Open 5G Platform

Dr. SHEN Fei

Shanghai Research Center for Wireless Communications
Key Lab of Wireless Sensor Network and Communication
SIMIT, Chinese Academy of Sciences
Outline

• Latest news from industry
• **Approach:** software defined mobile network
• **Challenges:**
White House, July 15, 2016

• Advanced Wireless Research Initiative, USD 400 million, led by the NSF.

• Deployment of four city-scale testing platforms for advanced wireless research.

• (To) allow academics, entrepreneurs, and the wireless industry to test and develop advanced wireless technology ideas, some of which may translate into key future innovations for 5G and beyond.

Strong support from public and private sectors

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<th>NSF</th>
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<td>ATIS</td>
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<td>TIA</td>
<td>Source: White House</td>
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Qualcomm’s 5G vision: a unifying connectivity fabric, including enhanced mobile broadband, Mission-critical services, Massive Internet of Things

Qualcomm is driving 4G and 5G in parallel to their fullest potential, pushing LTE towards 5G with its unique end-to-end system approach

Qualcomm announces X16 and X50 modems for Gigabit LTE and 5G Connectivity
• World’s first global 5G modem with ultra-high throughput operation and low latency
• Operation in both sub-6 GHz and mm-Wave bands with compact chip kit
• Pairs with the world’s first 5G sub-6 GHz and 28 GHz RFICs
• Supports key 5G NR technology features, including low latency frame structure, advanced channel coding, massive MIMO and beamforming
• Pairs with LTE modems such as Intel’s XMM™ 7360 LTE modem for 4G/5G dual connectivity

Intel aims to cover all the bases for 5G. (Image: Intel)
Intel’s 5G Strategy

- Provide a full suite of products for covering almost every part of the new networks that will all seamlessly interact.
- 5G networks will have to be designed to be more flexible, relying on software that can be reprogramming to handle different tasks running on more generic hardware, instead of being built on more customized hardware dedicated to specific tasks.
- Links between different parts of the 5G network all made by Intel will be able to interact more efficiently and quickly, while Intel software gives users a smooth experience.

Source: Intel
Google is partnering with leading mobile network operators globally to build a platform for operators to run their network services.

Google will bring their expertise in SDN, NFV and Cloud to the carrier ecosystem, thus accelerate the transition to 5G and enable new features such as the application of machine learning.

The platform will provide plenty of APIs which will enable new operational models and help operators bring new features.

The platform is based on commodity hardware instead of dedicated hardware provided by telecom manufacturers.
• The Telecom Infra Project (TIP) is an engineering-focused initiative driven by operators, infrastructure providers, system integrators and other technology companies that aim to reimagine the traditional approach to building and deploying telecom network infrastructure.

• Focus areas: access, backhaul, and core and management.

• Open and collaboration!

Members (growing)

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<th>AMN</th>
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- **Challenges:**
5G Technical Requirements

• Can one 5G network satisfy all diversified requirements?
• How to make 5G networks super flexible and adaptive?

Source: Nokia
Motivation: Flexible and Adaptive

- To decouple software and hardware designs
- To realize flexible deployment of network functions

Current: Dedicated Hardware Platform

Future: GPP-based Platform
Dedicated accelerations with FPGA and DSP

Virtualization of baseband resources

Making up the weakness of general processor, providing standard function of CODEC, MDM, resource mapping, FFT/IFFT/DFT and etc.

Virtual logic applications provide support to GSM, TD-LTE and other wireless protocols.

Based on multi-core CPUs and general purpose servers, virtual logic applications provide physical computing, network and storage resources.

Source: Alcatel-Lucent Shanghai Bell
Facebook OpenCellular: an Open Source Wireless Access Platform

- **Radio**: Radio with integrated front-end, which is based on SDR/SoC and supports network-in-a-box or access point.
- **GBC**: General Baseband Computing
- **Function**: SMS messages, voice calls, basic data connectivity using 2G implementation.
You think it is just a mini PC

Intel NUC 5i7RYH
Core i7-5557U
3.1 GHz-3.4 GHz
Dual-core
4 MB cache
Price: < 600 USD

Source: Internet

Radio Access Network (RAN)
Core Network (EPC)

SGW
MME
PCRF
PGW
Open 5G Platform Architecture

- GPP-based platform to realize software defined EPC and eNB BBU
- CPRI between BBU and RRU
- FPGA/DSP Acceleration
Software Defined Mobile Network

• Based on OAI open-source LTE platform
• Real-time software defined LTE network (including RAN and EPC) on a multi-core GPP-based platform
• FDD and TDD modes
• Support multiple commercial LTE mobile terminals for each eNB
• Support video streaming and web browsing traffic
Heterogeneous Wireless Testbed

- **LTE + 5G hierarchical network architecture**
  - 6 macro-cell base stations
  - 10~20 micro-cell base stations
  - 100+ small base stations
  - Trial of GPP-based BSs

- **802.11ac high speed WLAN**
  - 100~200 outdoor APs
  - 1000~10000 indoor APs
  - UDN, multi-carriers
  - Trial of GPP-based APs

![ShanghaiTech University](image1)
![LTE+5G macro-cell BSs](image2)
![802.11ac outdoor APs](image3)
Innovation and Impact

Open 5G Platform

- **Professor**: evaluation of creative ideas
- **Student**: learning by doing
- **Industry**: fast prototyping and trials of new products
- **Application**: cross-domain customized services
Customized Enterprise Applications

- GPP-based 5G network supports fast prototyping of special industry requirements on soft terminals, open RAN and open EPC.
- Quick deployment of dedicated network slices for customized industry applications.
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• **Challenges:**
• TD-LTE uplink and downlink on a GPP-based platform;
• Hardware acceleration for standard function such as CODEC.

Source: China Mobile

Turbo decoding: 3 iterations
Delay of baseband signal processing

- **Our GPP-based platform**: IBM System x3400 M3 with 2.13GHz CPU, quad-core Intel Xeon E5606, 4G RAM, 256G HDD, Linux Debian 7 OS with the version 64 bits Ubuntu 14.04 DeskTop.
- **Turbo decoding** is the bottleneck for real-time processing.

<table>
<thead>
<tr>
<th>Function</th>
<th>Rate (Mbps)</th>
<th>Processing Time(µs)</th>
<th>2.152</th>
<th>8.76</th>
<th>13.536</th>
<th>17.56</th>
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<tr>
<td>De-scrambling</td>
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<td></td>
<td>7.96</td>
<td>21.93</td>
<td>33.38</td>
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<td>De-modulation</td>
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<td>De-interleaving</td>
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<td>6.27</td>
<td>30.19</td>
<td>48.68</td>
<td>72.11</td>
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<tr>
<td><strong>Turbo decoding</strong></td>
<td><strong>113.44</strong></td>
<td><strong>465.01</strong></td>
<td><strong>734.86</strong></td>
<td><strong>1047.61</strong></td>
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Join us in this OPEN world!

Thanks you!

Dr. Yang Yang
Email: Yang.Yang@wico.sh
Google Edge Nodes

Map of metros where at least one Edge node (GGC) is present.
5G Vision: GPP-based Platform

- Software defined mobile network and resource/network function virtualization could meet different diversified 5G use cases and business models, i.e. eMBB, mMTC and uMTC.
it is a just mini PC

Intel NUC 5i7RYH
Core i7-5557U
3.1 GHz-3.4 GHz
Dual-core
4 MB cache
Price: < 600 USD

Intel Core i5-4670K
Intel NUC NUCi7RYH (i7-5557U)
Intel Core i5-3470
Intel NUCi5RYK (i5-5250U - Samsung SSD)
Intel NUCi5RYK (i5-5250U - Intel SSD)
AMD A10-6800K
Intel NUC DC3217BY (i3-3217U)

Futuremark PCMark 7
Overall PCMark Score
Intel NUCi7RYH - Core i7-5557U
Higher Scores = Better Performance

Source: Internet
Network Slicing for Various Use Cases

- **Open Source Software**: to build a collaborative community and ecosystem for innovations in EPC, eNB and terminals.
- **GPP-based Hardware**: to replace dedicated hardware (e.g. ASIC), thus enabling flexible and adaptive service creations and deployments for various use cases and business models.
5G: a Game Changer