Experiences from TU Berlin and Fraunhofer FOKUS on NGN testbeds and tools

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About the Speakers

Prof. Dr. Ing. habil Thomas Magedanz

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

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

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

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

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

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

Marius Corici received his Diploma in the Science of Systems and Computers – Computers Engineering from University “Politehnica” of Bucharest, Romania in 2005. He joined the Next Generation Network Infrastructures (NGNI) competence center of Fraunhofer FOKUS Institute in 2005. His research work includes multiple patent applications submitted in the area of IP network architectures and multiple publications in the area of NGN and Mobile Broadband Networks in collaboration with various industry partners.
Dipl.-Ing. Dragos Vingarzan

Dragos Vingarzan graduated as Dipl. Ing. at the “Politehnica” University of Bucharest, Romania in February 2005, the Computer Engineering program on base software, compilers and computer networks with a Diploma Thesis at Fraunhofer FOKUS which represented the first milestone of the Open IMS Playground. Since 2005, he continued his research activity at the same institute in the area of feasibility and performance studies on NGN/converged NGN architectures. Currently he is working on his PhD in the area of IMS core and Evolved Packet Core (EPC) networks, with special interests in prototyping, open source in telecommunications, performance benchmarking and interoperability. He is an active member of various IMS working groups.
About the Speaker

Dipl. Inform. Julius Müller

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

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

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

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

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

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

- 3GPP Evolved Packet System (EPS) Overview (E-UTRAN + Evolved Packet Core)
- Showcase: The Berlin FUSECO Playground
- An EPC testbed toolkit for academia and industry R&D
- Open research issues in the scope of EPC
- Conclusion
3GPP Evolved Packet System (EPS) = E-UTRAN (LTE) + Evolved Packet Core (EPC)

Source: 3GPP
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)

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**ANDSF**

**MME**

**HSS**

**PCRF**

**AF**

**S-GW**

**PDN GW**

**AAA Server**

**ANGw**

**ePDG**

**Trusted Non-3GPP**

**Untrusted Non-3GPP**

Diagrams:
- Diameter
- OMA DM over HTTP/other
- GTP/PMIP
- IP
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-3GG → ANDSF assisted
    - Only hard handovers (except CDMA 2000)
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OpenEPC forms the heart of the Future Seamless Communication (FUSECO) Playground

- State of the art testbed infrastructure as a cooperation of Berlin’s Next Generation Mobile Network expertise for
  - **EPC** from Fraunhofer FOKUS
  - **LTE-Advanced** at the Fraunhofer HHI
  - **WLAN** networks at the Berlin Open Wireless Network from the Dt. Telekom Labs @ TU Berlin

- Enabling to prototype application support for
  - handover optimization across heterogeneous networks
  - support for Always Best Connected (ABC)
  - subscriber profile based service personalization
  - QoS provisioning and related charging
  - controlled access to IMS-based services
  - controlled access to Internet/Mobile Clouds

- More information: [FUSECO-playground.org](http://FUSECO-playground.org)
Mobile Broadband Data Transport and Seamless Handover between WLAN and LTE-A

Short LTE-A facts:

- 2.6 GHz UMTS extension band and 800 MHz digital dividend, 2x2 MIMO
- Optical links between eNBs for LTE-Advanced studies
- 20 MHz bandwidth
- 150 Mbps downlink PHY-layer data rates
- 8 ms end-to-end delay
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Motivation for a Future Seamless Communication Testbed

- Similar to NGN also Mobile Broadband Networks is a very complex environment
- Similar to IMS also EPC is a very expensive and complicated platform
- Besides technology complexity also business models are uncertain
- Simulators are not enough for early prototyping, practical experimentation and awareness creation
- Open infrastructure = testbeds are needed
- Vendors only offer „specific interpretations“ of the standards (vendor dependence)
- Operators won´t go soon for a full EPC platform and won’t open their infrastructures for third party access
- Independent actors are needed to setup and deploy such open testbeds
- Fraunhofer FOKUS has a long tradition in providing independent testbeds
What is the FOKUS OpenEPC Platform?

- In Next Generation Mobile Networks, multi access network support (incl. fixed & cable) and multi application domain support (OTT, IMS, P2P etc.) will become key for multimedia service delivery.

- Based on the success of the Open IMS Core, Fraunhofer FOKUS is developing a **NON-OPEN SOURCE** EPC platform, enabling academia and industry to:
  - Integrate various network technologies and application platforms into a single local testbed, thus lowering own development costs.

- This platform can be used to perform R&D in the fields of:
  - QoS, Mobility, Security, Management

- OpenEPC is aligned with 3GPP specifications:
  - High performance
  - Adaptable to different deployments
  - Extensible to specific research needs
  - Configurable

- More information: [www.OpenEPC.net](http://www.OpenEPC.net)
OpenEPC Architecture

- OpenEPC includes the main functionalities of 3GPP's Evolved Packet Core (Release 9)
- The principles of standard alignment, configurability and extensibility have been respected in the overall architecture and the specific components
- In Rel. 1, a subset of functionalities and features is available as depicted below
  - Subscription based procedures for
    - Always Best Connected
    - Resource Reservation
  - Mobility Support
  - Mobile Equipment support for EPC

**PLEASE NOTE:** OpenEPC does not claim 100% standard compliance but allows for early prototyping
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Open research topics

- Zero packet loss handover
- Charging of multiple PDN-GW
- Selecting networks for handovers using ANDSF (ABC)
- Traffic offload
- Enhance security by introducing suitable enabler
- Sp interface transporting Identity and AAA
- Traffic classification mechanisms
- Etc.
Zero packet loss dual radio handover between WLAN and E-UTRAN

1. UE uses an un-trusted non-3GPP access system (WLAN) to access a service and sends/receives data through the PDN GW (as PMIPv6 LMA)
2. UE discovers the E-UTRAN
3. The UE sends an Attach Request to the MME with Request Type indicating "Handover" Attach. (The MME may contact the HSS and authenticate the UE)
4. The MME performs location update procedure and subscriber data retrieval from the HSS, MME selects an APN, a serving GW and PDN GW
5. Serving GW sends a Create Session Request (Handover Indication) message to the PDN-GW, which responds with a Create Session Response message over to MME includes the IP address of the UE

<table>
<thead>
<tr>
<th>Standard 3GPP TS 23.402</th>
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<tr>
<td>6. The MME sends a Modify Bearer Request over SGW to PDN tunnel packets into new AN</td>
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<tr>
<td>7. PDN GW acknowledges by sending Modify Bearer Response over SGW to MME</td>
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<tr>
<td>8. PDN GW shall initiate resource allocation deactivation procedure from the UE at the PDN GW and UE detaches, before the second tunnel is established.</td>
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<th>OpenEPC</th>
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<tr>
<td>6. A second Radio and Access bearer is established in parallel over the new AN.</td>
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<tr>
<td>7. UE has two active bearers over two different ANs. Last packets are received over the WLAN bearer and packets are send over the new established E-UTRAN bearer.</td>
</tr>
<tr>
<td>8. Zero packet loss is ensured by waiting 5 sec. after receiving the first packet over the E-UTRAN bearer, until the old WLAN bearer is detached.</td>
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Sp interface transporting Identity and AAA

- HSS Home Subscriber Server
- PCRF Policy and Charging Rules Function
- ANDSF Access Network Discovery and Selection Function

QoS control and Charging control is done in the EPC following the architecture of the *Policy and Charging Control (PCC)* which has been available since 3GPP Release 7.

- We use the existing Sh instead the not yet standardized Sp interface to pull or push profile information. Bearer information are missing in the Sh.

- Dynamically adapt bearer based on profile changes pushed from the HSS to the PCRF on-the-fly.

3GPP TS 23.203, Policy and charging control architecture
Mobile Traffic Offload in Mobile Broadband Networks

- Bypass the EPC for some part of the data traffic
  - Reduce the impact of the data traffic on the EPC core
  - The data traffic is separated into two classes for mobile devices:
    - Traffic which requires mobility support (state full)
    - Traffic which does not require mobility support (stateless)
  - A harmonization with TISPAN is required at least for Femto access
Interconnection EPC with Applications and Enablers

- Video Streaming Application with adaptative bit-rates
  - fast show-casing video applications over wireless
  - adaptation to the current access network of the mobile device
  - initial demonstration of applications created especially for the wireless environment

- HTTP Interceptor
  - simple Deep Packet Inspection tool
  - enables resource reservation for Over-The-Top (OTT) applications

- Open Source IMS Core (www.openimscore.org)
  - demonstration of operator services based on IMS (e.g. VoIP or media streaming) in all-IP wireless environments
  - the project’s components have been extended and fully support the integration and the inter-operability between the IMS and the EPC layers
Charging of multiple PDN-GW

- Multiple/parallel PDN-GW/PCEF support for the same IMSU/subscriber
- For scalability reasons and traffic offload
FUSECO Playground – R&D Topics

- Goal is to **cover the entire technology spectrum for communication for vertically integrated research in the area of future mobile communications**
  - From mobile device to applications

**Network Support for Future Mobile Applications**
- Mobile Cloud Computing
- Remote management of smart home environment
- M2M communication / sensor network integration
- Ambient Aware Applications / Future Internet Network Enablers

**Mobility Management**
- Harmonization of mobility layers
- Scalability of future mobile broadband networks
- Multi-access and IP flow mobility
- Traffic steering
- Optimized Access Network Discovery and Selection
- Mobile device support for mobility

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

- There is a lot of hype around LTE and its commercial deployment.
- LTE roll out will require interworking with other existing and emerging wireless access network technologies.
- The 3GPP EPC is the new mobile core network supporting seamless mobility, QoS and charging across multiple IP access networks, incl. 3GPP and non-3GPP access.
- EPC shares a lot of concepts with IMS, e.g. overlay architecture concept, HSS, PCC, etc.
- EPC maintains seamless IP connectivity and thus supports multiple application domains, including IMS and internet platforms.
- LTE provides IP services only, thus voice services, representing still the operator cash cow, are currently a potential show stopper.
- IMS provides a lot of needed capabilities in the voice domain and value added multimedia services domain (e.g. RCS, IPTV, etc).
- Early prototyping of all-IP broadband wireless environments will be crucial to gain practical experiences.
- OpenEPC toolkit from FOKUS has been designed for this purpose.
Questions ???

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Questions ???
Recent Publications


- Corici M., Magedanz T., Vingarzan D., Weik P., „Prototyping Mobile Broadband Applications with the Open Evolved Packet Core”, 2010 14th International Conference on Intelligence in Next Generation Networks (ICIN) - Weaving Applications into the Network Fabric, Berlin, Germany, to be published by IEEE, October 2010;


- Corici M., Magedanz T., Vingarzan D., „3GPP Evolved Packet Core – the Next Generation Mobile Networks all-IP architecture”, World Telecommunications Congress 2010, Vienna, Austria, to be published by VDE Verlag, August 2010;
Recent Publications II


