Fraunhofer FOKUS

NGNI
Next Generation
Network Infrastructures

OpenEPC

An Evolved Packet Core Prototype

Rel. 1 of OpenEPC Launched

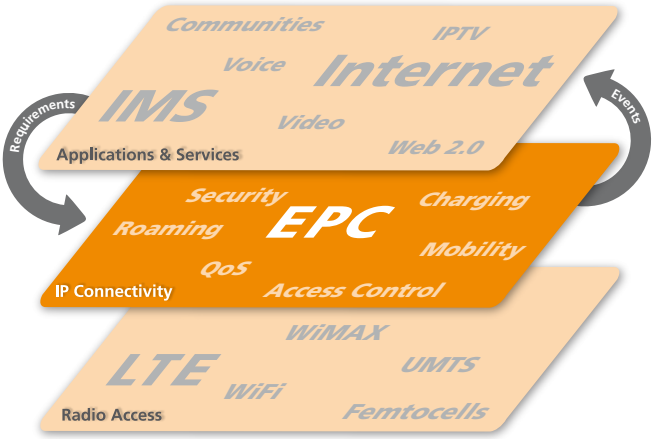
An Evolved Packet Core Prototype to Enable Testbeds

OpenEPC is a software implementation that was inspired by the innovative all-IP aspects of the 3GPP Evolved Packet Core (EPC) standards and developed by the Fraunhofer Institute FOKUS. The EPC will act as the central IP connectivity control platform of upcoming wireless broadband access technologies – including the 3GPP Long Term Evolution (LTE). It will bring about the seamless, QoS controlled connection of mobile users across the different access technologies enabling multiple application platforms such as high-bandwidth Internet applications or the IP Multimedia Subsystem (IMS) to insert rules into data traffic and receive event notifications from the access domain over standardized interfaces. EPC will be supporting the application sphere of the Future Internet tailored for the broadband mobile communication market.

With OpenEPC Rel. 1 FOKUS launched a set of software components offering advanced all-IP mobility schemes, policy-based QoS (Quality of Service) control and integration with different application platforms in converging network environments. In addition to fostering research and development, this novel toolkit enables academia and industry to rapidly realize state-of-the-art broadband wireless core network infrastructures and application testbeds for prototyping future seamless communication platforms while using standard hardware.

The Next Generation Mobile Networks

Just as the fixed telco network services evolved towards broadband all-IP Next Generation Networks (NGNs), the future of the wireless world lies in the Next Generation of Mobile Networks, as envisioned by the NGMN Alliance. The technical realization of this vision is governed by the 3GPP Evolved Packet System (EPS) specifications, formerly known as System Architecture Evolution (SAE). The EPS consists of the LTE for broadband access network technology and of EPC for the connectivity control core network operating above the LTE. EPC as the wireless control core network also enables connectivity for other access network technologies such as WiMAX, CDMA2000, WiFi or 3G networks. For this heterogeneous wireless environment it provides convergent mobility management, QoS, charging and security support and the integration of multiple application platforms.



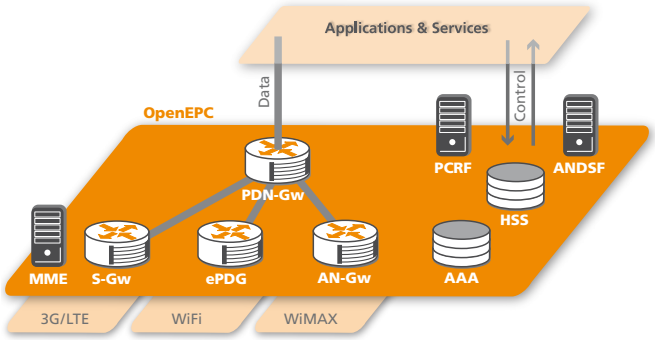
Wireless Broadband Access Networks and the Evolved Packet Core

Linking multiple wireless access network technologies to multiple application platforms requires a highly complex control platform. EPC provides this seamless, secure and resource guaranteed subscription-based wireless IP connectivity by adopting standard protocols and paradigms from the Internet world. Additionally, it provides the capabilities to push requirements to access networks from any service platform (be it IMS-based for the Session Initiation Protocol (SIP), proprietary platforms or from the plain Internet) and to receive event notifications for optimized service delivery support for a broad range of IP applications.

There will be a need for research, rapid prototyping and testing to be done in the coming years in order to enable a fast deployment of the novel all-IP technology of EPC. Fraunhofer FOKUS has already gained expertise from developing reference implementations for emerging networking infrastructures with the SIP Express Router and the Open IMS Core. The launch of OpenEPC aims to push forward the research and development of EPC concepts for the integration of new access network technologies, mobility management, resource management, security enhancements and network support for the development of future applications especially customized for the mass wireless broadband market.

The Evolved Packet Core in a Nutshell

In Release 8, 3GPP finalized the standardization of LTE. Additionally, a new all-IP core network architecture was defined as System Architecture Evolution (SAE) or Evolved Packet Core (EPC), which was then further refined in Release 9. The EPC is a novel network architecture that, based on standard IETF protocols, extends the IP communication for the wireless environment beyond a best-effort approach that eliminates the shortcomings of IP communication for the wireless environment. 3GPP's EPC defines a variety of entities with multiple functional components including subscription data entities, control entities and gateways.



The main EPC components

- The subscription data entities – the Home Subscriber Server (HSS) and the AAA Server store, update and transmit notifications on the subscription profile of the users and supply the information for the authentication and authorization of the mobile devices.

- The control entities – the Policy and Charging Rules Function (PCRF), the Mobility Management Entity (MME) and the Access Network Discovery and Selection Function (ANDSF) make policy-based decisions for the connectivity and the resources allocated for mobile devices.

- The gateways – forward the data traffic of mobile devices and ensure that the access control, gating, QoS and mobility management is enforced according to the rules provided by the control entities. The access network specific gateways (Serving GW [S-Gw], the evolved Packet Data Gateway [ePDG] and the generic Access Network Gateway [AN-Gw]) provide the interconnection with the various access network technologies. The Packet Data Network Gateway (PDN-Gw) is the anchor point for the data traffic of the mobile devices in the core network and provides the interfaces to the charging functions.

In order to provide a network layer mobility concept, EPC specifications include a large variety of IP-based protocols and their correspondent entities such as the GPRS Tunneling Protocol (GTP) and multiple Mobile IP (MIP) variants. The mobility management is enabled by the gateway components ensuring a transparent IP connection for mobile devices roaming through the wireless environment.

The QoS control is based on the 3GPP Policy and Charging Control (PCC) architecture, including the PCRF as the policy-based decision entity which communicates using the Diameter protocol with the Bearer Binding and Event Report Function (BBERF) located within the access network specific gateways and the Policy and Charging Enforcement Function (PCEF) in the PDN-Gw, ensuring as such the enforcement of QoS, gating and charging policies on the data path.
The interconnection with applications is ensured by the PDN-Gw, which breaks out the data traffic to the IP service domain. The PCRF offers a signaling interface based on Diameter which allows the various service platforms and applications to transmit their requirements for network support on the data flows exchanged with the mobile devices, permitting dynamic QoS management and also service adaptation to the wireless link conditions.

For more details on the current status of the standard development of the 3GPP Evolved Packet Core please refer to the tutorial provided on the OpenEPC web page: *www.openepc.net*

Technical Aspects of OpenEPC Rel. 1

Rel. 1 of OpenEPC is offering a self-contained environment for starting testbed setups of Evolved Packet Core systems. The testbeds then enable developers to prototype, measure, monitor or test and to simply perform research and development for future mobile applications and for optimizing the core network functionality for broadband mobile networks.

OpenEPC Rel. 1 includes the main functionality for handling all-IP wireless core network communication as much as possible and is inspired by the innovative parts of Release 9 of the 3GPP EPC standards. However, please note that within the limited testbed prototyping scope and with the EPC concepts being relatively new and developing quite dynamically within standardization, the OpenEPC Rel. 1 does not claim full support of the relevant specifications.

The software modules of OpenEPC are based on a highly modular core structure named Wharf (as a synonym for dock). Wharf is a new framework developed at Fraunhofer FOKUS and provides a flexible and powerful prototyping platform for NGN components. The framework recruits its software architecture from a very successful project, which was also launched at Fraunhofer FOKUS – the SIP Express Router. However, instead of targeting a single individual protocol stack, Wharf offers a convenient, C-based framework and a modular approach towards supporting multiple protocols and applications.
OpenEPC Release 1 supports setups within IPv4 and IPv6 environments and its components can be categorized into four main feature sets and some additional demonstration enablers.

Core Network Mobility Management

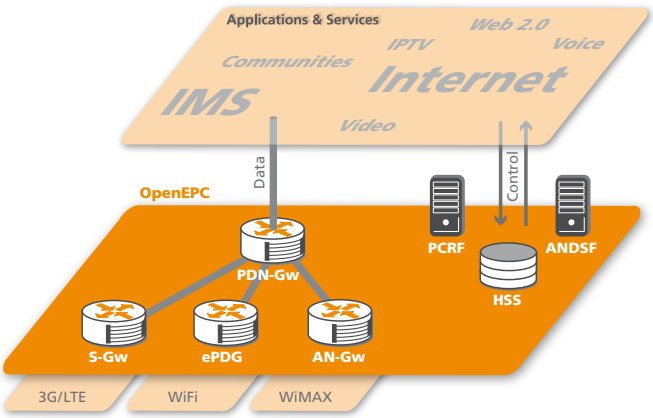
A Proxy Mobile IP (PMIP) implementation on the gateways, together with attachment procedures using DHCP, provide a convenient mechanism for rapid showcasing of transparent IP connectivity and vertical handovers with standard client platforms.

Policy and Charging Control (PCC)

OpenEPC implements all the PCC components and a major set of its functionality, focusing in Rel. 1 on the policy-based QoS mechanisms. PCC enables policy-based connectivity and QoS control as well as notifications on events from the network level to the application layer. Rel. 1 offers a Policy and Charging Rules Function (PCRF), Policy and Charging Enforcement Function (PCEF), Bearer Binding and Event Reporting Function (BBERF) and a Subscription Profile Repository (SPR) and supports the Rx, Gx, Gxx and Sp reference points. The focus of PCC for Rel. 1 is on QoS related features and it is deferring charging functionality to a coming release. The PCC system is also bundled with enablers like an Rx Client, practical usage examples and integration with the core network mobility enablers.

Subscription Management

OpenEPC enables customization of policy decisions for client mobility support and PCC through its own subscription management implementation. Rel. 1 provides an extended Home Subscriber Server (HSS) with features from the Subscription Profile Repository (SPR) and will also work for upcoming releases on AAA-server prototypes. Similar to the HSS from the Open Source IMS Core project for functionality and data structures, but written in C and performance optimized, the HSS of OpenEPC adds support for the data structure and reference points required in EPC.



The OpenEPC Rel. 1 Components

Developing with the Help of OpenEPC – Hands on Experience for Prototyping Future Seamless Applications

Client Mobility Support

OpenEPC supports policy-based access network discovery and selection of mobile devices as well as access network selection assisted by the operator network.

Rel. 1 features Access Network Discovery and Selection Function (ANDSF), a client Mobility Manager (MM) for Linux and other operating systems, and a supporting mobility manager GUI. The ANDSF features built-in policy engines and has support for both access network discovery information and inter-system mobility policies, such that new Always Best Connected (ABC) concepts can be prototyped and trialled.

The Client Mobility Manager provides the abstraction layer on the client devices, such that the EPC hand-over mechanisms and policies can be showcased independently. It exports an open API, illustrated by an open source mobility manager GUI, which shall provide the integration point with 3rd party mobile frameworks and applications.

EPC Demonstration Enablers

For demonstration purposes, OpenEPC provides demonstration enablers like a HTTP interceptor with the Rx interface support for access network requirement and event handling as well as an extended Proxy Call Session Control Function that performs resource reservation and service authorization for IMS applications and services. OpenEPC Rel. 1 targets the provision of a comprehensive setup which can be showcased out of the box. Therefore additional components, scripts and extensions are provided together with the software.

For the latest details on Rel. 1 features of the OpenEPC and on the most recent new features implemented please refer to the OpenEPC web page: *www.openepc.net*

Open EPC Demonstration Scenarios

Rel. 1 of OpenEPC enables rapid deployment of testbeds and demonstrations. The following demonstration scenarios outline various aspects of the setup:

Transparent core network mobility in heterogeneous wireless environment: OpenEPC provides the means to seamlessly hand over the active sessions of a mobile device between the different access networks. The effect of vertical handovers can be showcased separately or together with the ABC scenario using the OpenEPC applications: real-time applications including video streaming as an IMS service, as a plain SIP service or as Internet service (through the web browser).

ABC (Always Best Connected) – Access Network Discovery and Selection: OpenEPC provides the means for access network discovery and selection either through the assistance of the operator or directly from the mobile device. A mobile device is receiving information on the momentary preference of the operator depending on its location and on the subscription profile. This enables an automatic discovery and selection of the best-suited access network to support the communication.

Open EPC's Use for Research and Development

OpenEPC enables a quick start for prototyping applications for emerging all-IP broadband mobile networks with the EPC architecture. The software offers:

Easy development: OpenEPC is implemented in alignment with the standards of 3GPP Rel. 9 and is available for licensing with its entire source code. All developed components were inspired by the current standards with optimizations for operation in all-IP environments.

Configurability: OpenEPC can be provided, deployed and configured to match the needs for testing only some components or use cases. As an example, all interfaces are both IPv4 and IPv6 ready and can be provisioned as required.

Extensibility: adding new functionality features to the components, whether new mobility schemes or QoS protocols or something else, is easy due to the modular architecture provided by OpenEPC's Wharf.

Licensing of OpenEPC and the Support Options

OpenEPC is available under a paid licensing model for object but foremost also for source code copies. You can contact us via email to request a license for using a complete OpenEPC testbed or just selected individual components for research and development purposes. The exact licensing terms for the OpenEPC Rel. 1 software can be found on the project website.
Best-effort support for using the software is offered with each license and additional technical support bundles are available upon request. Additional features, components or extensions of reference points can be developed under the umbrella of defined R&D projects with Fraunhofer FOKUS. We are also offering to provide on-site coaching, local deployment and integration activities & support.

Releases and Roadmap

April 2010: Rel. 1 of OpenEPC launched with support for mobility management and roaming configuration support and support for subscription management and policy control.
November 2010: Rel. 2 with an update of OpenEPC features and extensions.

Rel. 1 is just the beginning of the OpenEPC project. An aggressive roadmap was put in place which targets major releases every 6 months with new feature previews every 3 months. Upon customer request, currently missing functionality of Rel. 1 can be added in a prioritized manner, including mobility management for 3GPP access networks, other mobility protocols (e.g. GTP, DSMIP, FACoA MIP), advanced PCC mechanisms and support for novel wireless adapted services.

For additional information on features, demonstration scenarios and detailed information on the OpenEPC components and modules visit *www.openepc.net* or send us your questions or licensing requests to *info@openepc.net*.

Research Institutions & Universities

can use OpenEPC for practical mobile broadband networks research. They get discounts for using OpenEPC as a black box for application prototyping, or for using the source code to extend individual or multiple EPC components and/or for developing new EPC functionality and protocols to provide new capabilities for integrating new networks or enabling new applications.

R&D departments of network operators

can use OpenEPC to prepare for the upcoming all-IP NGN and mobile broadband world using an open and vendor independent testbed infrastructure.

Manufacturers

of individual EPC components or EPC platforms can use OpenEPC to test their products in concert with a standards-aligned mobile broadband network environment.

Application developers of future mobile applications

can use OpenEPC to certify that their applications work in Mobile Broadband Environments and take advantage of the functional capabilities offered by EPC to the applications domains.

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Fraunhofer FOKUS

Kontakt

OpenEPC
info@openepc.net
www.openepc.net

FOKUS
Fraunhofer Institute for
Open Communication Systems
Kaiserin-Augusta-Allee 31
10589 Berlin
+ 49 30 3463 7000
www.fokus.fraunhofer.de

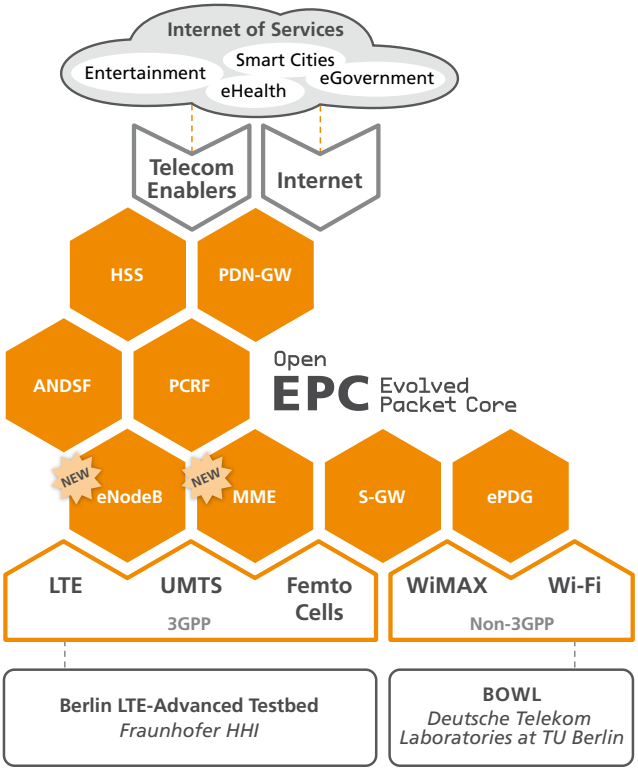
Acronyms

3GPP:	3rd Generation Partnership Project
ANDSF:	Access Network Discovery and Selection Function
BBERF:	Binding and Event Reporting Function
DSMIP:	Dual Stack Mobile IP
EPC:	Evolved Packet Core
EPS:	Evolved Packet System
FACoA:	Foreign Agent Care of Address
GPRS:	General Packet Radio Service
GTP:	GPRS Tunnelling Protocol
HSS:	Home Subscriber Server
IETF:	Internet Engineering Task Force
IMS:	IP Multimedia Subsystem
LTE:	Long Term Evolution
MIP:	Mobile IP
MME:	Mobility Management Entity
NGMN:	Next Generation Mobile Networks
NGN:	Next Generation Networks
PCC:	Policy and Charging Control
PCEF:	Policy and Charging Enforcement Function
PCRF:	Policy and Charging Rules Function
PMIP:	Proxy Mobile IP
SAE:	System Architecture Evolution
SIP:	Session Initiation Protocol
UMTS:	Universal Mobile Telecommunications System

Rel. 2 of OpenEPC Preview

Rich, Customizable Vendor Independent EPC Software Toolkit

Based on the overwhelming demand, the OpenEPC toolkit enters the next stage of evolution – Rel. 2. Including all features, functions and protocol stacks from the previous version, OpenEPC Rel. 2 adds many functional components, interfaces and features. The 3GPP Release 9 was the major guideline when designing the new OpenEPC release. The main highlight is the introduction of LTE specific access network elements (eNodeB, MME, corresponding interfaces and protocols, additional extensions to S-GW and HSS/HLR).



New Components: MME and eNodeB

As one of the key components for LTE support, the **Mobility Management Entity** (MME) is in charge of all the Control plane functions related to subscriber and session management. The MME features end-user authentication security procedures as well as terminal-to-network session handling.

The prototype **evolved NodeB** (eNodeB) includes all network side functions, MME selection and forwarding of data between the wireless device and the core network. Interfaces to mobile terminal are simulated, with which standard wireless can be used in place of the LTE radio part for cost efficient LTE prototyping.

New Protocols and Interfaces

OpenEPC supports many new interfaces and protocols, which are **GTP-C**, **GTP-U**, **S1AP**, **S1-U**, **S1-C**, **S11**, **S6a** and **S6d**. These interfaces and protocols integrate the new components into the existing EPC network. The main focus is here on the separation of control and user interfaces, as well as on the option to deploy MME and SGW in separate instances for better development and testbed design.

New Features

The OpenEPC Rel.2 includes many new features, as an improved provisioning and debugging mechanism, zero-packet-loss handovers (truly seamless), lower latency attachments and IP-flows live monitoring. All features are aiming at a professional testbed setup and on running procedures.

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Kontakt

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FOKUS
Fraunhofer Institute for
Open Communication Systems
Kaiserin-Augusta-Allee 31
10589 Berlin
+ 49 30 3463 7000
www.fokus.fraunhofer.de