core net dynamics

Build your own Professional Networks

Fraunhofer FOKUS

Forgetting about legacy

- supporting 2G/3G/LTE voice on a single NGN platform -

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Future SEamless COmmunication Playground

Test-bed Toolkits for the Academia and the Industry

Fraunhofer FOKUS

- **Comprehensive test-bed prototypes – one-stop shop, growing, modular, flexible, integrating with 3rd parties**

- Targeted at test-beds and technology trials
- Driven by your demand

- Implementing **90% of the standards with 10% efforts**
  - All the required security mechanisms, but unsecure for real-life deployments
  - Functionality wins over stability
  - No high-availability
  - Basic provisioning but not proper management
  - Decent performance, without deep acceleration

This is not a “proper” car either, but it beats the Ferrari

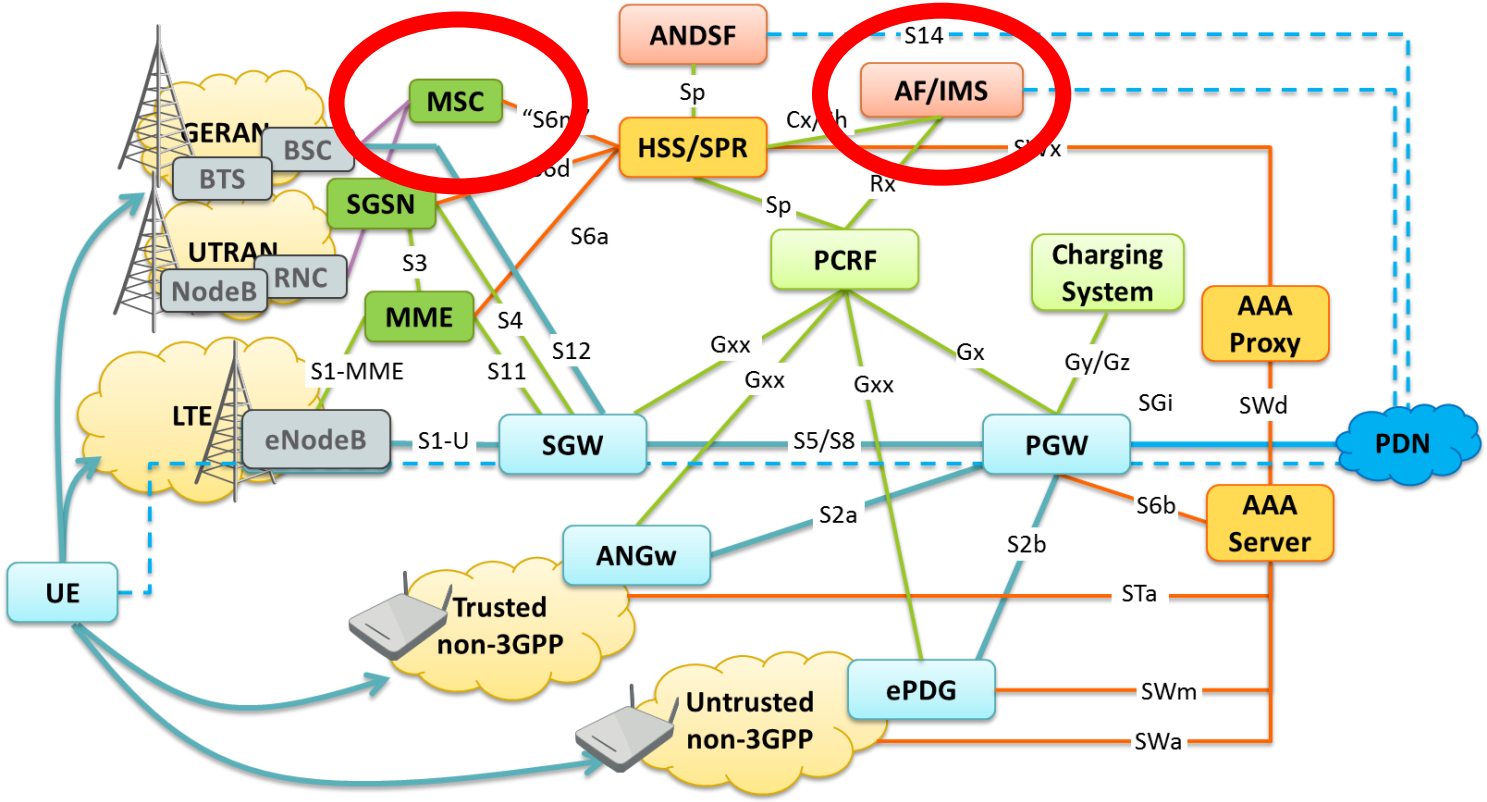
- **No 100% compliance claimed** (mostly for legal reasons, as in no product-like warranties)
  - Yet doing very well on interoperability
  - Always going for the latest concepts (think 3GPP Rel. 11/12, IETF drafts, crazy new ideas to make-it-work)

- But nothing wrong with not-a-product
  - It takes just days to get a new concept working
  - Sometimes it’s actually faster and better

- If it’s not enough, we have a spin-off company to take care of OpenEPC outside test-beds

The 3GPP Evolved Packet Core in a Nutshell

- The Mobile Core Network for 4G/LTE, but also supporting 2G, 3G, WiFi, etc
- An overlay for the mobile Radio Access Networks providing all-IP connectivity



What is FOKUS/CND OpenEPC Platform?

- R&D project started around **2008**
- NON-OPEN SOURCE
  - sorry, but with 15+ functional elements, the cost of development was much higher than for the 4 elements of the OpenSourceIMSCore

- Fraunhofer **FOKUS developed OpenEPC until 2013**
  - world-first Inter-System Mobility platform for **ANDSF**, with seamless vertical hand-overs
  - **IMS** integrations from day-one
  - works with **2G/3G/4G** off-the-shelf Base Stations
  - as well as with non-3GPP cost-effective **WiFi**
  - including Policy and Charging Control, AAA, etc

- **40+ Licensees** (major operators, universities, vendors, etc)

- **CND has taken over development since 2013**
  - targeting carrier-grade performance & features

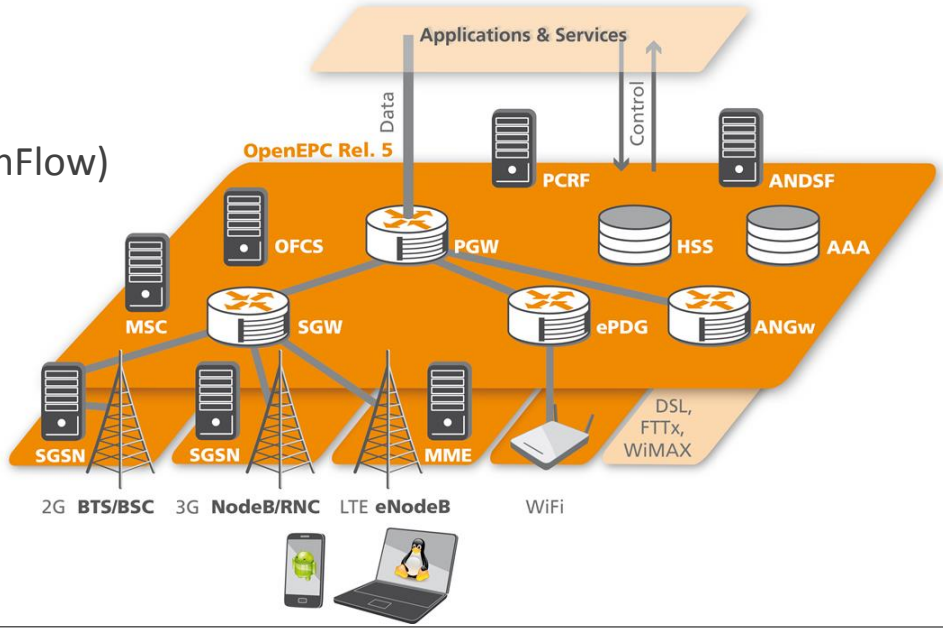
OpenEPC Rel. 5: Mirroring the Future Operator Core Network

- Includes almost all the elements in 3GPP Release 8→12 architecture
  - From PGW down to MME and SGSN, even including NodeB/eNodeB emulations

- **Open**: aligned to the standards, all functional elements, all protocols and open on all interfaces

- Using standard tools and hardware
  - Linux + x86 would do, others also possible
  - NFV, SDN concepts built right in (e.g. OpenFlow)

- Works with standard cells, phones, modems, SIM cards, etc

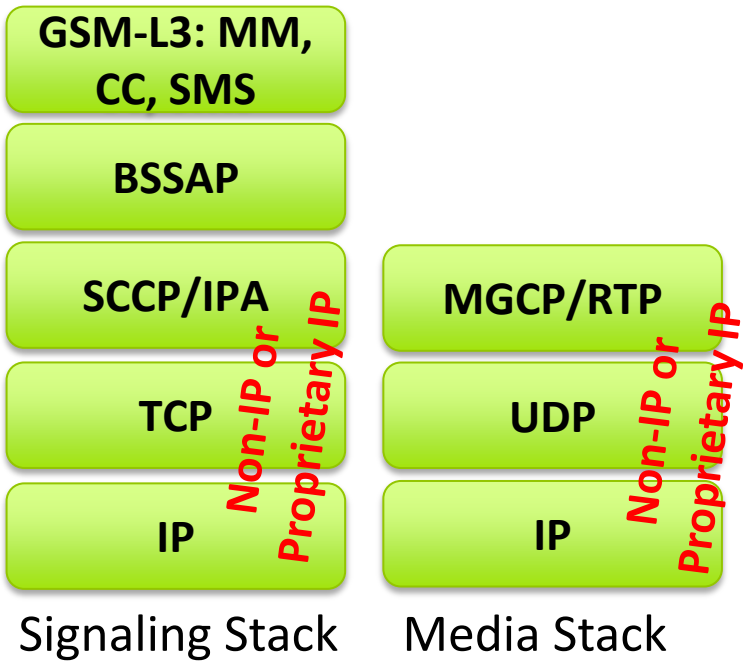


PLEASE NOTE: OpenEPC does not claim 100% standard compliance, but allows for early prototyping

2G Mobile Radio Interface Signalling/Media Stack

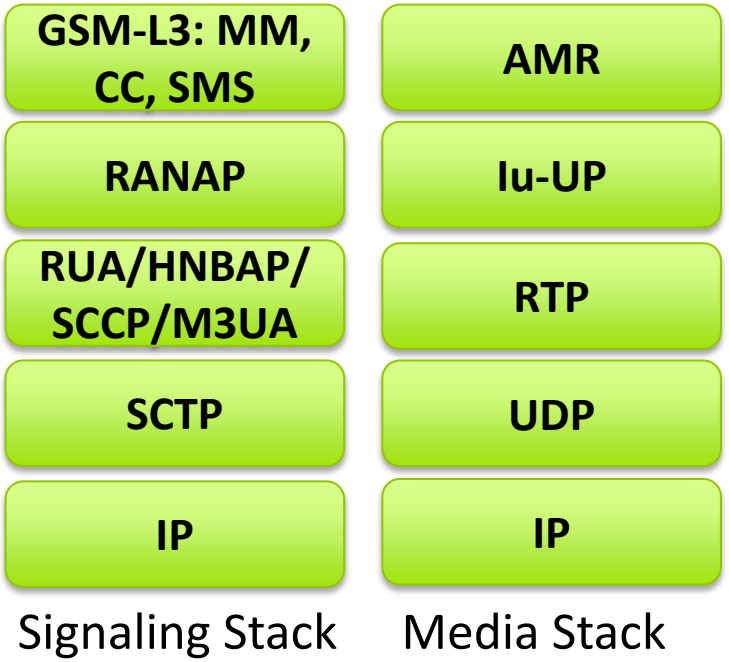
- Signaling Protocols
  - GSM-Layer 3 (aka DTAP): 3GPP TS 24.008
    - Mobility Management
    - Call Control
    - SMS
  - Base Station System Application Part: 3GPP TS 48.008
  - Signaling Connection Control Part: ITU-T Q.714
  - And/or other proprietary protocols

- Media Protocols (Non-IP or proprietary/custom over IP)
  - Media Gateway Control Protocol: RFC 3435
  - Real-Time Transport Protocol: RFC 3550

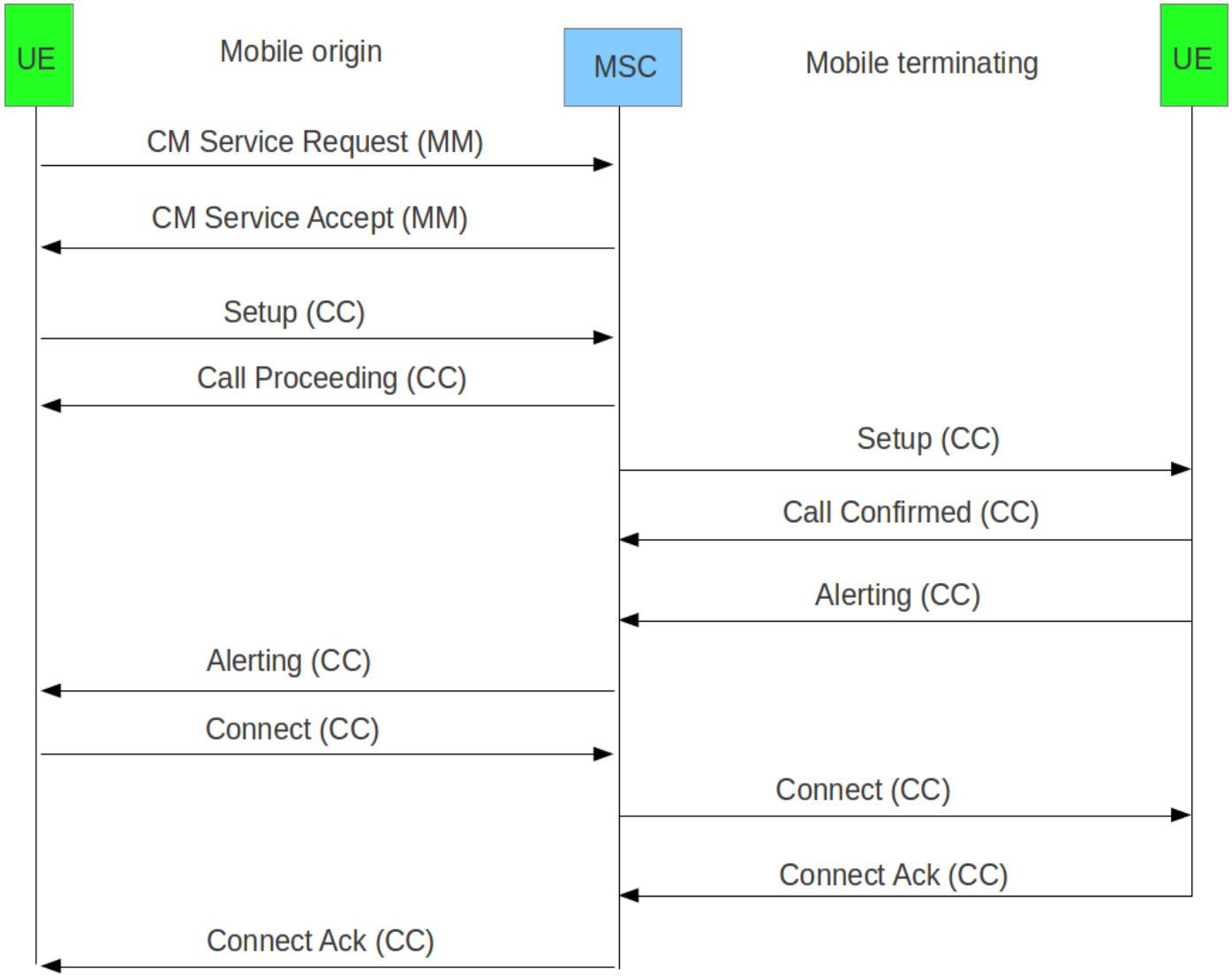


3G Mobile Radio Interface Signalling/Media Stack

- Signaling Protocols
  - GSM-Layer 3 (aka DTAP): 3GPP TS 24.008
    - Mobility Management
    - Call Control
    - SMS
  - Radio Access Network Application Part: 3GPP TS 25.413
  - RANAP User Adaptation / Home NodeB Application Part: 3GPP TS 25.468, TS 25.469
  - Signaling Connection Control Part: ITU-T Q.714
  - Stream Control Transmission Protocol: RFC 4960
- Media Protocols
  - Adaptive Multi-Rate Codec: 3GPP TS 26.104
  - Iu U-Plane: 3GPP TS 25.415
  - Real-Time Transport Protocol: RFC 3550



2G/3G Mobile Radio Interface Signaling – CS Calls



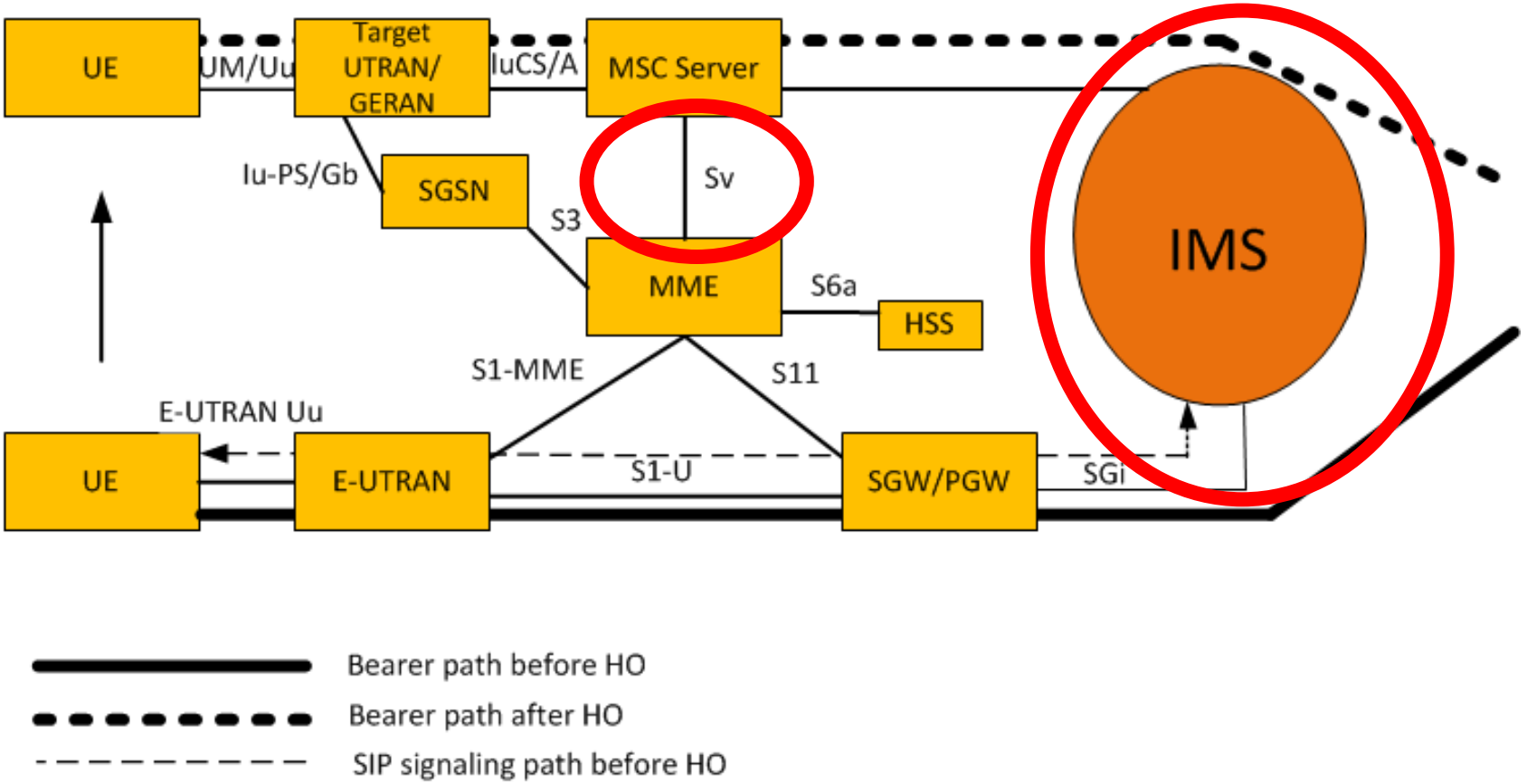
Telephony in LTE Networks – PS Calls – the Options

- **No CS-service in LTE**: There were some efforts to transport GSM-L3 over IP, but in practice too complex to maintain legacy.
- **CSFB (Circuit Switched Fallback):** LTE is only providing data services. When a call is initiated the UE is falling back to circuit switched networks (2G/3G). This procedure leads to longer delays for call setup and loss of broadband data capabilities while in call.
- **SVLTE (Simultaneous Voice and LTE):** The UE is connected to 4G and a 2G/3G network. Disadvantage of this solution is a high power consumption of the UE, doubled signaling in the core, etc.
- **VoLTE (Voice Over LTE):** is based on the **IP Multimedia Subsystem (IMS)** network, with specific profiles for control and media planes of voice service on LTE. IMS delivers voice calls as data flows over LTE data bearer in 4G Networks. IMS is not supporting Circuit Switch voice calls, but can interoperate.

But… mind the gap…

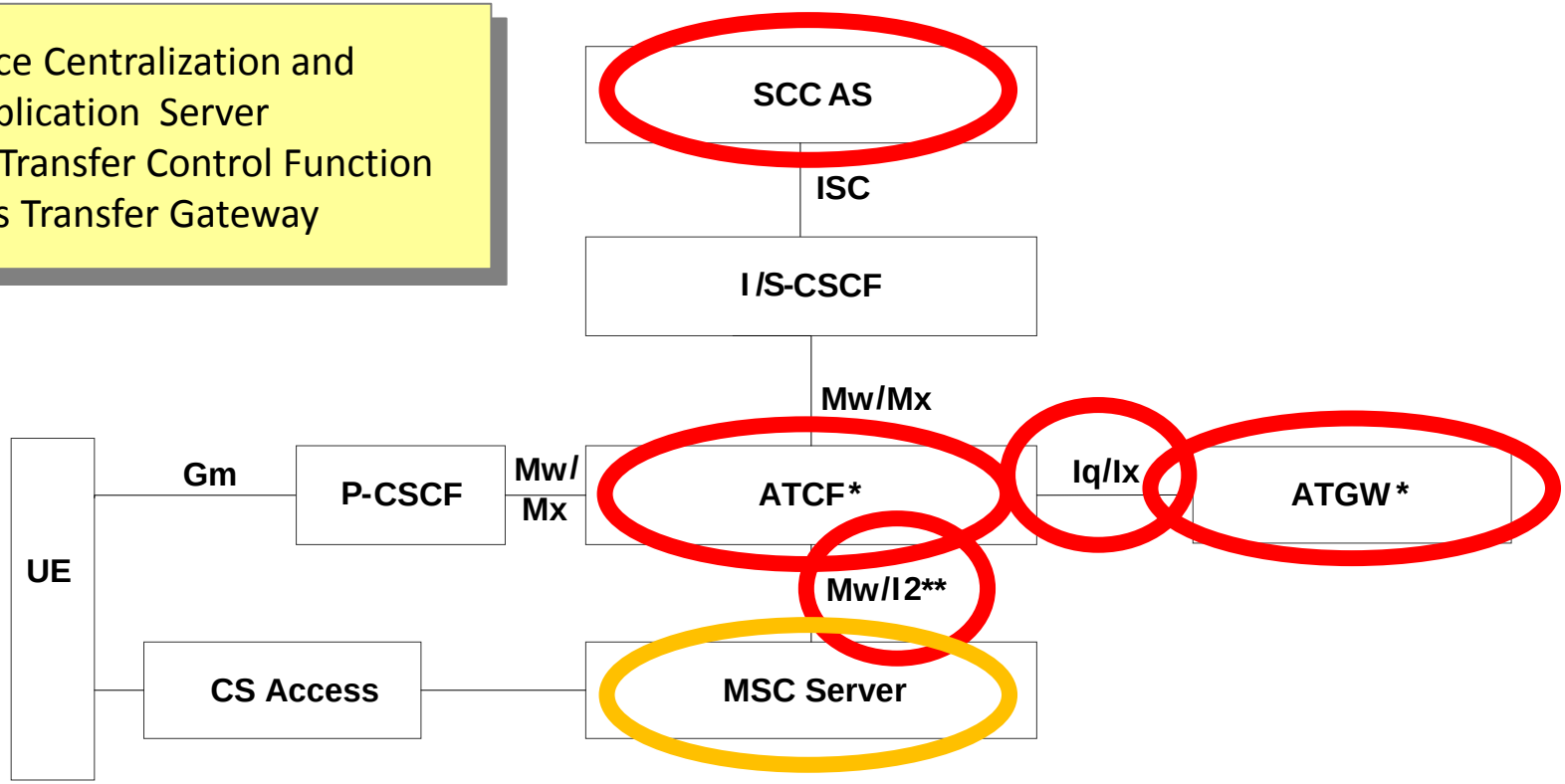
- Just a very small percentage of current LTE networks actually use VoLTE
  - Most use CSFB
- IMS is a small part of the problem, but we know already how to do that
  - E.g. Already deployed heavily in the fixed network
- **Big(ger) Issue: Voice Call Continuity**
  - Because it is not enough to provide VoLTE
  - Eventually you run in/out of LTE connectivity – yet you need a seamless experience
- **"Big" Solution: Single-Radio-VCC**
  - Quite complex
  - Requires MSC upgrades – very old equipment by today's standard; you're a bit lucky if you have IP interfaces
  - Requires MSC – IMS interfacing
  - Requires MSC – MME/SGSN cooperation during hand-overs (think upgrading 2G gear as you roll-out LTE)
  - Did I mention MSC is already the old thing we were supposed to replace with NGN/IMS?
  - Yet we can't still get rid of it…

SRVCC – Voice over LTE PS or 2G/3G CS (TS 23.216)



PS Voice Channel (TS 23.237)

SCC AS : Service Centralization and Continuity Application Server
ATCF : Access Transfer Control Function
ATGW : Access Transfer Gateway



*: Location of functionality depends on deployment and collocation scenario

**: Reference point dependent on MSC Server capability

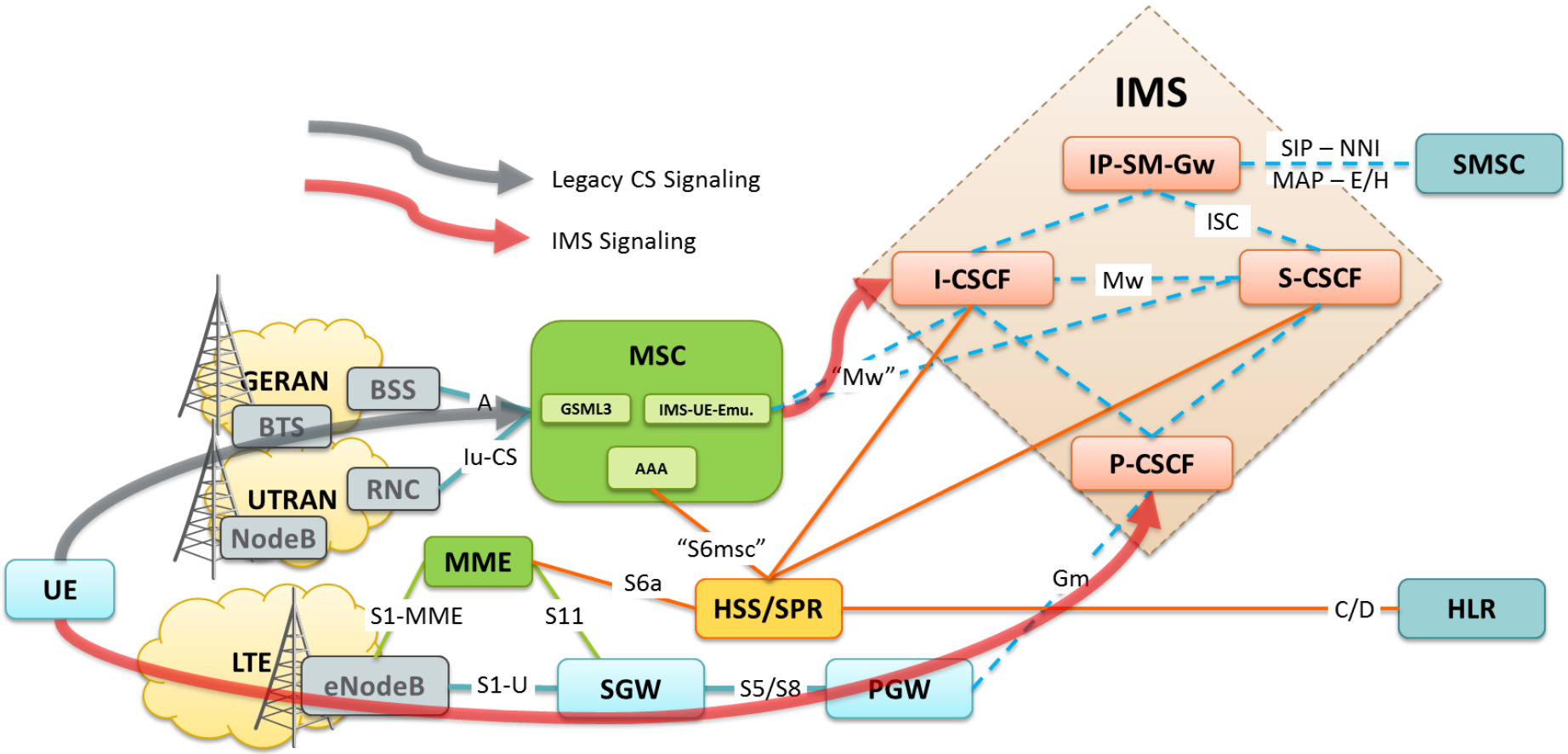
Crazy Idea from R&D

- Drop All Legacy!
  - Drop MSC as we know it, drop all the CS-Voice-Core-Network!
  - Forget about SRVCC! It is too complex!
  - Concentrate on One-Voice-Core-Network
    - (IMS? Or just SIP would do too)
- VoLTE/VoWiFi is done
- 2G/3G Terminals
  - Remember GSM-L3/Call-Control? Only this is needed to signal with the Mobile Terminals
  - **Introduce a new MSC**
  - Instead of SS7/INAP/MAP, we will directly translated GSM-L3 CC to SIP/Diameter
  - Each 2G/3G phone will have a virtual IMS UE registered while connected to the network, emulated by the MSC

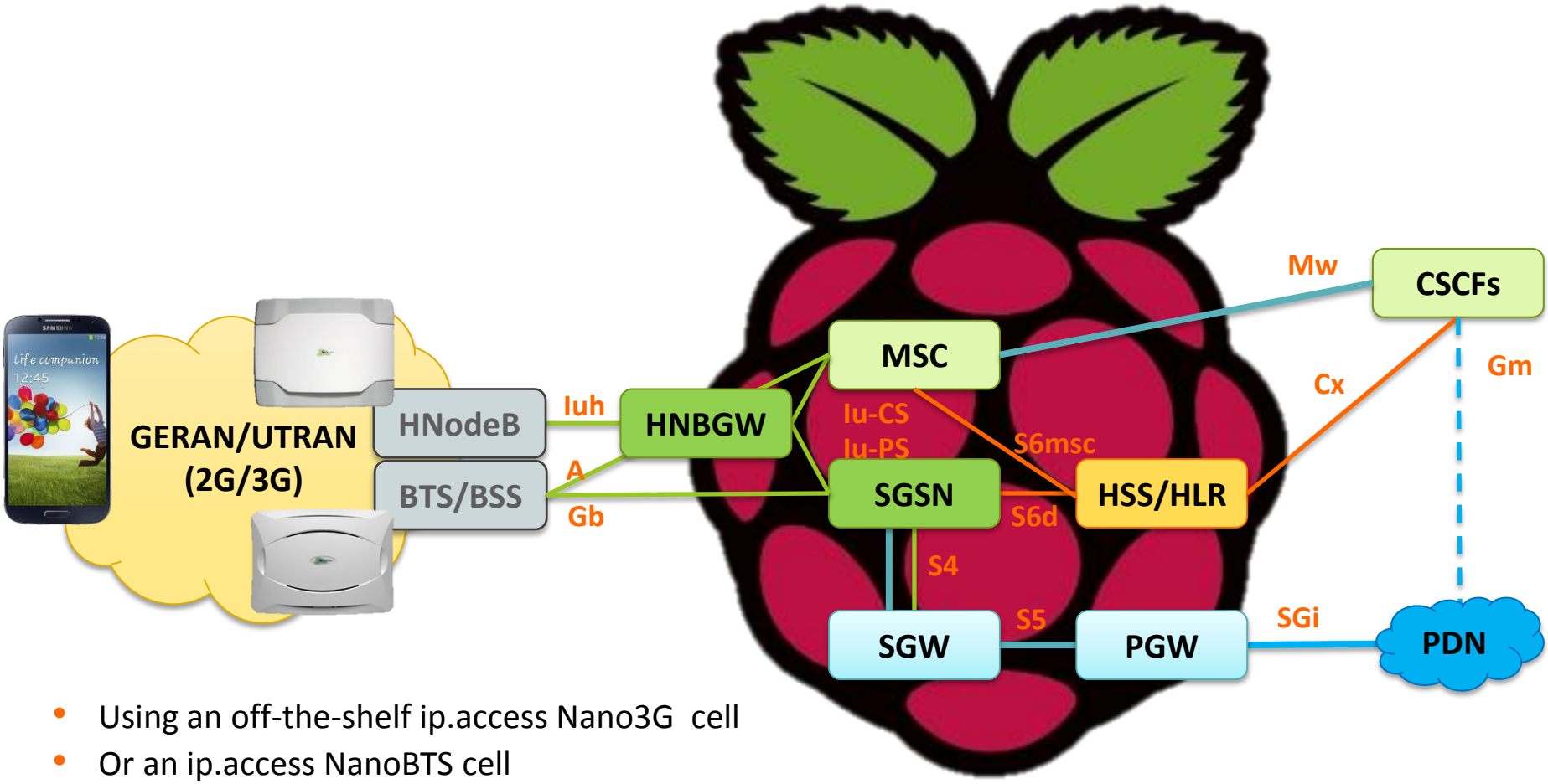
MSC-for-IP-Services

- Advantages
  - One-Voice-Core-Network!
  - Common provisioning/services/management/etc
  - More space in your data center ;-)
  - Simplified architecture
  - Keeping legacy to a minimum and isolated in the RAN
  - Multi-Access Ready – can easily select radio interface in case more than one available
  - SMS is trivial
  - Existing interfaces for MME/SGSN can be easily extended for this new MSC
  - VCC = Handovers → no need for new nodes, interfaces, etc
- Supplementary Services – no IN/CAMEL/etc – to be provided instead by MMTel/RCS/ICS/etc
- Risks
  - Unfortunately quite a bit of change for in-exploitation networks
  - Hopefully can be introduced gradually with session-aware load-balancers for the A/Iu-CS interfaces
  - BSS/RNC interfacing for media is not always standard and/or IP-based
  - Interfacing with SMSC, HLR might still be required – or proxy though through IMS-AS/HSS

Support for Legacy CS-services



Now for a simple demonstrator



- Using an off-the-shelf ip.access Nano3G cell
- Or an ip.access NanoBTS cell
- Low cost hardware and low power (ARMv7 here)
- Of course, works best on multi-cores, x86, etc
- CS and PS services

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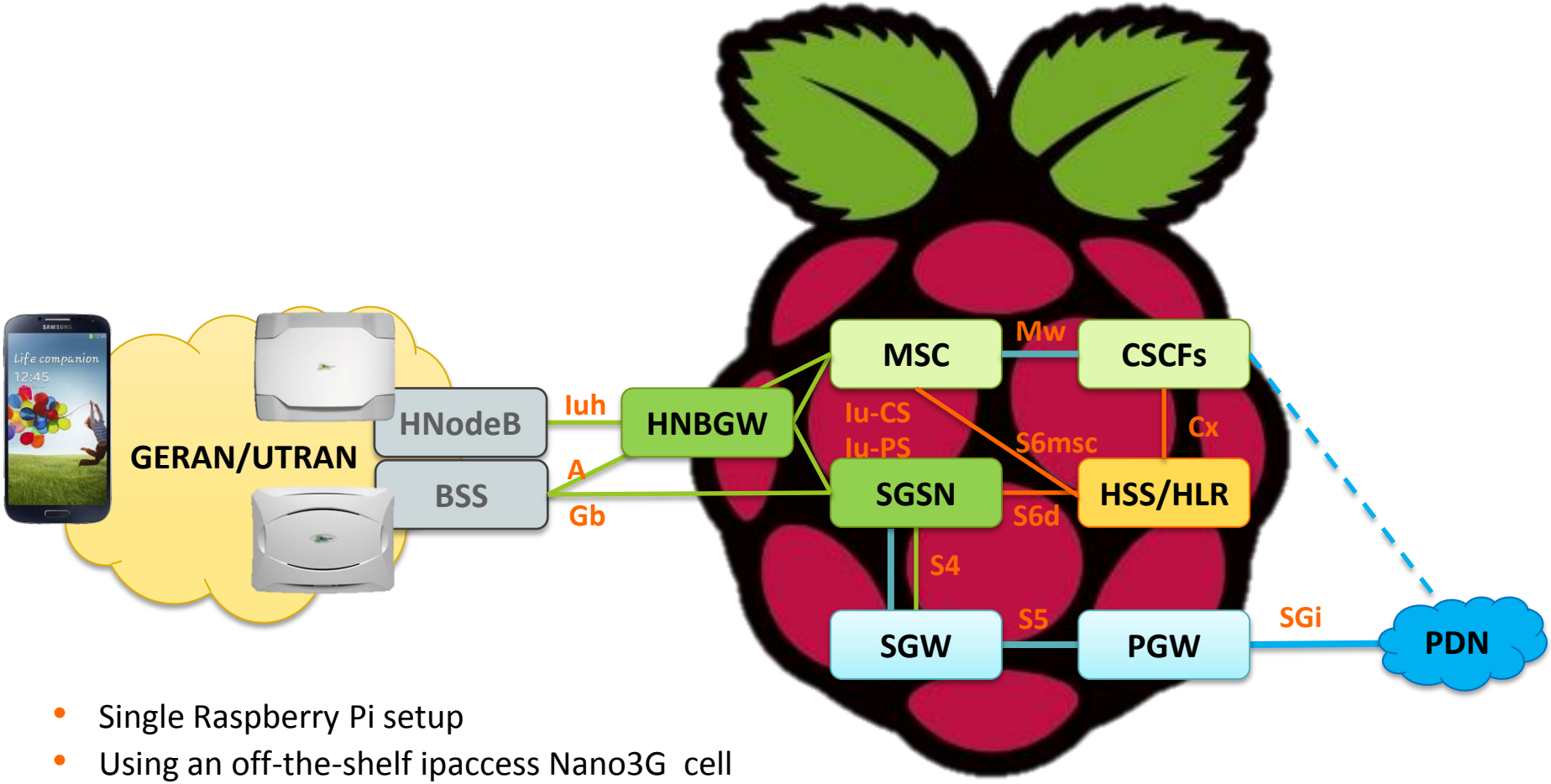
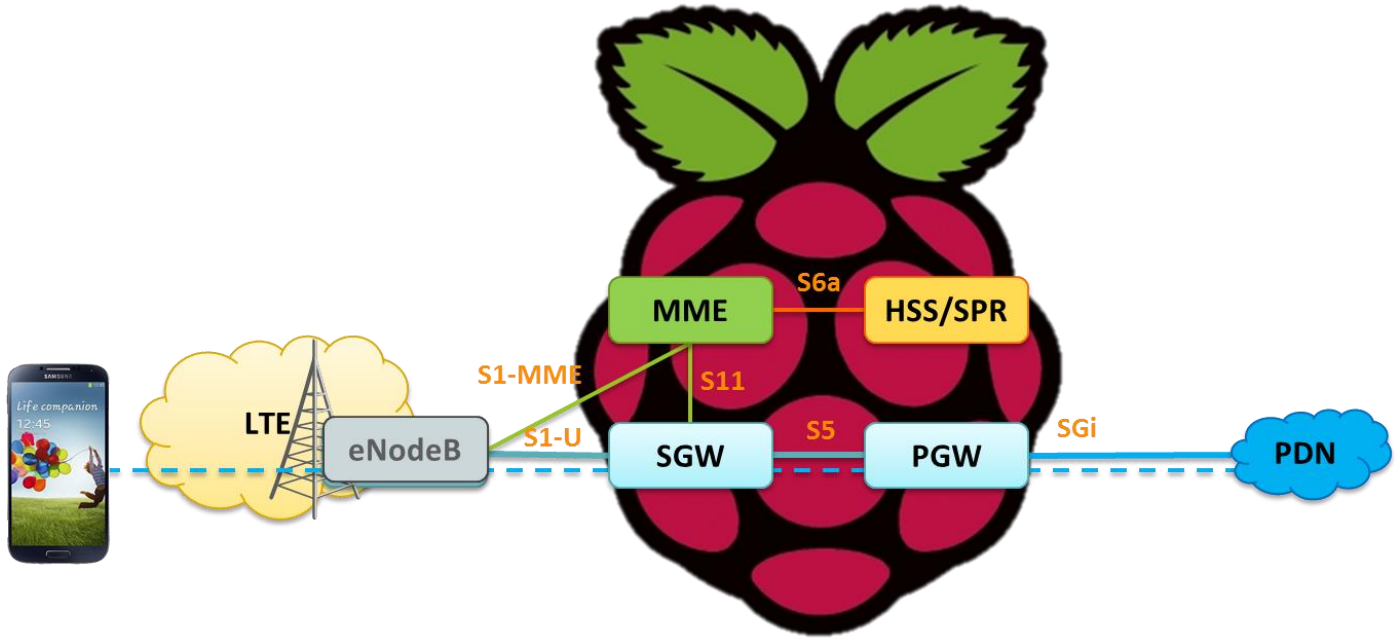


- Single Raspberry Pi setup
- Using an off-the-shelf ipaccess Nano3G cell
- Low cost hardware and low power (ARMv7 here)
- Of course, works best on multi-cores, x86, etc
- CS and PS services

OpenEPC Rel.5 Demos

From Raspberry Pi to the Cloud



- Single Raspberry Pi setup for complete LTE connectivity break-out; using for example an off-the-shelf femto-cell
- Many other options feasible
  - complete CS/PS Voice/SMS solution for 2G/3G/LTE with IMS
- Low cost hardware and low power (ARMv7 here)

- No purpose in itself, but demonstrates feasibility of:
  - Complete Core Network co-location in the Base Station
  - Self-sufficient emergency systems in the Base Stations
  - 2G/3G Base Station adaptations to single-core-network (no need to keep investing in legacy core network capacity)

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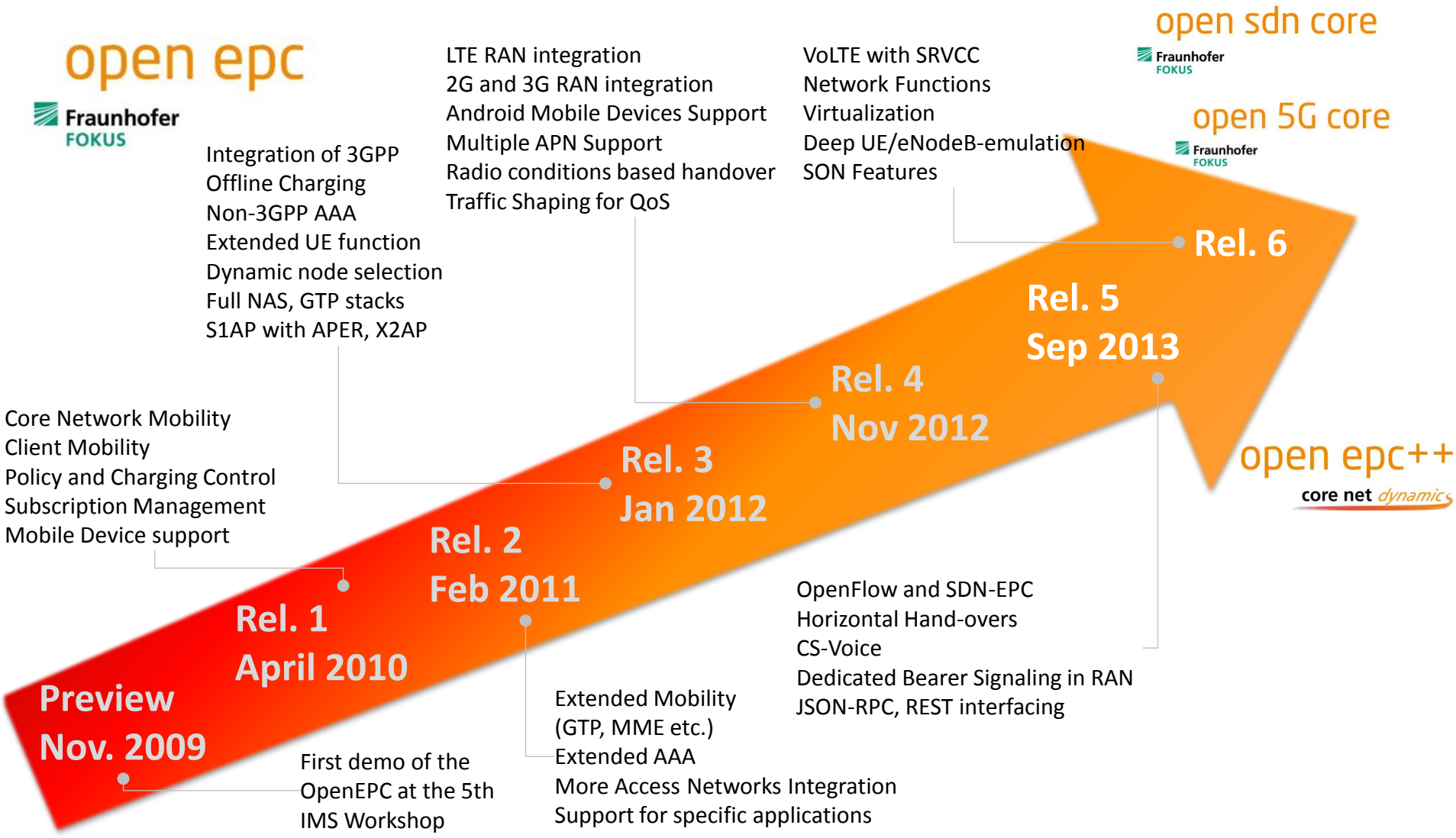
OpenEPC R&D Roadmap

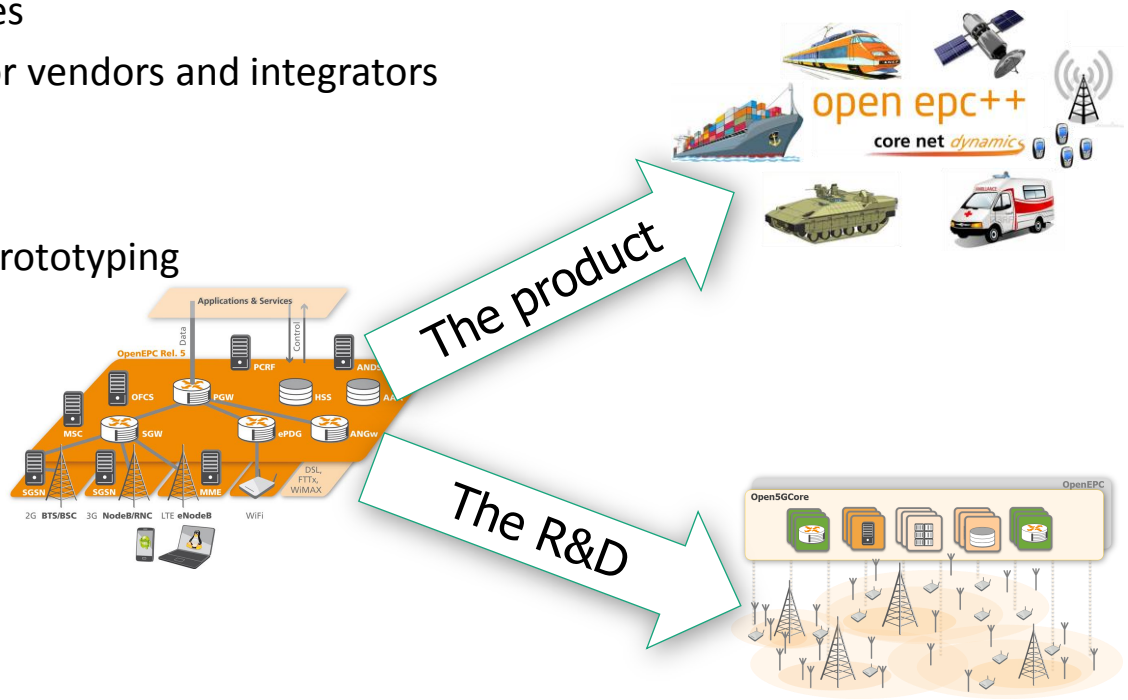


Core Network Dynamics

The OpenEPC Productization Path

- Providing Core Network technologies based on Fraunhofer FOKUS OpenEPC
  - Customized, standard aligned core platforms for Professional Mobile Radio
  - Network-in-a-box for highly specialized applications
  - EPCaaS for specialized services
  - Technology provider for major vendors and integrators

- Main values:
  - Agile development and fast prototyping
  - Comprehensive functionality
  - Future proof approach
  - Highly customizable
  - Performance and scalability
  - No hardware locking
  - Flexible roadmap



OpenSDNCore

The OpenEPC Future R&D Path

- OpenSDNCore is a practical implementation of a future core network based on the latest network evolution paradigms:
  - Software Defined Networks (SDN)
    - Separation of control and data plane
    - Flexible forwarding mechanisms
    - Aggregated control plane
  - Network Functions Virtualization (NFV)
    - Self-orchestration of network components
    - Network topology awareness
- 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
- Integrates well with OpenEPC and OpenSourceIMSCore
- OpenSDNCore is a non-open source, standards inspired toolkit designed for adaptable deployments

open sdn core

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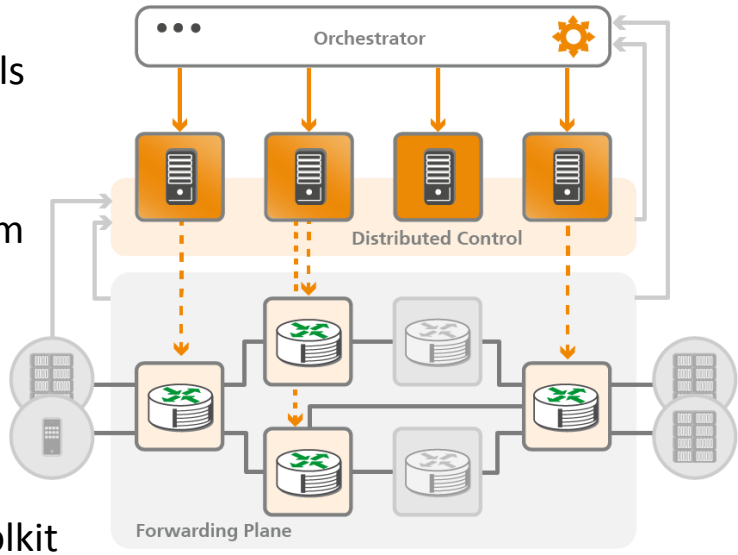
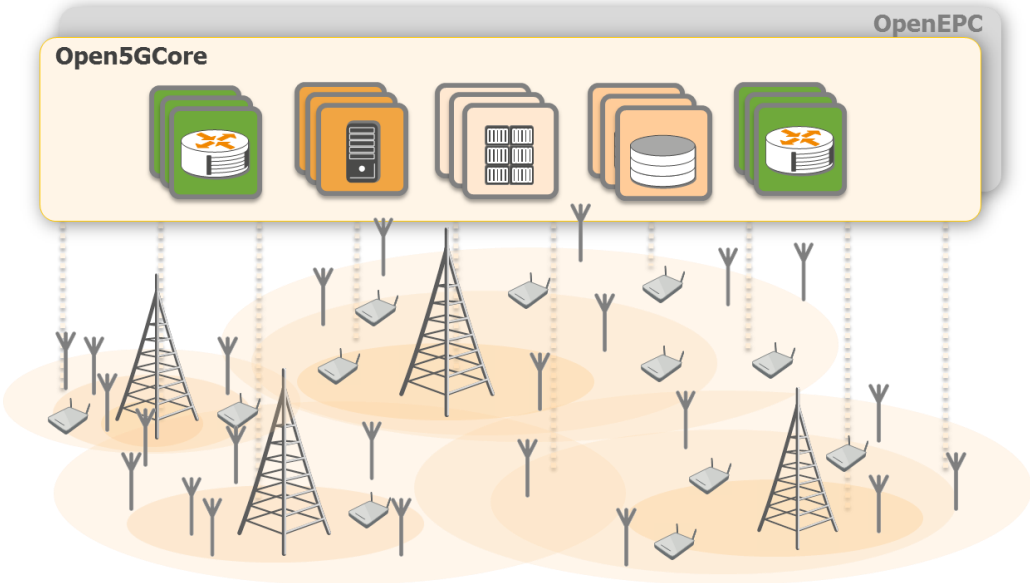


Open5GCore (a.k.a. OpenEPC Rel.6 for R&D)

The testbed platform one step ahead of anybody else

- Open5GCore aims at a pre-standard operator core network test-beds beyond 3GPP EPC including long term innovative features such as:
  - Dynamic self-adaptable spectrum management mechanisms
  - Ultra-low delay, 100x Gbps data plane realization – transport network based on own cost efficient programmable switches
  - Advanced access selection/offloading mechanisms – dynamic carrier aggregation and flow based routing over heterogeneous access networks
  - Signaling over radio networks (NAS, PDCP, RRC, RLC evolution)
  - Highly distributed mobile control plane – scalability and delay



- Open5GCore Rel. 1 will be available from April/May 2014
  - Replaces OpenEPC Rel. 6 R&D
  - Novel features are already available

OpenEPC Rel.5 in Quick Numbers (as of Nov. 2013)

- 10800 revisions
  - And this is just the internal development tree
  - 35+ external/project-specific development trees
- 8.5 commits / week-day (again just internal tree)
- Wharf source code statistics (our platform)
  - 219 Mbytes
  - 5700+ files
  - 600K lines of C code
  - 78K lines of comments
  - 90K lines of PHP (GUI and provisioning)

OpenEPC

Releases and Roadmap – Technical Overview