP)**

**Reusable Transport Support Systems**

**Web 2.0**
- What about other IP Applications
- VoIP/Skype

**Best effort Internet**

**PSTN**

**End-User Functions**

**Network Attachment Control Functions**

**Resource and Admission Control Functions**

**Transport User Profiles**

**Transport Functions**
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 or Fixed IP Network

IP Multimedia Subsystem (Control Overlay)

(S)IP-based Applications

(Service Delivery Platform)

Evolved Packet Core (Control Overlay)

Any 3GPP or non-3GPP Mobile IP Network

HTTP-based Applications

SIP-based Applications

(Service Delivery Platform)
Mobile Network Architecture Evolution

1991

2015 ?

PSTN

Circuit Switched

Access

2G GSM

1991

Packet Switched

IMS

3G / IMS Evolution

2G / GPRS / EDGE Evolution

Packet Core

EPS (LTE/EPC)

VolTE

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

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, …)
PCC’s Architecture Evolution (R6-R7-R8-onwards)

- **Release 6 Policy Control (only QoS and gate control)**
  - was developed to cope with IMS based services
  - two components: the Policy Decision Function (PDF) and the Policy Enforcement Point (PEP).
  - Policy decisions transferred by Go Interface using Common Open Policy Service (COPS) protocol.

- **Release 7 PCC (Policy and Charging Control)**
  - More complex architecture; it unifies QoS, policy and charging control;
  - Provides separation from the entities from the IMS domain;
  - A new component is added Subscriber Profile Repository (SPR) for subscription related policy control.

- **Release 8 PCC**
  - New Bearer Binding and Event Reporting Function (BBERF);
  - The BBERF is specific to each IP-CAN type and is allocated in the corresponding Gateway through the Gxx interface
Who is Who in Next Generation Mobile Network context?

- NGMN Alliance defines LTE/EPC Requirements
  - http://www.ngmn.org

- 3GPP develops LTE/EPC Specifications
  - http://www.3gpp.org/Highlights/LTE/LTE.htm
  - http://www.3gpp.org/Specification-Numbering

- LSTI performs Proof of Concept / Interoperability Tests
The EPC is a multi-access core network architecture based on the Internet Protocol (IP) common for:

- 3GPP access networks (LTE-A, LTE, HSPA+, UMTS, GPRS)
- Non-3GPP access networks
  - Trusted networks (cdma2000, WiMAX)
  - Un-trusted networks (WiFi)

EPC provides **connectivity** to IP service domains

- IMS
- Internet or other (M2M, Cloud, P2P etc.)

The enhanced IP connectivity features include:

- Authentication and authorization
- Secure communication
- Transparent mobility management
- Connectivity management support
- Policy based QoS and charging
3GPP EPC Architecture

- Gateways – Access Network Specific and Centralized
  - Data forwarding
  - Unified policy based Enforcement
  - Transparent Mobility

- Control Entities – Subscription based:
  - Mobility Management in 3GPP accesses
  - Policy and Charging decisions
    - Based on the App. requirements
  - Access Network Discovery and Selection

- Subscription Entities
  - Home Subscriber Server
    - Imported from IMS
  - AAA server for communication with non-3GPP Accesses
3GPP EPC Protocols

- Mobility and forwarding protocols
  - GPRS Tunneling Protocol (GTP)
  - Proxy Mobile IP (PMIP)
  - Mobile IP (MIP)

- Control protocols
  - Diameter for the communication with:
    - Subscription Repositories
    - Applications
    - Enforcement Points

- Communication with Mobile Devices
  - OMA Device Management (DM)

![Diagram showing the connections between various 3GPP EPC components: ANDSF, HSS, MME, S-GW, PCRF, PDN GW, AAA Server, ePDG, and ANGw. Connections are made using lines indicating Diameter, OMA DM over HTTP/other, GTP/PMIP, and IP protocols.]
3GPP EPC Functional Features

- Network Access Control Functions
  - Authentication and Authorization
  - IP reachability context
  - Indirection tunnel establishment
  - Default bearer is initialized
- Resource Management Functions
  - Application and UE triggered resource reservations
  - Policy based decisions
  - Enforcement of QoS rules on the data path
- Mobility Management Functions
  - Intra-3GPP → MME controlled
    - Soft handovers
  - With non-3GPP → ANDSF assisted
    - Only hard handovers (except CDMA 2000)
What is 3GPP EPC?

3GPP Evolved Packet Core

- Transparent Connectivity to Applications
- Application Req. based Connectivity
- Secured Access
- Heterogeneous Access with Transparent Mobility
- Scalable
- Subscription Based
- Session Based Resources and Charging
- Session Based Resources and Charging
- Subscription Based
- Scalable
Simplified EPC Architecture

- **GSM/PSTN/UMTS**
- **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

**Key Functions**
- **VoLTE** - Voice Interworking
- **IP Services** (e.g. IMS)
- **Operator Application Functions**
- **Internet**
- **User Authentication**
- **Mobility Management**

**Network Components**
- **VCC**
- **E-UTRAN**
- **User Equipment**

**Signatures**
- **HSS**
- **MME**
- **PDN GW**
- **SGW**
- **PCRF**
- **eNB**

**Network Protocols**
- **GSM/PSTN/UMTS**

**Networking**
- **User Plane**
- **Policy & Charging**
- **Mobility Mgt**

**Authoriz & Authent.**
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.
IMS VoIP in EPC Architecture is called VoLTE

Note that VoIP in the initial LTE deployments is challenging due to limited coverage.
Voice over LTE (VoLTE)

- GSMA VoLTE (Voice over LTE) - a standard way of delivering voice and messaging services for Long-Term Evolution (LTE)
  - VoLTE = Voice and SMS for LTE

- VoLTE is based on the One Voice Initiative (from 2009) which was based on the 3GPP IMS
  - VoLTE is not a new standard
  - VoLTE selects pieces of the IMS standard

- VoLTE realization principles:
  - Single implementation promotes scale
  - Single implementation reduces complexity
  - Single implementation enables Roaming
VoLTE Features

**MMTel**
Telephony and Supplementary Services
SR-VCC

**IMS**
Control and Media Features
SMS
Emergency Calls
Roaming

**EPC**
IP flow and bearer management Features
Roaming

**LTE**
Radio Capabilities for VoIP
IMS over GPRS/UMTS/LTE plus EPC Architecture

IMS for Value Added Services

Interworking and Evolution

PSTN

GMSC
MSC/VLR
RNC
NodeB
UTRAN

GGSN
SGSN
HSS
P/I/S-CSCF
IMS
MGW
AS
PDN GW
Serving GW
PCRF

S1

eNB
E-UTRAN

UTRAN

Interworking and Evolution
From IMS to M2M Platforms above EPC

Main Idea: Common Control Overlay Architecture dedicated for M2M Communication needs unifying the existing variety of specialized M2M SDPs

(Service Delivery Platform)

IMS-based M2M Applications

IP Multimedia Subsystem (Control Overlay)

Evolved Packet Core (Control Overlay)

Mobile or Fixed IP Network

Fixed or Mobile NGN

(Mobile Packet Switched Telco Domain)

M2M Applications

Common M2M Platform

Evolved Packet Core (Control Overlay)

Any 3GPP or non-3GPP Mobile IP Network
Global Mobile Data Traffic Forecast 2012 - 2016

- 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 HD video streaming

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Growth in Users, 2011-2016 CAGR</th>
<th>Growth in Mobile Data Traffic, 2011-2016 CAGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smartphone</td>
<td>24%</td>
<td>119%</td>
</tr>
<tr>
<td>Portable gaming console</td>
<td>56%</td>
<td>76%</td>
</tr>
<tr>
<td>Tablet</td>
<td>50%</td>
<td>129%</td>
</tr>
<tr>
<td>Laptop and netbook</td>
<td>17%</td>
<td>48%</td>
</tr>
<tr>
<td>M2M module</td>
<td>42%</td>
<td>86%</td>
</tr>
</tbody>
</table>

Source: Cisco VNI Mobile, 2012

Figures in legend refer to traffic share in 2016. Source: Cisco VNI Mobile, 2012

Only M2M in 2016 nearly as much as all the data traffic today
What is M2M? Some characteristics ...

- It's all about scale!
- Heavily growing market
  - # of devices
  - # of connections / amount of traffic
  - # of applications
- Highly heterogenous traffic
  - from simple sensor nodes to high definition video cameras
  - from a “four byte” fire alarm to a continuous real-time HD video streaming
- Invisibility & Automatism (e.g. fridge)
- Critically (e.g. eCall)
- Intrusiveness (e.g. fridge posting images of my food to facebook ...)
### M2M – Fraunhofer FOKUS Positioning

<table>
<thead>
<tr>
<th>MACHINE</th>
<th>-- TO --</th>
<th>MACHINE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Communication terminal independent of human interaction</strong></td>
<td><strong>Network facilitating the M2M communication</strong></td>
<td><strong>Core network (or terminal) automating the services</strong></td>
</tr>
<tr>
<td>- Acting automatically or on remote request</td>
<td>- Access &amp; core network, backhaul, application server</td>
<td>- Sensor data aggregation, processing and presentation</td>
</tr>
<tr>
<td>- Managed remotely</td>
<td>- Enabling connectivity (AAA &amp; security, session management, QoS, charging, mobility management)</td>
<td>- Data caching and interpretation</td>
</tr>
<tr>
<td>- Mobile and fixed terminals</td>
<td>- Supporting the data traffic of terminals (e.g. for direct and infrastructure communication)</td>
<td>- Real-time communication</td>
</tr>
<tr>
<td>- Monitoring device (sensor)</td>
<td>- Supporting the signaling of terminals</td>
<td>- Automatic decision, processing, control followed by communication with other machines through:</td>
</tr>
<tr>
<td>- Actuator device (e.g. switch)</td>
<td></td>
<td>- Instructions</td>
</tr>
<tr>
<td>- Associated order of magnitude: trillion = $10^{12}$</td>
<td></td>
<td>- Notifications</td>
</tr>
</tbody>
</table>
Competence Center NGNI

Fraunhofer FOKUS

Automotive

Security

Tracking & Tracing

Payment

Healthcare

Classic M2M Segments

Consumer Electronics

Metering

Remote Maintenance and Control
M2M sectors

Machine-to-machine connections by sector, 2020

Source: Machina Research 2011

Source: Machina Research: „Connected Intelligence database 2020 connected devices overview“, 2011
Target Industries

Main industry drivers today:

1. Transport & Logistics
2. Utilities
3. Automotive

SOURCE: Informa-SAP M2M Communications Survey, 2012
Investment priorities

The machine-to-machine communication investment priorities today:

1. Service Management
2. Product dev. / R&D
3. System integration

SOURCE: Informa-SAP M2M Communications Survey, 2012
Convergence of M2M Services & Applications

**Today**
- SMS based.
- Vertical isolated systems.
- INTRAnet of Things

**Future**
- Global horizontal approach.
- INTERnet of Things.
ETSI M2M Horizontal Approach goes into the same direction for M2M

- ETSI TS M2M approach allows for a mutualization of functions in order to transform the vertical approach into a horizontal one.
High Level ETSI M2M System Architecture

- Architecture includes:
  - M2M Device Domain
    - Based on existing standards and technologies e.g. DLMS, CEN, CENELEC, Zigbee etc.
  - Network and application domain
    - Based on existing standards e.g. 3GPP, TISPAN, IETF

- M2M is an extension of the current network architecture with:
  - M2M Service Capabilities
  - M2M Applications

- *The User of the system does not control directly the M2M device domain*
Service Capabilities (SC): provide functions that are shared between different M2M applications

- Can use core network capabilities through a set of exposed interfaces specified by 3GPP, TISPAN, 3GPP2
- SC can involve other SCs (to be further studied)
- SC can interface with CNs

Three interfaces are defined:
- dIa, mIa, mId
ETSI M2M Service Capabilities

- A set of standardized Service Capabilities (SC) is defined in M2M Core and M2M Device/Gateway, to provide functions that are to be shared by different M2M Applications.

- M2M Service Capabilities:
  - provide recommendations of logical grouping of functions
  - expose functionalities through a set of open interfaces
  - use Core Network functionalities
  - simplified, optimized application development and deployment through hiding of network specificities from applications
  - can interface to one or several Core Networks

Not all M2M SCs are foreseen to be instantiated in the different parts of the system.

Only external interfaces are mandated and are required for compliance.

- M2M SCs provide recommendations of logical grouping of functions
- M2M SCs do not mandate an implementation
ETSI M2M Service Capabilities

1. Application Enablement (xAE);
2. Generic Communication (xGC);
3. Reachability, Addressing and Repository (xRAR);
4. Communication Selection (xCS);
5. Remote Entity Management (xREM);
6. SECurity (xSEC);
7. History and Data Retention (xHDR);
8. Transaction Management (xTM);
9. Compensation Broker (xCB);
10. Telco Operator Exposure (xTOE);
11. Interworking Proxy (xIP).

where x stands for: N for Network, G for Gateway, D for Device
M2M Functional Architecture
Reference Points

- **mIa** enables an Application to access the M2M SCs in the Network and Applications Domain.

- **mId** enables an M2M Devices to communicate with the M2M SCs in the Network and Applications Domain.
  - Relying on the interfaces between Core Networks and the devices.

- **dIa** enables an application residing in an M2M Device or M2M Gateway to access M2M SCs in the same M2M Device or in an M2M Gateway.
ETSI M2M RESTful Style for Data Exchange

- Adopted for some of the procedures of the M2M ETSI procedures

- Four basic procedures:
  - CREATE: Create child resources
  - RETRIEVE: Read the content of the resource
  - UPDATE: Write the content of the resource
  - DELETE: Delete the resource

- Additional Procedures:
  - NOTIFY: on a change event
    - RETRIEVE for polling
    - UPDATE for pushing
  - EXECUTE: for executing a management command/task
    - Not mapped yet.
Example: Connected home
The New Value Chain

- Building on OpenMTC and an associated SDK, operators can cover more parts of the M2M value chain.

- Strong strategic partnerships will still be essential for operators:
  - to cover system integration & app. development
  - to cover domains with specific hardware requirements
IN Concept Evolution toward SDP

Main Idea: Reusable Service Enablers designed in a Service Oriented Architecture (SOA) way and abstraction from underlying network protocols by means of Application Programming Interfaces (APIs) enable uniform service realization on top of converging networks.
Increasing Service Diversity requires Abstractions & Partnering

Strategy of the broadening „T(elecoms)“: Broad top, sleek bottom

Consumers
- Communities
- Kids
- Youth
- Families
- Retired
- Small

Business Customers
- SMEs
- Big Enterprises
- MNE

SalesCos.
SalesCos.
SalesCos.

Marketing and Sales Services and Contents

Open Interfaces and APIs

Effective Connectivity Control

Service Companies

NetCos.
NetCos.
NetCos.

Efficiency!

Modular
- Fast
- Segment specific

- One Platform
- Operations optimized
- Infrastructur(operations) partially outsourced
IMS, MTC and EPC Positioning within an SDP Environment

- **Enablers (incl. Content Delivery)**
- **Service Creation**
- **Service Execution Environment**
- **Abstraction Layer**
- **Exposure Layer**
- **SOA**

**IMS fits here**

**MTC fits here**

**EPC fits here**

**Control Layer**

- **Public network**
- **Private network**

- **Supervision**
- **Operation & Maintenance Provisioning**
- **CRM**
- **Billing**

**Mobile Access**
- GSM
- UMTS
- EDGE
- CDMA
- WiFi
- xDSL

**Fix Access**
- DECT
- PBX
- LAN

**Internet**
- Google
- Portals
- Blogs
- Gaming

**3rd Party ASP**
- icq

**Mobile Access**
- MediaGW
- App 1
- App 2
- App 3

**Service Creation Enablers**
- MRF
- Presence
- Exposure
- OSA
- Parlay/X
- OMA

**Abstraction Layer**
- IMS
- MTC
- EPC

**3rd Party ASP**
- Supervision
- Provisioning
- Billing
- CRM

**Service Execution Environment**
- Operation & Maintenance

**Exposure Layer**
- Service Creation
- Service Execution
- Abstraction Layer
Towards APIs / Enablers in the Smart City (SC) Context...

SC Application Providers and Services


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

Import of SC APIs

Export Of SC Enablers

- Resell available capabilities
- Enable value added services

Service Brokering

SC Enablers provided by SC Core Platform

(RCS, information access, QoS, Charging, Identity Mgt., Security, M2M)

Network Abstraction

IMS + MTC + Evolved Packet Core

Sensor Networks
Mobile IP Network
Fixed IP Network
Evolution of Network API Concepts in Telecommunications

- Open APIs: OSA/Parlay/JAIN
- CORBA
- RMI
- RPC
- Int. Net. (IN)
- CAMEL (IN in Mobile)
- IP Multimedia System (IMS)
- Web 2.0
- Servlets
- Internet Protocols
- RESTful
- JSON
- WSDL
- SOAP
- OMA
- PIOSE, PSA, NGSI
- GSMA ONE API
- Web Services: APIs
  - Parlay X
  - CORBA
  - RMI
  - RPC
  - WSDL
  - SOAP
  - JSON
Platforms for Smart Cities – the SDP approach

- SDP may provide abstraction over multiple control platforms and expose APIs to developers and services.

- Combination of communication APIs as:
  - OMA NGSI
  - GSMA OneAPI
  - RCS APIs for H2H communications

- M2M APIs for
  - data access
  - device control
  - connectivity control
Smart City Communication APIs: OMA NGSI, GSMA OneAPI & RCS-e

- OMA NGSI provides abstract APIs suited for OMA enablers
  ![OMA NGSI APIs](image)

- GSMA OneAPI profiles NGSI
  - NGSI extension for payment, data connection & device capability
  - Zonal presence for location

- RCS-e Network APIs
  - Defines services for GSMA OneAPI & NGSI
  - New API requirements:
    - Chat & capability discovery
    - OAuth for user/service authentication

![RCS-e API architecture](image)
Smart City M2M APIs

- API is divided into the following three categories:
  - Network,
  - Device, and
  - Data APIs.

- Network APIs deal with the roles related to the network applications and its session control with the M2M core.

- Device APIs find appropriate devices and gateway resources to fetch information from them.

- Data APIs handle functionalities related to accessing/manipulating data collected from devices/sensors.
From Telecommunications toward the Future Internet

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

Telecommunications Domain

Converged Telecommunication Services (FMC, Triple Play, IPTV, Telco 2.0)

Future Internet Applications (eGov, eHealth, eUtilities, eLogistics)

Future Internet Core Platform

Mobile or Fixed IP Network(s)

Fixed and/or Mobile Transmission Network(s)

Telecommunications Service Delivery Platform
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 (Flickr), 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.
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

FI = Towards a Thinner Protocol Stack
Cloud Services vs. Traditional Telco Services
Advantages of I-/P-/S-aaS Clouds

- **Infrastructure as a Service (IaaS)**
  - Enabling complete or hybrid IT infrastructure outsourcing and hosting options

- **Platform as a Service (PaaS)**
  - Scalability through dynamic Cloud elasticity, metering allowing pay-per-use
  - Turning CAPEX into OPEX allowing entrepreneurs a low risk market entry
  - Data aggregation / cloud data pool (Context, Sensor, M2M data)

- **Software as a Service (SaaS)**
  - Greatly improved manageability through centralized maintenance
  - Frequent updates and upgrades
  - Enhanced device independence, support for multiple devices, device-shift through cooperative devices, hand-overs
  - Access Network independence
  - Collaborative, multi-tenant services
  - Improved time-to-market
  - Enabling complex, multi-tenant value chains
Cloud Computing Service Models

- **Software as a Service (SaaS) Clouds**
  - offering complete cloud-based, *multi-tenancy* applications like
    - communication services
    - collaboration software and tools
    - business processes-oriented applications
    - gaming, etc.

- **Platform as a Service (PaaS) Clouds**
  - providing application developers with
    - application software
    - middleware
    - databases
    - development tools, etc.

- **Infrastructure as a Service (IaaS) Clouds**
  - utilizing a suite of virtual hardware through specific cloud management APIs providing
    - compute, storage & network resources on demand
    - *pay-per-use* charging options
    - resource elasticity
## Cloud Computing Deployment Models

### Public Clouds
- Services and infrastructure are provided off-site over the Internet
- Potential security and governance / IPR issues

### Private Clouds
- Services and infrastructure maintained on a private network
- Greatest level of security and control
- Software and infrastructure must still be purchased

### Hybrid Clouds
- Variety of public and private options with multiple providers
- “On-peak” outsourcing options!
- Potential security and governance / IPR issues

### Deployment Model

<table>
<thead>
<tr>
<th>Deployment Model</th>
<th>Private</th>
<th>Hybrid</th>
<th>Public</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics</td>
<td>- Pay per Use - Managed Service - Multi Tenancy - Resource Elasticity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service Model</td>
<td>- IaaS - PaaS - SaaS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Service Models
- IaaS
- PaaS
- SaaS
Decoupling Networks from Infrastructure

Management of virtual networks

Virtual Networks

Provisioning of virtual networks

Virtualised Substrate

Virtualisation of resources

Physical Infrastructure

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

Collection of virtual resources, aggregated to build virtual networks

Infrastructure made of virtualizable network resources

Source: EURESCOM Project P1956
OpenIMS in the Cloud

- First scenario
  - All the IMS infrastructure deployed in the cloud (private or public)
  - HSS highly reliable
  - Elastic Call Session Control Function (CSCF)
OpenIMS in the cloud

- Second scenario
  - Core components in a private cloud, and third party services moved to the public
Seamless Mobile Access to Cloud Services as Motivation for Smart Bitpipe

- Cloud services are already available for mass market (e.g. Amazon, Google etc.)
  - Transparent access to the service infrastructure
  - Better resource usage in the service layer
  - Localization of information

- Truly broadband mobile connectivity
  - High increase of the access network throughput
  - Available for a large number of subscribers
  - Enables functionality of the mobile devices to be transferred to the service infrastructure in the network (e.g. Remote OS functionality)
Switch Evolution towards Software-Defined-Networks (SDN)

- Ethernet Switch Architecture
- OpenFlow Switch Architecture and OpenFlow Controller interaction

### Ethernet Switch

**SOFTWARE (Control path)**
- Routing protocols, management and control, mobility management, Access Control Lists, VPNs, etc.

**HARDWARE (Data path)**
- Packet Forwarding

### OpenFlow Switch

**SOFTWARE (Control path)**
- Secure Channel (OpenFlow Protocol)

**HARDWARE (Data path)**
- Data Path / Flow Table (Hardware)
Open Networking Foundation (ONF)

- Accelerates the delivery and use of **Software Defined Networks (SDNs)** by standardizing OpenFlow

- SDN allows networks designers and operators to simplify networks by exploiting fundamental abstractions

- Open flow protocol between network controllers and switches makes it possible to add features, reduce costs and speed innovation.
Software Defined Network Architecture

**Features:**
- Decoupling of control and data path – enable the abstraction from the infrastructure layer
- Network intelligence and state are logically centralized
  - High programmability
  - Automation
  - Easy network control

**SDN architecture aims at:**
- Highly scalable networks (low complexity)
- Flexible networks
- Adaptable to specific business needs
- Increase network reliability and security
- Higher rate of innovation
- More granular network control

© Open Networking Foundation (ONF) – “Software-Defined Networking: The New Norm for Networks”
OpenFlow Switch Specification

- **OpenFlow Switch Components**
  - Flow Tables (one or more)
  - A Group Table
  - An OpenFlow Channel
    - Connects to an external controller
    - Uses the OpenFlow protocol

- **OpenFlow Controller**
  - Can add, update and delete flow entries in flow tables
  - Proactive and reactive operations
OpenFlow Flow Table

- A Flow Table consists of multiple *Flow Entries*
- A Flow Entry consists of:
  - Match fields
  - Counters
  - Instructions to apply on packets
- A packet is matched in each Flow Table
  - Flow Entries match packets in priority order
  - First matching Flow Entry is used
  - The specific instructions are executed
    - Actions on data packets:
      - Forwarding, group processing ...
    - Modification of the processing pipe-line
  - Packet is forwarded to a *Port*
OpenFlow Pipeline Processing

- A Packet is matched against the flow entries in a table
  - If a Flow Entry is found, the instructions associated are executed
    - Modify the packet and update the matching fields
    - Update the action set
    - Update the metadata used by the next table
  - If no Flow Entry is a Table Miss Flow entry may be used
    - A default action is executed e.g. drop, goto next table etc.

- At the end of the pipeline:
  - The action set is executed
  - (Probably) an output port is selected
OpenFlow Channel

- The OF Channel connects the OF Switch to a controller
- All OF Channel messages have to be formatted based on the OF Protocol
- OF Protocol
  - Supports 3 types of messages:
    - Controller-to-Switch
    - Asynchronous
    - Symmetric
  - Provides reliable message delivery and processing
  - Does not ensure acknowledgements or order of processing
  - Based on connections with reliable transport
OpenFlow Protocol Messages
Controller-to-Switch

- Messages initiated by the controller managing or inspecting the state of the switch
  - May or may not require a response

- Subtypes:
  - Features – the controller requires the capabilities of a switch
  - Configuration – the controller sets and configures the parameters of the switch
  - Modify-State – modify the state on the switch by add, delete or modify of flow/group entries
  - Read-State – querying information from the switch
  - Packet-Out – for packets passing through the controller
  - Barrier – message dependencies request
  - Role-Request – used when multiple controllers connect to the same switch
  - Asynchronous Configuration – controller puts filter on the asynchronous messages of the switch
OpenFlow Protocol Messages
Asynchronous

- Messages send by the switch to the controller with updates on:
  - Network events
  - Changes in the switch state

- Subtypes:
  - Packet-in – data packet is forwarded to controller
    - The packet may be buffered at the switch
    - The number of bytes to be received can be configured
  - Flow-Removed – inform the controller that a flow was removed due a timeout
  - Port-Status – inform the controller that a port has changed the status
OpenFlow Protocol Messages
Symmetric

- Symmetric messages may be initiated by any of the communicating parties

- Subtypes:
  - Hello – used during the connection setup
  - Echo – used to verify the liveliness of a connection
    - it must be responded with an echo reply
  - Experimenter – the means to offer additional functionality from the OF switch
    - Features meant for later releases
Vendor/Operator Open Flow Announcements


- Google runs all of its backbone traffic over OpenFlow software and hardware, OpenFlow @ Google - Urs Hoelzle, Google on Open Networking Summit 2012, [http://opennetsummit.org/](http://opennetsummit.org/), April 17, 2012

- “Verizon shows off OpenFlow’s benefits for carriers”, “Verizon has created a partnership with Intel, HP and networking company Adara to help test and understand the benefits that OpenFlow and software defined networks could have on its business. It’s trying to lower the cost of moving data between data center and more.”, [http://gigaom.com/cloud/verizon-shows-off-openflows-benefits-for-carriers/](http://gigaom.com/cloud/verizon-shows-off-openflows-benefits-for-carriers/), Apr 17, 2012

On-going work: IP Multimedia Subsystem and OpenFlow

- Application awareness towards network
- Optimized connectivity control
- Diameter and OpenFlow Protocol translation using Generic-Adaptive-Resource-Control functionality (GARC)
- GARC: 3GPP Policy Charging Control extension for heterogeneous access and core networks
Network Functions Virtualization (NFV) is a novel paradigm that presumes that the network functions:

- Are implemented only as software (programs)
- Can run on top of common servers

NFV implies that network functions:

- Can be moved as required
- Do not require special equipment

Classical Network Appliance Approach

Fragmented non-commodity hardware. Physical install per appliance per site. Hardware development large barrier to entry for new vendors constraining innovation & competition.

What is Network Functions Virtualization (NFV)

- The objective of NFV is to translate the classic network appliances to software modules:
  - Running on high volume servers with high volume storage
  - Interconnected by generic high volume switches
  - Automatically orchestrated and remotely installed

- NFV is a novel paradigm that presumes that the network functions:
  - Are implemented only as software (programs)
  - Can run on top of common servers

- NFV implies that network functions:
  - Can be moved as required
  - Do not require special equipment
ETSI NFV Internal Organisation

ETSI ISG NFV

NFV
- WI: Use Cases
- WI: Requirements
- WI: End-to-End Architecture
- WI: Terminology

WG: Architecture of the Virtualization
WG: Reliability & Availability
WG: Software Architecture
WG: Management and Orchestration
EG: Performance & Portability
EG: Security

Contributions towards others SDOs
NFV Use Cases

• All network functionality is considered (at least in this initial stage)
  – Mobile core networks
  – Fixed core networks
  – IMS and CDNs
  – Home Environment Functions
  – Radio Virtualization

• Realizing at different openness levels:
  – Infrastructure as a Service
  – Network Function as a Service
  – Platform as a Service

• Needs a very dynamic reconfigurable network
  – Service chaining, routing, and traffic engineering
NFV Requirements

- A main requirement/issue for NFV technology to be adopted are:
  - The performance – a penalty comes from the uniform hardware architecture
  - The cost gains vs. the investment costs
  - A clear migration path
NFV Architecture: A primer

- **Virtualised Network Functions (VNF)**
  - the software implementation of a network function which is capable to run over NFVI

- **NFV Infrastructure (NFVI)**
  - includes the diversity of physical resources and how these can be virtualised.
  - NFVI supports the execution of the VNFs

- **NFV Management and Orchestration**
  - the orchestration of physical/software resources that support the infrastructure virtualisation, and the management of VNFs
  - The service chaining and traffic engineering
Research and Development of the NFV Framework

1. Porting the non-virtualized system to COTS hardware → Basic VNF realization
2. Optimizing the VNFs to the new hardware architecture
3. Optimizing the hardware to the network communication characteristics
4. Optimization cycles of VNFs and hardware
Current Status

ETSI ISG NFV

Stable Drafts (July 2013)

- VG: Architecture of the Virtualization
- WG: Reliability & Availability
- WG: Software Architecture
- WG: Management and Orchestration
- EG: Performance & Portability
- EG: Security

Contributions towards others SDOs

NFV
- WI: Use Cases
- WI: Requirements
- WI: End-to-End Architecture
- WI: Terminology

Fraunhofer FOKUS
OpenEPC in the Cloud

- First phase – easy to cloud-ify some parts
- The rest is infrastructure (Gateways)
  - Yes, more can be done, but are we virtualizing just for the sake of virtualization?
  - highly influenced by latency!!! (e.g. GPRS core must have RTT <2ms)
OpenEPC in the Cloud

- But what to do with the Gateways?
OpenEPC with OpenFlow – Clean Infrastructure/Cloud Split

- EPC Control, Mobility and all signaling can be cloudified
- But the User Data Plane stays in the infrastructure → maximum performance
Worldwide Future Internet Research Activities

Previous activities

Research Initiatives

Internat, Asia, US, EU, German, Autonomic Computing, Autonomic Communication


PlanetLab, GENI, JGN2, P-I, P-II, Onelab, Onelab2, OpenLab, G-Lab, G-Lab Phase 2, F-I, FI Goes SC, Fed4FIRE, OpenLabs, FI Goes SC, FI PPP, FI (FP7), FIRE, FIA, SAC (FP6), EIFFE, FIND, NWGN/AKARI, FIF, FIF, NWGN/AKARI, FIND, JGN2, PlanetLab, GENI

with FOKUS and TUB contribution
Europe’s key Initiatives for Future Internet Research and Development

FIRE and the FI-PPP

NGNI is one of the most active contributors to:

– Europe’s **Future Internet Research and Experimentation Initiative (FIRE)**
– Europe’s **Future Internet Public Private Partnership Programme (FI-PPP)**
In FIRE, we utilize state-of-the-art federation tools to expose our Next Generation Network testbeds to Europe’s research community for testing and experimentation.
EU FI PPP Facts

- **Facts & Figures**
  - **2x € 300 million**
    - Investment by the European Commission & Programme Participants
  - **158 68% 18**
    - Partner Organizations and Companies
    - Industry Share in the Programme
    - Academic Institutions
  - **23 Countries Represented (2 from Outside Europe)**
  - **Industries Represented in the FI PPP Programme**
    - Academia 11%
    - Other TC’s 12%
    - Transport & Logistics 6%
    - Business Development & Management 7%
    - Cities 2%
    - Other Industries 3%
    - Defence & Security 4%
    - Media & Broadcasting 4%
    - Construction & Infrastructure 4%

* Other Technology Companies, such as artificial intelligence, marine, aerial and satellite R&D, or automobile and other hardware manufacturing. ** E.g. Banks, retail stores, agriculture and food producing industries. Note: Figures are based on the number of participating organisations and approximate, since there are stakeholders with notable overlap in industries.
FI-WARE: Collaborating with Usage Area Projects

**Envirofi:**
Environmental data in the public domain

**Finest:**
Increasing efficiency in international logistics value-chains

**Safety:**
Making cities safer

**SmartAgriFood:**
Making the food value chain smarter

**Instant Mobility:**
Using FI in personal mobility

**Outsmart:**
Making public infrastructure in urban areas more intelligent and efficient

**Fi-content:**
Networked media including gaming

**Finseny:**
Reaping the benefits of electricity management at community level
FI PPP Use Case Projects

ENVIROFI

http://www.envirofi.eu

FI-CONTENT

http://www.fi-content.eu

FINEST

http://www.finest-ppp.eu

FINSEN

http://www.fi-ppp-finseny.eu

INSTANT MOBILITY

http://instant-mobility.com

OUTSMART

http://www.fi-ppp-outsmart.eu

SAFECITY

http://www.safecity-project.eu

SMARTAGRIFOOD

http://www.smartagrifood.eu
FI-WARE – a collaboration effort between operators and IT providers with good participation from Academia

- The FI-WARE project will introduce a generic and extendible ICT platform for Future Internet services.
- The platform – also referred to as the “Future Internet Core Platform” or “FI-WARE” – aims to meet the demands of key market stakeholders across many different sectors, strengthen the innovation-enabling capabilities in Europe and overall ensure the long-term success of European companies in a highly dynamic market environment.
FI-WARE Mission

- The FI-WARE project will design, develop and implement the so-called Core Platform within the European Future Internet Public Private Partnership (FI-PPP) Program defined under the ICT FP7 Work Programme.
  - See http://www.fi-ppp.eu

- The FI-WARE project will introduce a generic and extendible ICT platform for Future Internet services.

- The platform – also referred to as the “Future Internet Core Platform” or “FI-WARE” – aims to meet the demands of key market stakeholders across many different sectors, strengthen the innovation-enabling capabilities in Europe and overall ensure the long-term success of European companies in a highly dynamic market environment.

- FI-WARE will be open, based upon elements (hereunder called Generic Enablers) which offer reusable and commonly shared functions serving a multiplicity of Usage Areas across various sectors.
FI-WARE Generic Enablers Overview

- **FI-WARE Generic Enabler (GE):** A functional building block of FI-WARE. Any implementation of a Generic Enabler (GE) is made up of a set of components which together supports a concrete set of Functions and provides a concrete set of APIs and interoperable interfaces that are in compliance with open specifications published for that GE.
FI Core Platform Architecture: Enablers are grouped in “chapters”

- Service delivery
- Cloud Hosting
- Internet of Things
- Context/Data Management

Developer tools

Interface to the Network

Operations

Trust and Security

Functionality
Interface to Networks and Devices (I2ND)

Overview

- I2ND provides a common and standard Interface to Devices that allows interoperability among applications running on different devices and the portability of applications across devices.

- The Generic Enablers provided to implement a standardized Interface to Networks and Devices (I2ND), can be used by other FIWARE elements, such as Cloud Hosting, Internet of Things etc., and also directly used by the applications in multiple Usage Areas.

- I2ND chapter addresses four different classes of interfaces:
  - connected device
  - cloud proxy
  - open networking
  - network services
Interface to Networks and Devices (I2ND)
Service, Capability, Connectivity, and Control (S3C) GE
Core Platform Instances and Use Case Trials

- Future Internet Applications run on top of “FI Core Platform Instances” built upon selection and assembly of “Platform Products” implementing “Generic Enablers” of the “FI Core Platform”
- Use Case trials will consist on application scenarios running on top of FI Core Platform Instances, involving real users
Fraunhofer FOKUS’ involvement in the FI-PPP
Evolution of Telecom Platforms towards the Future internet Deployments of the FI Core Platform across Europe for Large Scale Trials
FI-PPP Projects and Phases

### Use Cases
- Define Requirements
- Develop Specific Enablers
- Make Proof of Concepts

### FI-WARE
- Develop Generic Enablers

### INFINITY And XIFI
- Identify infrastructures

### Phase I
- Validate Ge/Se
- Perform trials
- Use infrastructure
- Prepare phase III ecosystems
- Refine, expand GEs
- Make available OIL
- Update infrastructure
- Federate infrastructure

### Phase II
- Take-up
- Target Ecosystems
- Involve software developers, Web entrepreneurs
- Provide, sustain GEs
- Open source GEs
- Operate infrastructures

### Phase III
FI-Ware
FI-PPP Use Case Projects

- **e-Health**
  - FI-STAR (Phase 2)

- **Transport, logistics and agri-food**
  - FInest (Phase 1)
  - SmartAgriFood (Phase 1)
  - FIspace (Phase 2)

- **Social connected TV, mobile city services, and video games**
  - FI-CONTENT (Phase 1)
  - FI-CONTENT 2 (Phase 2)
FI-Ware
FI-PPP Use Case Projects

- Smart Cities and public security
  - SafeCity (Phase 1)
  - OUTSMART (Phase 1)

- Smart energy
  - FINSENY (Phase 1)
  - FINESCE (Phase 2)

- Manufacturing
  - FITMAN (Phase 2)

- Personal mobility
  - Instant Mobility (Phase 1)
FI-Ware
FI-PPP Use Case Projects Sites

Phase 2
Use case trial sites
FI-Ware
Capacity Building and Infrastructures FI-PPP Projects

XIFI

- Support advanced experiments on the FI-PPP core platform in order to leverage existing public investments in advanced infrastructures

- Establishes a marketplace for test infrastructures and Future Internet services to cope with large trial deployments involving users

- Core federation of test infrastructures, and by coordinating efforts with ongoing FI infrastructures and pilots (FIRE, EIT ICT Labs, CIP pilots, Living Labs) assisted by investments in pan-European infrastructures such as GÉANT
FI-Ware
Capacity Building and Infrastructures FI-PPP Projects

XIFI Approach

- Provision of Generic Enablers developed in FI-WARE through high-available and reliable federation of infrastructures.
- Set up of Initial Federation of 5 Nodes in Europe (Berlin, Brittany, Seville, Trento, Waterford)
- Procedures and lifecycle support for FI components on the federated platform
- Processes and Tools for the Deployment of new nodes in the federation
- Open Call to FI-PPP Phase 2 Use Case Projects to use XIFI infrastructure for experimentation
FI-Ware
Capacity Building and Infrastructures FI-PPP Projects

FOKUS Main Contribution to Xifi
- Joint deployment, operation and maintenance of the German Xifi Node in collaboration with Deutsche Telekom
- Offering test platform for experiments in a mobile multi-RAT environment
- Support for Experiment Life Cycle Management and Monitoring
FI-Ware
Capacity Building and Infrastructures FI-PPP Projects

The INFINITY Project
- Objectives:
  To facilitate communication and collaboration between future internet infrastructure owners across Europe and organisations developing future internet applications in order to 1) position Europe at the centre of the future of the Internet 2) directly support experimentation for FI-PPP projects and investors 3) accelerate the development and uptake of social and commercial solutions that will provide benefit to the citizens, businesses and governments of Europe

- Main Delivery:
  - a new, useful and valuable repository of infrastructure capability and capacity that
    - relates the infrastructure demand to available offerings
    - facilitates the creation of an international community that can collaborate to deliver the Future Internet

Having in-depth knowledge about the FI-PPP Core Platform as well as Usage Areas, NGNI contributes to INFINITY’s methodology, infrastructure requirement analysis, infrastructure profiling and detection of interoperability constraints.
FI-Ware
Capacity Building and Infrastructures FI-PPP Projects Infinity & XiFi

What’s available

INFINITY Capacity Building and Infrastructure

FI-WARE Technology Foundation

XIFI Capacity Building

ENVIROFI
FINSEN
FI-CONTENT
FINEST
INSTANT MOBILITY
OUTSMART
SAFE CITY
SMARTAGRIFOOD

FI-Space
FI-CONTENT
Finesce
FI-Star
FITMAN

Coordination
Capacity
Usage
Technology

Call 1
Call 2
Call 3

2010
2011
2012
2013
2014
2015

Phase 1
Phase 2
Phase 3

SME Innovation

2011
2012
2013

CONCORD Programme Facilitation and Support

FINSENY
FI-CONTENT
FINEST

Instant Mobility
Outsmart
Safe City
Smartagrifood

Fi-Space
Fi-Content
Finesce
Fi-Star
Fitman

...now use it
 Agenda

- Smart Cities as Future Internet Show Case
- Smart City communication infrastructures requirements
- The Role of IP Multimedia Subsystem, Machine Type Communication, Evolved Packet Core and related Open APIs within emerging Smart City SDPs
- FOKUS Toolkits and practical examples
- Summary
- Q&A
Smart City ICT
Tools & Testbeds

www.fokus.fraunhofer.de/go/ngni
**Research Agenda of Fraunhofer: Smart City Vision**

<table>
<thead>
<tr>
<th>Environment</th>
<th>Energy</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cities that produce almost no more CO₂-Emissions.</td>
<td>Cities that are greatly energy-efficient.</td>
<td>Cities that are profoundly resource-efficient.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quality of life</th>
<th>Society</th>
</tr>
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<tbody>
<tr>
<td>Cities that provide the best life quality for all residents.</td>
<td>Cities that represent a post-fossil society.</td>
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<th>Smart City</th>
<th>Climate Change</th>
<th>E-Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cities that intelligently interlink all its potentials and city systems.</td>
<td>Cities that can easily adapt to the effects of climate change.</td>
<td>Cities that offer a medium for the change towards electromobility.</td>
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</tbody>
</table>
About the Fraunhofer Gesellschaft

The Fraunhofer Gesellschaft is Europe’s largest organization for applied research.

- Fraunhofer develops products and processes through to technical or commercial maturity
- Individual solutions are elaborated in direct contact with the customers
- The Fraunhofer Gesellschaft maintains
  - 66 self-contained Fraunhofer Institutes throughout Germany
  - with a staff of 22,000 scientists and engineers
  - 1.9 billion Euro annual budget
- More than 70% of funding are raised through innovative development projects, license fees and contract research
- Sub-companies and representative offices all over the world
Fraunhofer FOKUS – Activity Domains

System Quality Engineering
- eGovernment
- eHealth
- Public Security
- Smart Mobility
- Smart Energy

Public Innovation Management

Interoperability
- Critical Infrastructure
- Identity Management
- Virtualization
- Process Orientation
- Linking Legislation and Technology
- Business Analytics/Big Data

Smart Communication
Next Generation Network Infrastructures NGNI

Next Generation Network to Future Internet Evolution

NGNI works on universal control platforms for Human-to-Human and Machine-to-Machine communications in fixed and wireless networks as well as on integrated communication infrastructures.

Research & Development

- Integrated Service Architectures for convergence of telecommunication and Internet
- Reliable network infrastructures and end systems for Next Generation Networks
- Rich communication services
- Machine-Type Communication frameworks and M2M toolkits
- Seamless service access across mobile broadband networks
- Mobile Cloud Computing, monitoring and security
FOKUS Smart Cities Vision
Transforming Data into Information

- City as service provider for citizens, enterprises, institutions and tourists

- Smartness via
  - Always Best Informed and Inter-Connected Urban Actors (Machines, Systems and People)

- Information at any need, at any place, at any device, at any time, at any preference
WHERE TO START?

- ICT Architecture
- Data sources: government, citizens utilities, traffic data, open data
- Big Data (2020 30 Zettabytes) / Analytics
- Use Cases
- Legislation
- Business models
ICT in Smart Cities
Backbone for Smart Cities

City as a system of systems

Set of separate technical systems → Integrated systems

Affectivity and efficiency results from optimized integration of separated systems

Politics and Administration
Communication
Energy
Mobility
Public Services
Urban Security
Transport and Traffic
Urban Management
Health

Fraunhofer FOKUS

as Enabler and Integrator for ICT-based Solutions
Topics of Concern
FOKUS labs on ICT in Smart Cities

- Politics and Administration
- Communication
- Energy
- Mobility
- Urban Security
- Public Services
- Urban Management
- Transport and Traffic
- Health
A Smart City
A Smart City depends on a smart ICT Infrastructure.
A Smart City depends on a smart ICT Infra-structure that is inspired by FOKUS Labs.
Evolution of a Smart City ICT infrastructure

A Smart City ICT infrastructure is
- a vast distributed system of systems that is
- used for providing all kind of relevant services and data
- run by multiple actors (public and private organisations)
- continuously being redesigned and improved.

Urban ICT policy

New services, improved processes
Evolution of a Smart City

Validate your objectives
Get to know Best Practice
Test Systems & Solutions
Use Standards to integrate
Selected Urban Technologies @ FOKUS

City Applications
- Berlin youth welfare service
- Liquid Democracy tools
- Event Chaser
- MWR
- Electric Mobility App
- GoBerlin Apps
- Megastore
- eGov
- Open Budget
- OpenCityGuide
- Public Transit

City Platforms
- Traffic Data Pool
- MashWeb
- Enyport Web/API
- Open Data Platform
- IMSK Knowledge Fusion
- OpenMT
- Complaint Management Platform
- City Data Streaming
- WIND Kernel
- KF Toolkit
- Sensor Technology Gateway
- V2X Server
- Linked Data Repository
- mobile alerting services

City Networked infrastructure
- OpenCTK
- OpenEPC
- Cloud Broker
- OpenMTC
- IPv6 Testbed Infrastructures
- Data as a Service
- Sensor Networks
- Vehicle to X Technology

Security/Privacy
- V2X Security
- Webinos Security Framework
- Famium/AppDRM
- nPa
- IDM
- Enyport Security
- Model based Fuzzing Library

Standards
- ETSI
- W3C
- OIPF
- WAC

Engineering
- ModelBus
- Standards
- Metrino
- Open Source Dev.
- Multi Screen App Dev.
- Fokus MBT
- Tracino
- UMLBE
- OT3
Essential Technological Developments
Major Contributions by FOKUS

- Internet of Things
- e-Identity Management
- Internet of Services
- Smart Communication
- Open Data
- System Interoperability
- Business Intelligence
- Interconnected Media

Urban Technology Solutions
Solutions made by FOKUS
FOKUS labs on ICT in Smart Cities

Politics and Administration
Cloud/SOA-Lab
Open/Closed Source-Lab
Protocol Conf. and Interop Lab
Communication
Energy
Urban Security
Public Services
Urban Management
Mobility
Secure eIdentity-Lab
eGovernment Lab
Automotive Lab
Smart Communications Lab
eHealth Interop Lab
Transport and Traffic
CertLab
Health
Smart Metering Lab
Cloud/SOA-Lab
Open/Closed Source-Lab
Protocol Conf. and Interop Lab
Communication
Energy
Urban Security
Public Services
Urban Management
Mobility
Secure eIdentity-Lab
eGovernment Lab
Automotive Lab
Smart Communications Lab
eHealth Interop Lab
Transport and Traffic
CertLab
Health
Smart Metering Lab
A Smart City relies on Integration & Federation of Systems

Convergence will lead to a Common SC Service (ICT) Platform

Enablement of "Smarter Applications" by allowing these to make use of common/open data and common service capabilities provided by a Smart City service platform.

**Common SC Service (ICT) Platform**

Federation & Integration of different fixed and mobile Network Technologies to interconnect different machines (sensors, actuators) and people and for providing applications seamless.
Related FOKUS Testbed Evolution

OSA/Parlay Playground

open soa telco playground

iptel.org

open ims playground

Smart Communications Playground
Related FOKUS Testbed Evolution

IT Impact on Telecoms

Intelligent Network (IN)

Open APIs

OSA/Parlay/Java

IN Services based on SIBs

IN Overlay Architecture

Circuit Switched Networks

PSTN

IP

GSM

OSA/Parlay Playground

Telecom APIs

Parlay X, GSM One, OMA NGSI, etc.

Smart Cities, eGov, eHealth, eTransport, eUtilities

FI Applications

Core Platform

Network Abstraction

Evolved Packet Core (EPC)

Future Internet Core Platform

People & Things

ip tel.org

iptel.org

open soa telco playground

open ims playground

iupel.org

Embedded Future Internet

SIBs

Smart Communications Playground

Telecom APIs

Open APIs

OSA/Parlay/Java

IN Services based on SIBs

IN Overlay Architecture

Circuit Switched Networks

PSTN

IP

GSM

Open APIs

Parlay X, GSM One, OMA NGSI, etc.

Smart Cities, eGov, eHealth, eTransport, eUtilities

FI Applications

Core Platform

Network Abstraction

Evolved Packet Core (EPC)

Future Internet Core Platform

People & Things
Stakeholders

Operators

- Be prepared for all-IP mass mobile broadband world
- Validate new technologies

Manufacturers

- Validate their products against standard compliant EPC
- Looking for the missing pieces

Application developers

- Validating wireless applications
- Direct access to core functionalities

Research institutions and universities

- R&D on real network conditions
- Innovating new concept and algorithms
### Challenges

**The R&D Community Faces Intense Complexity in Realizing Meaningful Testbeds**

<table>
<thead>
<tr>
<th>Trust in Research</th>
<th>Complexity Limits Testbed Deployments</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Feasibility of new developed research concepts or components</td>
<td>- Heterogonous access technologies</td>
</tr>
<tr>
<td>- Alignment of application requirements and network functionality</td>
<td>- 3GPP or non-3GPP access networks</td>
</tr>
<tr>
<td>- Customizing and mirroring operator networks for supporting realistic experiments</td>
<td>- Customization and integration of distributed functionalities</td>
</tr>
<tr>
<td></td>
<td>- Uncertainty on which specific services will become revenue efficient</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Proprietary Systems</th>
<th>Standard Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Make Innovation Difficult</td>
<td>- No easy replication of standard components</td>
</tr>
<tr>
<td>- Most of core network components are delivered as closed box</td>
<td>- Developers look for open interfaces</td>
</tr>
<tr>
<td>- Challenges in customizing usage or features extension</td>
<td>- Researchers are interested in specific component from holistic view</td>
</tr>
<tr>
<td>- Use cost-efficient off-the-shelf hardware</td>
<td>- Up-to-date compliant with the standard</td>
</tr>
</tbody>
</table>
Objectives
A Realistic Testbed answers the Challenges

<table>
<thead>
<tr>
<th>Open Standard Compliant Testbeds</th>
<th>Configurability and Modularity</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Build the know-how of core network functionalities</td>
<td>- Easy configurable software toolkit implementation</td>
</tr>
<tr>
<td>- Easy to understand and to evaluate connectivity technologies</td>
<td>- Reduce the prototyping duration</td>
</tr>
<tr>
<td>- Mirror end-to-end operator network with various standard compliant components</td>
<td>- Software based core network toolkits</td>
</tr>
<tr>
<td>- Allow access to the source code</td>
<td>- Modular toolkit structure to select specific components</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Cost Effective Development</th>
<th>Extendibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Provide the means for wireless ready applications</td>
<td>- Enable to validate and evaluate new technologies or additional features</td>
</tr>
<tr>
<td>- Develop and evaluate wireless applications directly over realistic wireless networks</td>
<td>- Gradual support of new core network functionalities</td>
</tr>
<tr>
<td>- Support standard compliant interfaces to enable interoperability and to reduce time</td>
<td>- Single box operator network</td>
</tr>
<tr>
<td>- Fast and Cost Effective Prototyping</td>
<td>- Supporting and applying virtualization concepts</td>
</tr>
</tbody>
</table>
OpenEPC comes to meet the R&D requirements

- FOKUS Testbed Toolkits are especially designed for addressing R&D:
  - Enabling the hands-on understanding of technologies, resulting in new concepts
  - **Filling the gap between research and product development** by providing initial realistic environment prototyping
    - Providing trust in research through realistic environments testbeds
    - Mirroring operator core network functionality
  - Providing standard interfaces for product prototyping
  - Providing missing components for large integrated testbeds and trials
  - Providing the counterpart functionality for product realization

- Example below shows OpenEPC positioning (same is true for all other toolkits)
Commercial FOKUS NGN/IMS/EPC/SOA Testbed Deployments around the world
Fraunhofer Testbeds / Playgrounds

Smart Communications Playground

www.SC-playground.org

FUSECO Playground

www.FUSECO-Playground.org
FOKUS Smart Communication Research
A Generic Smart Communication Architecture

• Connecting Smart City objects across application domains
• Enabling the Internet of Things by using M2M gateways and network middleware to communicate efficiently
• Enabling multimedia communication services by integrating Telecoms APIs and platforms.
• Enable rapid application development using M2M and H2H network APIs and software development kits (SDK)
• Enable cross domain data analytics and fusion to serve the need of Smart Cities

visit: www.sc-playground.org
The Start: Open Source IMS Core

- Global reference for IMS test-beds
- 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 Open Source portal
  
  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

Note: IMS Client shown is MyMonster – see www.opensoaplayground.org/tcs
Telco Communicator Suite
Android Communication Client

• The software stems
  – Extended RCS Stack from Orange Labs for VoLTE
  – Compliant to GSMA RCSe specification
  – Client/Server API allows easy integration with Android native application

• Supported RCS/VoLTE key features:
  – Enhanced native address book with supported service capabilities and presence info
  – Messaging
    • File Transfer
    • 1-1 chat
    • Adhoc group chat
    • Location
  – Rich Call with multimedia content sharing
    • Image Sharing
    • Video Sharing
    • Video/Audio VoIP

see www.sc-playground.org/tcs for more information
FOKUS joyn App for Deutsche Telekom Extending RCS for Facebook Image sharing

- App uses Deutsche Telekom RCS network gateway to provide mobile image sharing for Facebook images
- Extends Facebook network with mobile operator RCS network
Combining WebRTC, Android RCS, EPC and Application Platform: Smart City Rich Communication Services

- WebRTC communication is enhanced by session-based QoS control.

- OCS provides WebRTC application and REST-based API towards EPC PCRF
  - setting of application-driven QoS policies for WebRTC session.

- OCS provides additionally REST-based interface to EPC ANDSF for application-driven network selection.

- Mobility manager on Android/PC allows seamless vertical hand-overs.
Introducing the FOKUS OpenMTC Platform

- Based on the success of the Open IMS Core and OpenEPC Fraunhofer FOKUS has developed a **NON-OPEN SOURCE** Machine Type Communication platform, enabling academia and industry to:
  - integrate various machine devices with operator networks
  - integrate various application platforms and services into a single local testbed, thus lowering own development costs
- OpenMTC is an intermediary layer between multiple service platforms, the operator network, and devices
- This platform can be used to perform R&D in the fields of machine type communication
- OpenMTC implemented features are aligned with ETSI M2M specifications:
  - Adaptable to different M2M scenarios (e.g. automotive)
  - Extensible to specific research needs
  - Configurable
  - Performant
- For more see [www.open-MTC.org](http://www.open-MTC.org)
OpenMTC Architecture – Release 1

- OpenMTC consists of the two main components
  - Network Service Capability Layer (NSCL)
  - Gateway Service Capability Layer (GSCL)
- Both SCLs contain several modules
  - e.g. NGC: Network generic communication, GSEC: Gateway security, etc.
  - Some of them are optional
- OpenMTC allows interworking with
  - OpenEPC (Evolved Packet Core)
  - OpenIMS (IP Multimedia Subsystem)
  - FOKUS Service Broker
- OpenMTC supports:
  - Various sensors and actuators (e.g. ZigBee, FS20 devices)
  - Multiple Access networks (e.g. fixed, mobile, xDSL, 3G, etc.)
  - Various Applications (e.g. Smart Cities, Smart Home, etc.)
OpenMTC Architecture
OpenMTC Application Enablement

- Exposes functionalities implemented in the service layers (N/GSCL) via the reference points
  - mIa
  - dIa
- Single contact point for
  - Network Applications (NA)
  - Gateway Applications (GA)
  - Device Applications (DA)
- Performs routing between applications and capabilities in the N/GSCL
- Routing is defined as the mechanism by which a specific request is sent to a particular capability
Integration and Interworking on all layers
Supporting Interoperability

Heterogeneous Application Integration

Heterogeneous System / Platform Integration

Heterogeneous Device Integration
OpenMTC
Releases and Roadmap

First Demos

Nov 2011

• IMS based demos
• Sensor integration in Telco world

OpenMTC Rel. 1

May 2012

• Generic communication
• Application enablement
• ETSI resource tree
• Remote management
• Integration with Telco Services

OpenMTC Rel. 2

Nov 2013

• New use case demos
• NSCL APIs & SDK
• Android D/GSCL
• Integration with 3GPP core network – EPC, PRCF/ANDSF, MTC-IWF
• Full REM SC, OMA DM
Smart City Services for Facilities and Campuses

- OpenMTC hides heterogeneity across a wider facility infrastructure (i.e. sensor and actor networks), communications (i.e. wireline or wireless, fixed or mobile), and services (i.e. M2M or proprietary) enabling data fusion and joint control.
Smart City Services for End Customer Domotics and Smart Metering

- OpenMTC provides a unified API to M2M client applications while hiding heterogeneity of end-customer premises equipment (i.e. domotics and smart meter) and the communication links between customer premises and M2M service center.
Example R&D Cooperation: TRESCIMO | Testbeds for Reliable Smart City Machine-to-Machine Communication

- **Context:** FP7 FIRE STREP: EU/SA collaboration
- **Motivation:** Urbanization issues in South Africa
- **Goal:** Reliable Smart City Communication Platform
- **Approach:**
  - Smart Technologies
    - CSIR: Smart Platform
    - i2CAT: Smart City Platform
    - Fraunhofer/TUB: OpenMTC / FITeagle
  - Smart Sensors
    - Eskom: Utility Load Manager
    - AirBase: Smart City Air Pollution Wireless Sensors
  - Evaluation
    - Pilots: San Vicenç dels Horts and Johannesburg
    - Testbeds: TUB and University of Cape Town
- **Web:** [http://trescimo.eu](http://trescimo.eu)
Smart City Services for Early Warning and Emergency Management

- OpenMTC aggregates sensor information and environmental warnings, implements application logic and policies, and can automate counter-measures (e.g. multi-channel hazard warning, facility management, and traffic control) via dedicated application logic.
KATWARN – An example for cost-effective solutions
An adaptable combination of existing technologies for public alerting
KATWARN-App
Smart City Services for eHealth and Support of Elderly People

- OpenMTC supports various eHealth devices and can communicate health information to hospitals and first responders. In conjunction with traffic & location information and data about medical staff occupancy, critical time savings and cost reduction can be achieved.
FI-STAR is a FP7 FI-PPP 2nd Phase user case trial project in the domain of e-Health. The project started in April 2013 and will run for 24 months.

FI-STAR is establishing early trials in the health care domain, building on future internet technology, creating a robust framework based on a “software to data” paradigm.

FI-STAR proactively engages with FI-PPP to propose specifications and standards.

FI-STAR will use the latest digital technologies to build communities made up of developers and users.

FI-STAR will generate new business development and prepare for new partners through open calls.
The health care domain has rejected a data to software approach. The market has reacted and public cloud services were suspended.

No Data Upload!

Privacy? Security?

Governance? QoS?
Zum Auswählen der korrekten Farbe mit dem Tool »Farbe auswählen« auf das jeweilige Feld unten klicken oder den Web/RGB Farbwert manuell eingeben:
Download of Generic Enablers
Specific Enablers
Apps & Services

Billing & Licensing

No Patient Data Upload

Private/Community Cloud

Public Cloud

Software Updates

Certification

Specific Enablers

Billing, Licensing

S2D Architecture
FI-STAR will execute seven early trials across Europe. Trials will validate the FI-PPP core platform and will introduce ultra-light interactive applications for user functionality.

Osakidetza, in Bilbao, Spain.
Developing Interactive Future Internet based services for people with Mental Health problems. Improve access to care and apply Core Platform to other already existing services successively.

Medichem, in Leeds, UK.
To implement the 2-D Pharmacy bar-coding, offering a real time reverse supply chain model to prevent error and counterfeiting and create interfaces to additional third part services.

CUP 2000, in Bologna, Italy.
Developing healthcare networks to allow healthcare professionals to share data in real-time, allowing citizens to access healthcare data anytime, anywhere.
Norwegian Centre for Integrated Care and Telemedicine in Tromsø, Norway.
To improve the existing telehealth network for Diabetes patients, aiming at the development of smart phone based multi-channeling, allowing for streaming of different data at the same time (sensor data and audio and video).

University of Medicine and Pharmacy Carol Davila in Bucharest, Romania.
Online Cardiology service for people with heart failure by testing software, applications and internet-monitoring. Improvement of physical training and also the improvement in secondary prevention programs.

John Paul II Hospital, in Krakow, Poland.
Designing interactive facilities for cancer patients, using life monitoring sensors, tablets, cameras, web based, treatment diary, mobile and video conferencing client.

Klinikum Rechts der Isar, Technical University, in Munich, Germany.
Implementation of the virtualization of operating theatres to develop methodologies for minimal invasive operating theatre environments with real time data integration for monitoring, to reduce error rates.
Future Seamless Communication (FUSECO) Playground

- State of the art testbed infrastructure as a cooperation of Berlin’s Next Generation Mobile Network expertise for
  - **Open IMS** for H2H communications
  - **OPenMTC** for M2M communications
  - **OpenEPC** for seamless access
  - Various access network technologies

- 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:
What is FOKUS OpenEPC Platform?

- Future massive broadband communications will be realized through multi-access support (LTE, 3G, 2G, WiFi, fixed networks ...) and multi-application domains (OTT, IMS, P2P, M2M, Cloud, ...)

- Fraunhofer FOKUS is developing the **NON-OPEN SOURCE** OpenEPC, enabling:
  - 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, Charging, Mobility, Security, Management, Monitoring

- OpenEPC represents a software implementation of the 3GPP EPC standard addressing academia and industry R&D:
  - Configurable to different deployments
  - Customizable to the various testbed requirements
  - Extensible to specific research needs
  - Reliable & highly performant
  - Based on 3GPP standards

- More information: [www.OpenEPC.net](http://www.OpenEPC.net)
OpenEPC Scales for different deployments

- OpenEPC components can be deployed in almost any configuration possible
  - Large testbeds – each component on a separate machine
  - Smaller testbeds – components are grouped in same servers
  - Single box testbed – components are virtualized on the same machine
  - Minimized testbed – the OpenEPC components run as parallel programs on the same box
OpenEPC is highly modular and easy to extend.

- Retrieving the current status
- Development of a new interface using a protocol
- Creating a new component
  - Modifying an existing one
- Re-creating state
- Remote Procedure Calls
- Using the interfaces in new contexts
- Replacing Interfaces with Proprietary Ones

OpenEPC is highly modular and easy to extend.
OpenEPC Roadmap

**Preview**
Nov. 2009

First demo of the OpenEPC at the 5th IMS Workshop

**Rel. 1**
Feb. 2011

Extended Mobility (GTP, MME etc.)
Extended AAA
More Access Networks
Integration
Support for specific applications

**Rel. 2**
Jan. 2012

LTE RAN integration
2G and 3G RAN integration
Android Mobile Devices Support
Multiple APN Support
Radio conditions based handover
Traffic Shaping for QoS

**Rel. 3**
Nov. 2012

OpenFlow and SDN-EPC
VoLTE with SRVCC
Network Functions Virtualization
UE/eNodeB-emulation-with-WiFi
Self Organized Networks Features
...

**Rel. 4**
...

**Rel. 5/6**
...

**Core Network Mobility**
**Client Mobility**
**Policy and Charging Control**
**Subscription Management**
**Mobile Device support**

Integration of 3GPP
Offline Charging
Non-3GPP AAA
Extended UE function
Dynamic node selection
Full NAS, GTP stacks
S1AP with APER, X2AP
What are the next steps wireless broadband?

- 1000x more connected devices
- 10000x more data traffic
- Higher diversification of communication requirements
- Cloudification of applications
- Wide spread of multimedia caches

Timeline:

- 1998: Initial 3G Deployment
- 2001: Initial 3G Deployment
- 2004: Bittorrent
- 2007: Initial LTE Deployment
- 2010: Amazon EC2 Youtube
- 2013: 500000 Data Centers
- 2017: 1000x data traffic
- 2020: 10000x devices
- Global applications
- Local Delivery
Fraunhofer FOKUS Toolkits and Technology Evolution Path

2005 2010 Today 2015 2020+

**open ims core**
Converged *Session control* for SIP multimedia services on top of IP networks

**open epc**
*IP Connectivity*, Charging, Security, QoS Control, Mobility, Heterogeneous Access Network support

**open SDN core**
Network component *orchestration* and management; Adaptable *distributed control* platform; Programmable switches

**open 5G core**
Towards *5G Core Evolution*, 5G RAN support, *SDN data path concepts*, Flatter architecture

2G (GSM/GPRS) / 3G (UMTS/HSPA(+)) 4G (LTE/LTE-A) 5G (LTE-B / 5G-RAN)
OpenSDNCore Scope

- To provide self-adaptable connectivity at the following levels
  - Data Path – providing the basis for developing novel forwarding mechanisms
  - Control Plane – integrating novel Internet and Telecom principles in a simplified modular manner
  - Orchestrator – self-adaptable network deployments

www.opensdncore.org
OpenSDNCore Switch

Features

- OpenFlow 1.3.2 support
  - Other protocols can be considered
- Flow based matching & routing conditions
- GTP and GRE tunneling support
  - Other encapsulations can be considered
- Asynchronous metrics (statistics)
  - At port and at matching rule level

Implementation info:

- Linux based implementation (only for start)
- Implemented on WHARF (OpenEPC platform)
- C based data packets processing
- Highly modular
- Designed for high parallelism
Agenda

■ Smart Cities as Future Internet Show Case
■ Smart City communication infrastructures requirements
■ The Role of IP Multimedia Subsystem, Machine Type Communication, Evolved Packet Core and related Open APIs within emerging Smart City SDPs
■ FOKUS Toolkits and practical examples
■ Summary
■ Q&A
NGN2FI Evolution is a Challenge

Information Technologies
(Service Oriented Architectures & Cloud Computing)

Smart Cities

RCS
FMC
IPTV
IMS
SDP
MTC
OTT
EPC

VoIP and Instant Messaging
Fixed and Mobile Telecommunications
Cable Networks

Next Generation Network

Fixed and Mobile Telecommunications

Evolution

Revolution

Internet

Telecommunications

Future Internet

Internet of Services
Internet of Things
Network Virtualization
Self Organising Networks

Fixed and Mobile Telecommunications

Cable Networks
UNIFI Workshop @ 4th FOKUS „Future Seamless Communication“ Forum (FFF) Berlin, Germany, November 28-29, 2013

- Theme: „Smart Communications Platforms for Seamless Smart City Applications – Fixed and Mobile Next Generation Networks Evolution towards virtualized network control and service platforms and Seamless Cloud-based H2H and M2M Applications“

- FUSECO FORUM is the successor of the famous FOKUS IMS Workshop series (2004-09)
  - FFF 2010 attracted 150 experts from 21 nations
  - FFF 2011 was attended by around 200 experts from 30 nations
  - FFF 2012 was attended again by around 200 experts from 30 nations

- See www.fuseco-forum.org
UNIFI Mission

- **UNIFI** – UNIversities for Future Internet
- UNIFI is an initiative of the Chair of Next Generation Networks (AV) at the Technische Universität Berlin aiming at building sustainable teaching and research infrastructures in the areas of Future Internet through global collaboration among academic institutions.
- The initiative intends to reach its goals via enablement and empowerment of all stakeholders of academia:
  - the creation and development of high quality curricula, integration and exchange of teaching personnel, students, postgraduates and researchers among the partner universities
  - the creation of Competence Centers for a sustainable development and bundling of local expertise
  - the creation and development of an open, general purpose, and sustainable large-scale shared Next Generation Networks Infrastructures & Future Internet Technology Experimentation and Research Facility via federation of interoperable local testbeds.
  - the creation and operation of an International Multilateral Academic Network as a communication hub and motor for intercultural understanding in the international FI academic community

www.daad-unifi.org
DAAD Project University Future Internet
*Unifying Education and Testbeds around the Globe*

- **TU Berlin**
  - www.av-tu-berlin.de
- **AV Next Generation Networks**
- **Hanoi University of Science and Technology**
  - en.hustech.edu.vn
- **Universidad de Chile**
  - www.uchile.cl
- **University of Cape Town**
  - www.uct.ac.za
- **Chulalongkorn University**
  - www.chula.ac.th

Enabled by **teagle** - A Pan-European Laboratory Project

www.daad-unifi.org
DAAD Project University Future Internet
Unifying Education and Testbeds around the Globe

Joint R&D Projects

R&D

Joint R&D

Workshops

Awareness Creation

Workshops

Unified Lectures

Lectures

Lectures

Lectures

Federated Testbeds

Testbeds

Testbeds

Testbeds

Enabled by teagle

A Pan-European Laboratory Project

www.daad-unifi.org
IT Telkom as Partner in DAAD UNIFI
Unifying Education and Testbeds around the Globe

www.daad-unifi.org

www.ucl.ac.za

Universidad de Chile
www.uchile.cl

Chulalongkorn University
www.chula.ac.th

Hanoi University of Science and Technology
en.hustech.edu.vn

University of Cape Town
www.uct.ac.za
Beyond DAAD UNIFI

Unifying Testbeds and Education for Local Industry

- Joint R&D Projects
- Awareness Creation
- Unified Lectures
- Federated Testbeds

R&D
Workshops
Lectures
Testbeds

Joint Industry R&D Projects
Workshops
Lectures
Testbeds

www.daad-unifi.org
Example R&D Cooperation: TRESPIMO | Testbeds for Reliable Smart City Machine-to-Machine Communication

- **Context:** FP7 FIRE STREP: EU/SA collaboration
- **Motivation:** Urbanization issues in South Africa
- **Goal:** Reliable Smart City Communication Platform
- **Approach:**
  - Smart Technologies
    - CSIR: Smart Platform
    - i2CAT: Smart City Platform
    - Fraunhofer/TUB: OpenMTC / FITeagle
  - Smart Sensors
    - Eskom: Utility Load Manager
    - AirBase: Smart City Air Pollution Wireless Sensors
  - Evaluation
    - Pilots: San Vicenç dels Horts and Johannesburg
    - Testbeds: TUB and University of Cape Town
- **Web:** http://trespimo.eu
Evolution of Telecommunication Platforms toward Smart Communications

- **IT Impact on Telecoms**
  - Intelligent Network (IN)
  - Open APIs
    - OSA/Parlay/JAIN
    - Telecom APIs
    - Parlay X, GSM One
    - OMA NGSI, etc

- **Open Service APIs (Enablers)**
  - Service Delivery Platform (SOA based)
    - Network Abstraction
  - IP Multimedia System (IMS)
  - IP Networks
    - (NGN)
    - UMTS
    - WLAN
    - Cable
  - VoIP / SIP
  - All-IP

- **SC Cloud Applications:**
  - RCS, UC, eGov, eHealth, eTransport, eUtilities

- **APIs (Enablers)**
  - Smart City / Future Internet
  - Core Platform
  - Network Abstraction
  - IMS
  - Evolved Packet Core (EPC)
  - MTC

- **IN Services based on SIBs**

- **IN Overlay Architecture**

- **Circuit Switched Networks**
  - PSTN
  - GSM

- **IP**

- **DSL**

- **UMTS**

- **WLAN**

- **LTE**

- **WiMAX**

- **Mobile Broadband IP Networks**
Questions ???