Network Softwarization/ Network Slicing for 5G Mobile Network

Aki Nakao
The University of Tokyo
2016/5/24
5G Mobile Network Promotion Forum

General Assembly

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- Strategy & Planning of 5G mobile and develop outcomes from this forum
- Contact, coordinate and confer with suitable organizations in and outside Japan
- Coordinate among the various committees of this forum

- Study technology and frequency requirements for 5G mobile
- Contact, coordinate and confer with international standards organizations and overseas organizations regarding technologies

- Study mobile applications for the 2020’s

- Study overall network architecture for 5G mobile
- Study requirements and technologies for network infrastructure
Network Softwarization view of 5G mobile

Goal: End-to-End Quality and Extreme Flexibility to Accommodate Various Applications & Services with various requirements (M2M/IoT, Content delivery, Tactile)

Virtualized networks/platform

- Slice Control
- UE/Device
- Radio access network (RAN)
- Mobile packet core
- Cloud

Management Orchestration

Network management and orchestration

Network Softwarization

Physical infrastructure (network, computing and storage resources)

- UE/Device
- Computation and storage resources
- Data Centers
- Mobile Edge Computing
- Network resources
  - RAT(s)
  - MFH
  - MBH
  - Transport
- Fronthaul Backhaul
“White screen of Death”
Pulling Necessary Files Out of Broken Mac
Only Option for Reinstalling “El Captain” is Network Install

That took 5 hours !!
OS upgrade via network is a “Killer” app for operators in a difference sense!
Network Softwarization

Network softwarization is an overall transformation trend for designing, implementing, deploying, managing and maintaining network equipment and network components by software programming, exploiting characteristics of software such as flexibility and rapidity of design, development and deployment throughout the lifecycle of network equipment and components,

Draft Contribution at FG IMT-2020 as of 2015/11/6
The basic concept of the Network Softwarization is “Slicing” as defined in [ITU-T Y.3011], [ITU-T Y.3012]. Slicing allows logically isolated network partitions (LINP) with a slice being considered as a unit of programmable resources such as network, computation and storage.

FG IMT-2020: Report on Standards Gap Analysis
EU-Japan Collaboration Project Proposal

5G!Pagoda
“A network slice for every service”


Call:
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FOKUS
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KDDI R&D LABS
HITACHI
orange
MANDATE
UNIVERSAL DEVICE GATEWAY
NEC Networks & System Integration Corporation
Waseda University
5G!Pagoda Abstract
5G!Pagoda represents the next evolution step in softwarized networks as supported by NFV, SDN and aimed at by the 5G network evolution. The top objectives of 5G!Pagoda are i) the development of a scalable 5G slicing architecture towards supporting specialized network slices composed on multi-vendor network functions, through the development of ii) a scalable network slice management and orchestration framework for distributed, edge dominated network infrastructures, and convergent software functionality for iii) lightweight control plane and iv) data plane programmability and their integration, customization, composition and run-time management towards different markets in Europe and Japan. 5G!Pagoda will develop a coherent architecture enabling research and standardization coordination between Europe and Japan.
# End-to-End Slicing and RAN Slicing

## Overall Architecture

<table>
<thead>
<tr>
<th>Core</th>
<th>FH/BH</th>
<th>UE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Horizontal Extension of Slicing</td>
<td>4. Edge Computing</td>
<td>5. Softwarized Data Plane (in support of e.g. ICN)</td>
</tr>
</tbody>
</table>

**Platform/Middleware Applications**

- 2. Vertical Extension of Slicing
- 3. Horizontal Extension of Slicing
- 4. Edge Computing
- 5. Softwarized Data Plane (in support of e.g. ICN)

**Infrastructure**

- Core
- FH/BH
- UE
RAN (Fronthaul) Slicing (Dynamic Resource Allocation for Small Cells)
RAN (Midhaul:BBU) Slicing (Virtual BBU)
RAN (Backhaul) Slicing (Elastic OADM Ring)
FG (Focus Group) IMT-2020 was formed under ITU-T SG13 in Apr. 2015.
FG IMT-2020 (phase-1) studied gap analysis of existing technologies against the requirements of IMT-2020, and delivered its report in Dec. 2015.
Based on the outcome of phase-1, FG IMT-2020 (phase-2) has been started with the goal of compiling recommendations on enabling technologies for IMT-2020, targeted at the end of 2016.

**Gap Analysis**

**Network Softwarization (SDN/NFV)**
- Fronthaul/Backhaul
- E2E Management Architecture
- Emerging Technologies (ICN)

**ITU-T SG13**
- (2015.4) FG was formed
- (2015.12) FG phase-2

**FG IMT-2020 (phase-1)**
- #1 meeting (2015.6)
- #2 meeting (2015.7)
- #3 meeting (2015.9)
- #4 meeting (2015.10)

**FG IMT-2020 (phase-2)**
- #1 meeting (2016.3)
- #2 meeting (2016.5)
- #3 meeting (2016.8/9)
- #4 meeting (2016.11/12)

Gap Analysis of existing technologies, such as NFV/SDN, ICN/CCN, Fronthaul/Backhaul, and so forth.

Compiling recommendations on enabling technologies
Prototyping, Showcases, Use of open source is also planned.
**Gap : Network Slicing for 5G**

<table>
<thead>
<tr>
<th>Gap B.6.2.1: Efficient accommodation of various applications</th>
<th>Priority: High</th>
</tr>
</thead>
</table>

**Description:** It is envisioned that such an infrastructure that efficiently supports a diversified set of application requirements across end-to-end paths, ranging from M2M communication, to autonomous and collaborative driving, virtual reality and video streaming, etc. Network softwarization technologies including SDN, NFV and their extensions for supporting IMT-2020 mobile networks are expected to provide slicing capability both in wired and wireless parts of communication infrastructure, so that each slice provides an isolated environment to efficiently accommodate individual applications meeting specific requirements. The slice should be capable of dynamically adjusting resources to meet the application requirements. The network infrastructure is expected to provide extreme flexibility to support those different capabilities with reasonable cost.

**Related work:** ITU-T Y.3011, Y.3012, Y.3300, ETSI ISG NFV, Network Functions Virtualization, 3GPP, IEEE SDN
## Gap: Deep Data Plane Programmability

|---|---|

Description: The current SDN technology primarily focuses on the programmability of the control plane, and only recently the extension of programmability to the data plane is being discussed both in the research community and in ITU-T SG13 but without well-defined use cases. For IMT-2020 mobile networking, there are several use cases for driving invention and introduction of new protocols and architectures especially at the edge of the network. For instance, the need for redundancy elimination and low latency access to contents in content distribution drives ICN at mobile backhaul networks.

Protocol agnostic forwarding methods such as Protocol Oblivious Forwarding (POF) discuss the extension to SDN addressing forwarding with new protocols. In addition, protocols requiring a large cache storage such as ICN needs new enhancement.

A few academic research projects such as P4 [b-P4] and FLARE [b-FLARE] discuss the possibility of deeply programmable data planes that could implement new protocols such as ICN, but there is no standardization activity to cover such new protocols to sufficient extent.

### Gap B.6.2.2-4: Support for emerging network architectures

<table>
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<th>Priority: Medium</th>
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**Description:** There are both academic and commercial research activities for defining emerging network architectures that do not assume the underlay network runs TCP/IP protocols. A representative example of such network architectures is **ICN (Information Centric Networking)**. Although the current state of ICN could run on top of TCP/IP as an overlay, inherent benefits of the architecture can be achieved if implemented natively, i.e., directly on top of the underlay, e.g., L1 or L2 networks. There exists a gap in supporting such emerging network architecture in the current network technology, especially when it uses such an emerging network architecture in the context of heterogeneous service delivery and function chaining. Network softwarization provides slicing such that such multiple emerging network architectures could be realized within individual slices.

**Related work:** ITU-T Y.3011, Y.3012, Y.3300, SG13 Q15
FG IMT-2020

ITU-T Focus Group on IMT-2020

Meeting in Focus
6 September (2 PM) - 9 September 2016, Palo Alto, United States, hosted by PARC

- Announcement (incl. phone numbers)
- Registration
- Documents

Future Meetings
November 2016, ITU, Geneva, Switzerland
Details coming soon

Past Meetings
1. 8-9 June 2015, San Diego, United States: Announcement - Participants - Report
3. 21-24 September 2015, Turin, Italy: Announcement - Participants - Report
4. 27-30 October 2015, Beijing, China: Announcement - Participants - Report
5. 8-11 March 2016, Seoul, Korea: Announcement - Participants - Report
6. 17-20 May 2016, Beijing, China: Announcement - Participants - Report

Tools
- Terms of Reference (2016); (2015)
- Recommendation ITU-T A.7: "Focus groups: Establishment and working procedures"
- ITU-T basic document template
- Manual for rapporteurs and editors
- Author's guide for drafting ITU-T Recommendations
- Quick guide for remote meeting attendees (GoToMeeting)
- Mailing list subscription
- Mailing list archive

Contact
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Network Softwarization view of 5G mobile

Goal: End-to-End Quality and Extreme Flexibility to Accommodate Various Applications

Applications & Services with various requirements (M2M/IoT, Content delivery, Tactile)

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Fronthaul Backhaul
Wireless Performance Requirement in 5G

ITU-R IMT Vision (IMT2020)
Breakdown of E2E Delay

User Equipment

Application (Incl. Sensors)

Platform

Radio IF

Mobile Network

Control (MME, PCRF, etc)

Radio IF

MFH

RRH

BBU

S-GW

P-GW

Transport

Inter-Domain Network

Server

Application

Platform

Network IF

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ ⑪

One way latency defined in 5G: ② + ③ + ④ + ⑤

RRH (Remote Radio Head)
BBU (Base Band Unit)
S-GW (Serving Gateway)
P-GW (Packet Data Network Gateway)
MME (Mobility Management Entity)
PCRF (Policy and Charging Rule Function)

MFH (Mobile FrontHaul)
MBH (Mobile BackHaul)
Mobile Edge Computing

Mobile-edge Computing provides IT and cloud-computing capabilities within the Radio Access Network (RAN) in close proximity to mobile subscribers.

- On-Premises
- Proximity
- Lower Latency
- Location Awareness
- Network Context Information

http://www.etsi.org/technologies-clusters/technologies/mobile-edge-computing
MEC Introductory Technical White Paper
Use Case 1: Active Device Location Tracking

http://www.etsi.org/technologies-clusters/technologies/mobile-edge-computing
MEC Introductory Technical White Paper
Prototype of Infrastructure-based Control System

Fig. 5 The prototype using the micro-car

Fig. 6 The micro-car platform
Deviation From the Center of the Road

Fig. 8 Evaluation method of the vehicle path the stability
Cloud MEC Cooperative Driving PoC (Toyota&UTokyo)

With 100msec delay from UE to Cloud
Cloud MEC Cooperative Driving PoC (Toyota&UTokyo)

With 150msec delay from UE to Cloud

40% of the trajectory is out of the course
Edge Server Achieves Better Control

(a) Edge Server (0ms)
Discussion

- New technologies are getting interconnected quickly
  - 5G
  - SDN/NFV/Mobile Edge Computing
- Standardization and Experimentation are necessary