SUMMARY REPORT
ON
FOCUS GROUP ON
IMT-2020

8th-9th June 2015
San Diego/United States

Prepared by:

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IMT Working Group
MTSFB

On Behalf
MALAYSIAN TECHNICAL STANDARDS FORUM BHD

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1. Abstract

The rapid adoption of mobile broadband services and growing expectations from users for superior mobile broadband experiences are motivating industry, academia and governments to explore how to meet these demands. In early 2012, ITU embarked on a programme on “International Mobile Telecommunications (IMT) for 2020 and beyond”, setting the stage for IMT-2020 research, development, and marketing activities around the world.

In this context, ITU-T Study Group 13 has led ITU's standardization work on next-generation networks and now caters to the evolution of NGNs, while focusing on future networks and network aspects of mobile telecommunications. It is mandated to study the requirements, architectures, capabilities and mechanisms of future networks including mobile. There is a desire to establish an open platform for experts representing both ITU members and non-members in order to gain deep understanding of the IMT-2020 agenda and to explore if there is a gap to be filled by ITU-T Study Group 13 studies, from non-radio transmission related network perspective.

This Focus Group on IMT-2020 has been established under ITU-T Study Group 13 to identify the specific areas for ITU-T Study Group 13, in order for ITU-T Study Group 13 to make constructive contributions to IMT-2020, together with other standardization bodies. It was stressed that this Focus Group will not have any radio transmission related aspect in its work scope. The objective of the FG is to produce materials of gap analysis of IMT-2020 in order to identify the relevant scope of ITU-T Recommendations on the fixed network of IMT-2020. The gap analysis may be accompanied by high level technical aspects such as use cases, requirements and other aspects. The Focus Group also serves as an open platform for network architecture experts representing ITU members and non-members to move forward in the IMT-2020 direction. Unlike other ITU Working Groups, the FG on IMT-2020 is open to all to attend and participate, with options for remote participation.

2. List of Participants

The first Working Party meeting for IMT-2020 was attended by 60 delegates from 18 countries with 14 participants attending remotely – please refer to Appendix 1: FG IMT-2020 participants.

3. Introduction / Background

The first meeting of this new Focus Group on IMT-2020 was held in San Diego, United States, 8 – 9 June 2015. The meeting was chaired by Mr. Peter Ashwood-Smith (Huawei, Canada). The meeting was held immediately prior to the International Telecommunication Union Radio communication Sector (ITU-R), which took place from 10-18 June 2015, also in San Diego, United States. A total of 60 participants, of which 18 were remote participants, attended the meeting with 33 contributions. The Terms of Reference (ToR) were discussed at this meeting and agreed. The full details of the ToR may be found in Appendix 2: FG IMT-2020 ToR. The lifetime of this FG is until Dec 2015.

4. Agendas / Topics

The specific tasks and deliverables of FG on IMT-2020 is to perform a gap analysis and identify necessary areas for standards on non-radio network supporting IMT-2020 by:

- Collecting, categorizing and proposing high-level use cases for IMT-2020 and their requirements, and
- Proposing and describing high level requirements and other aspects of non-radio network supporting IMT-2020.

For this kick-off meeting, the specific agenda covered the following:

- 5G overview(s), status, timelines, technologies
- Views and requirements from carriers
- Views and requirements from academia, SDOs
- Views and requirements from vendors
- Open discussions and way forward

5. Findings

Since this was the kick-off meeting, there were no specific findings from this meeting. Rather it was a series of presentations under the agenda headings. The following are the list of presentations given. The detailed document report is included in Appendix 4: FG IMT-2020 Report.

5.1. 5G Overview(s), Status, Timelines, Technologies

- Keith Mainwaring representing ITU/TSB presented "Review of 5G / IMT-2020 white papers."
- Luca Pesando of Telecom Italia presented an update on the NGMN alliance
- Aki Nakao of The University of Tokyo presented "5G Mobile Network R&D in Japan"

5.2. Views and Requirements from Carriers

- Dr. Ali Amer of Saudi Telecom Company presented "Paving the way towards 5G."
- Hyungsoo Kim of KT Corporation presented "KT's view on IMT-2020"
- Aki Nakao of The University of Tokyo presented "TTC Ad-hoc Group on Future Mobile Networking"
- Namseok Ko of ETRI presented "A View on IMT-2020 Network"
- MinGeun Yoon of SK Telecom's perspective of 5G
- Yachen Wang of China Mobile presented "5G view and work of China Mobile"

5.3. Views and Requirements from Academia, SDOS

- Nacho Solis of Palo Alto Research Center (PARC) presented "CCNx Overview"
- Peter Ashwood-Smith of Huawei Technologies and Chair of IMT-2020, noted that a Liaison Statement was submitted by ETSI

5.4. Views and Requirements from Vendors

- Michael Recchione of Cisco presented "Rethinking the Mobile Core for 5G"
- Philip Kelley of Alcatel-Lucent presented "5G is coming"
- Frank Effenberger of Huawei Technologies presented "The demands of IMT-2020, and introduction to potential Optical Access solutions"
- Frank Effenberger of Huawei Technologies presented "NG PON2 for Fronthaul"
- Frank Effenberger of Huawei Technologies presented "Radio Over Fiber"
- James Huang of Huawei Technologies presented "Low Latency Requirements of backhaul network for 5G"

5.5. Open Discussions and Way Forward

- Hyungsoo Kim of KT Corporation presented "Proposal of Study Issue for FG on IMT-2020"
- Hyungsoo Kim of KT Corporation presented "A Survey on QoS-related Studies and White papers for IMT-2020"
- Hyungsoo Kim of KT Corporation presented "Gap Analysis of Different QoS Standards"
- Hyungsoo Kim of KT Corporation presented "Baseline document- QoS framework for IMT-2020"
- Jian Wang of Ericsson presented "Proposal for work plan, structure and potential deliverables"
- Namseok Ko of ETRI presented "Work Group Proposal for IMT-2020"

- Namseok Ko of ETRI presented “Problem statement of current network technologies for emerging IMT-2020 services”
- Namseok Ko of ETRI presented “Baseline document – high-level network architecture for IMT-2020”

6. Conclusion

The kick off meeting of the Focus Group saw an introduction in the Focus Group logistics. Context was provided by a presentation by the Chair of ITU-R Working Party 5D (IMT Systems), Mr. Stephen Blust.

A total of 33 contributions was presented and discussed. The Focus Group identified a number of work items to be carried forward. Each work item will be championed by one organization responsible for advancing the work in-between meetings. Not all the work items have a champion assigned for the moment. The Focus Group Chair was invited to provide a report of the meeting results to the ITU-R Working Party 5D opening plenary and both parties agreed to collaborate closely.

It is recommended that the MTSFB continue to participate in this FG on IMT-2020 as it presents a wide vision of the support ecosystem for IMT-2020 radio technologies. This participation is via the IMT Working Group and in particular the 5G SWG. This participation keeps Malaysia updated with the latest developments in IMT and at the forefront of mobile technology. The 5G SWG acts as a focal point for coordination and fostering of collaboration and partnership between academia and industry in 5G R&D activities in Malaysia. As such it is well positioned to contribute to the IMT-2020 specifications and have an influence on its direction.

7. Acknowledgement

The author would like to express thanks to both MTSFB and MCMC for supporting and sponsoring the attendance at the ITU-T FG on IMT-2020 meeting held in San Diego, United States of America from 8th to 9th June 2015.

8. Appendix 1: FG IMT-2020 participants

List of Participants – Focus Group on IMT-2020, San Diego, California, 8-9 June 2015

Final- List of participants FG IMT-2020 15 June 2016

	Name	Entity	Country
1076562	Mr ADOLPH Martin	TSB	
1076361	Mr AMER Ali	Saudi Telecom	Saudi Arabia
1076236	Mr ASHWOOD-SMITH Peter	Huawei Technologies	Canada
1076548	Mr AUFFRET Jean-Pierre*	George Mason University	United States
1076464	Mr BANNISTER Jeffrey	Malaysian Technical Standards Forum	Malaysia
1076235	Mrs BELHASSINE-CHERIF Rim*	Tunisie Télécom	Tunisia
1076496	Mr BLUST Stephen	AT&T	United States
1076792	Mr BONIN Jean Pierre	Alcatel-Lucent International	France
1076579	Mr BROWN Phillip	Fujitsu Laboratories of America	United States
1076575	Mr CARUGI Marco*	NEC	Japan
1076709	Mr CHEN Junhua	Huawei Technologies	China
1076788	Mr EDENS Glenn	PARC	United States
1076790	Mr EFFENBERGER Frank	Huawei Technologies	United States
1076629	Mr EGAWA Takashi	NEC	Japan
1076246	Mr GLUDOVACZ Dieter*	Deutsche Telekom	Germany
1076797	Mr HAN Xiaoyong	China Mobile Comm. Corp.	China
1076486	Mr HONG Kyung-Yeop*	Cisco Systems	United States
1076434	Mr HU Kai	Huawei Technologies	China
1076462	Mr HUANG Jing	Huawei Technologies	China
1076237	Mr IBARRA Dante	United States	United States
1076308	Mr IMANAKA Hideo	NTT	Japan
1076697	Mr KELLEY Philip	Alcatel-Lucent International	France
1076479	Ms KHACHLOUF Ameny*	Tunisie Télécom	Tunisia
1076380	Mr KIM Dong Wook	KT Corporation	Korea (Rep. of)
1076650	Mr KIM Hyungsoo	KT Corporation	Korea (Rep. of)
1076232	Mr KO Nam-Seok	ETRI	Korea (Rep. of)
1076255	Mr KOO Eng Wei	JDSU	Germany
1076422	Mrs KURAKOVA Tatiana*	TSB	
1076282	Mr LEHMANN Leo	Switzerland	Switzerland
1076297	Mr LIN Tzu-Ming	ITRI	United States
1076444	Ms MADDOX Shakeyia*	FiberOpt Installation, Inc.	United States
1076795	Mr MAINWARING Keith*	TSB	
1076239	Mr MALLINSON Keith	WiseHarbor	United Kingdom
1076561	Ms MALUTI Patricia*	Zambia	Zambia
1076324	Mr MARTINKOVICS Leslie	Verizon Communication	United States
1076793	Ms MOHYELDIN Eiman	Nokia	
1076691	Mr NAKAHIRA Yoshihiro	Oki Electric Industry	Japan

	Name	Entity	Country
1076581	Mr NAKAO Akihiro	The University of Tokyo	Japan
1076443	Mr NASIELSKI Jack	Qualcomm	United States
1076544	Mr NDIAYE Achime Malick*	Senegal	Senegal
1076583	Mr NISHITANI Takashi	Mitsubishi Electric	Japan
1076704	Mr PARK Noik	ETRI	Korea (Rep. of)
1076520	Mr PESANDO Luca	Telecom Italia	Italy
1076633	Mr PIKE Simon	Vodafone Group Services	United Kingdom
1076794	Mr RANGANATHAN Raghu*	Ciena Corporation	United States
1076724	Mr RECCHIONE Michael	Cisco Systems	United States
1076363	Mr ROMASCANU Dan	Avaya	United States
1076707	Mr ROSE Aaron*	ROI3, Inc.	United States
1076381	Mr SCHEELE Peter	Germany	Germany
1076586	Ms SHEN Yang*	Nokia	
1076378	Ms SO Tricci	ZTE TX Inc	United States
1076789	Mr SOLIS Ignacio	PARC	United States
1076525	Mr SOUZA FILHO Agostinho	Brazil	Brazil
1076299	Ms STANCAVAGE Jayne	Intel	United States
1076791	Mr TONG Wen	Huawei Technologies	Canada
1076573	Mr WADE David L	Integral Engineering and Research Associates	United States
1076787	Mr WANG Guo Qiang	Huawei Technologies	United States
1076582	Mr WANG Jian	Telefon AB - LM Ericsson	Sweden
1076796	Mr WANG Yachen	China Mobile Comm. Corp.	China
1076649	Mr YOON Mingeun	SK Telecom	Korea (Rep. of)

Total : 60

9. Appendix 2: FG IMT-2020 ToR

FG IMT-2020 Focus Group Terms of Reference

INTERNATIONAL TELECOMMUNICATION UNION

TELECOMMUNICATION STANDARDIZATION SECTOR

STUDY PERIOD 2013-2016

FOCUS GROUP ON IMT-2020

IMT-I-005

English only

Original: English

WG(s): San Diego, 8-9 June 2015

DOCUMENT

Source: FG IMT-2020 management team

Title: Focus Group terms of reference

Introduction

The terms of reference (ToR) of ITU-T Focus Group on IMT-2020 are reproduced below. The Focus Group is invited to review and discuss the ToR.

Terms of Reference of the Focus Group IMT-2020

1. Rationale and scope

The rapid adoption of mobile broadband services and growing expectations from users for superior mobile broadband experiences are motivating industry, academia and governments to explore how to meet these demands.

In early 2012, ITU embarked on a programme on *"International Mobile Telecommunications (IMT) for 2020 and beyond"*, setting the stage for IMT-2020 research, development, and marketing activities around the world.

ITU-T Study Group 13 is mandated to study the requirements, architectures, capabilities and mechanisms of future networks including mobile. There is a desire to establish an open platform for experts representing ITU members and non-members in order to gain deep understanding of the IMT-2020 agenda and to explore if there is a gap to be filled by ITU-T Study Group 13 studies, from non-radio transmission related network perspective. Recognising activities being undertaken around the world, it is necessary to identify the specific areas for ITU-T Study Group 13, in order for ITU-T Study Group 13 to make constructive contributions to IMT-2020, together with other standardization bodies. This Focus Group will not have any radio transmission related aspect in its work scope.

At the current early stage of IMT-2020 journey, the outcomes of this Focus Group will consist of defining the visions and objectives and performing gap analysis by focusing on use cases and high

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level requirements and other aspects related to IMT-2020, in order to identify goals for ITU-T Study Group 13 on IMT-2020.

2. ITU-T Focus Group on IMT-2020 (FG IMT-2020)

2.1 Objective

The objective of the Focus Group is to produce materials of gap analysis of IMT-2020 in order to identify the relevant scope of ITU-T Recommendations on the fixed network of IMT-2020. The gap analysis may be accompanied by high level technical aspects such as use cases, requirements and other aspects. The Focus Group also serves as an open platform for network architecture experts representing ITU members and non-members to move forward in the IMT-2020 direction.

2.2 Specific tasks and deliverables

Perform a gap analysis and identify necessary areas for standards on non-radio network supporting IMT-2020 by;

- Collecting, categorizing and proposing high-level use cases for IMT-2020 and their requirements, and
- Proposing and describing high level requirements and other aspects of non-radio network supporting IMT-2020.

2.3 Parent group

ITU-T Study Group 13 is the parent group of this Focus Group.

2.4 Relationships

The Focus Group will work in close cooperation with related ITU-T and ITU-R study groups, standards developing organizations, industry forums and consortia, research and development communities.

2.5 Leadership

See clause 2.3 of Recommendation ITU-T A.7.

2.6 Participation

See clause 3 of Recommendation ITU-T A.7. A list of participants will be maintained for reference purposes and reported to the parent group.

It is important to mention that the participation in this Focus Group has to be based on contributions and active participations.

2.7 General financing

See clauses 4 and 10.2 of Recommendation ITU-T A.7.

2.8 Administrative support

See clause 5 of Recommendation ITU-T A.7.

2.9 Meetings

The Focus Group will conduct regular meetings. Location and dates of the meetings will be determined by the Focus Group and announced by electronic means (e.g. e-mail, website, etc.) at least six weeks in advance.

The Focus Group will endeavour to utilise remote collaboration tools to the maximum extent. Focus Group meetings will be accompanied by thematic workshops as appropriate.

2.10 Duration and milestones of the Focus Group

The Focus Group lifetime is until the SG13 meeting (December 2015), but extensible if necessary by decision of the parent group.

A preliminary set of milestones includes:

- June 2015: 1st meeting;
- July 2015: 2nd meeting.

2.11 Working language

The working language is English.

2.12 Technical contributions

Contributions are to be submitted at least seven calendar days before the meeting takes place.

2.13 Intellectual property rights

See clause 9 of Recommendation ITU-T A.7.

2.14 Approval of deliverables

Approval of deliverables shall be taken by consensus.

2.15 Progress reports

See clause 11 of Recommendation ITU-T A.7.

2.16 Announcement of Focus Group formation

The formation of the Focus Group will be announced via TSB Circular to all ITU membership, via the ITU-T Newslog and other means, including communication with the other involved organizations.

2.17 Working guidelines

See clause 13 of Recommendation ITU-T A.7.

10. Appendix 4: FG IMT-2020 Report

Summary report of first meeting of ITU-T Focus Group on IMT-2020 (San Diego, 8-9 June 2015), and Unedited Summary of Contributions.

INTERNATIONAL TELECOMMUNICATION UNION

TELECOMMUNICATION STANDARDIZATION SECTOR

STUDY PERIOD 2013-2016

FOCUS GROUP ON IMT-2020

IMT-O-001

English only

Original: English

WG(s): San Diego, 8-9 June 2015

OUTPUT DOCUMENT

Source: FG IMT-2020 management team

Title: Meeting report

Table of Contents

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1. Organization of Meeting

The first meeting of Focus Group on IMT-2020 was held in San Diego, United States, 8 – 9 June 2015. The meeting was chaired by Mr. Peter Ashwood-Smith (Huawei, Canada) with the following vice-chairmen:

Dr. Hideo Imanaka, NTT, Japan

Dr. Luca Pesando, Telecom Italia, Italy

Dr. Namseok Ko, ETRI, Korea

Mr. Yachen Wang, China Mobile, China (remotely participated)

A total of 60 participants, of which 18 were remote participants, attended the meeting with 33 contributions.

The list of participants is available at IMT-I-034.

1.1 Meeting agenda

The Meeting Agenda was published in IMT-I-001.

1.2 Meeting documents

Documents considered at this meeting are listed as part of the agenda. All documents are available at https://extranet.itu.int/ITU-T/focusgroups/imt-2020/.

2. Meeting results

2.1 Key results

The kick off meeting of the Focus Group saw an introduction in the Focus Group logistics. Context was provided by a presentation by the Chair of ITU-R Working Party 5D (IMT Systems).

A total of 33 contributions was presented and discussed. The Focus Group identified a number of work items to be carried forward. Each work item will be championed by one organization responsible for advancing the work in-between meetings. Not all the work items have a champion assigned for the moment.

NOTE: The Focus Group Chair was invited to provide a report of the meeting results to the ITU-R Working Party 5D opening plenary and both parties agreed to collaborate closely.

Output documents:

- This meeting report and its attachment

The attachment to this meeting report contains an unedited summary of contributions, kindly provided by the representative of ROI3, Inc.

2.2 Liaison Statements

One liaison statement was reviewed (ETSI ISG IP6), see section 2.3.4.

2.3 Contributions

2.3.1 Welcome and Opening session

1) IMT-I-002, IMT-I-003, IMT-I-004 (Chairman)

- The followings are explained

- Working methods and logistics
- Focus Group framework (Recommendation ITU-T A.7)
- ITU IPR policy

□ Disposition: No objections and opinions from floor. No IPR claims.

2) IMT-I-006 (ITU-R WP5D / Stephen Blust)

□ Discussion

- Overview of ITU-R Working Party 5D activities on IMT for 2020 and beyond

□ Q&A

- Q1: Why isn’t IETF included in the list?
- A1: IETF is not directly related to mobile networks. They are working with 3GPP.
- Q2: 5G is, more than radio and just a network, a social infrastructure. Plan to work with non-telecommunication space?
- A2: Not directly with the non-telecommunications space, but through use cases,
- Q3: How will ITU organize and coordinate all the licensed and unlicensed spectrums which will be used for 5G?
- A3: Clear answer not possible at this moment. It has to be addressed when the requirements on that are defined.
- Q4: When we look at the technical performance requirements that was mentioned from the radio system perspective, how do you relate that to overall requirements for end-to-end and how do you apportion different aspects to different part of networks?
- A4: Industry collectively still is working on ITU-R.
- Q5: The relationship between WP5D work and regulatory constructs from WRC-15?
- A5: There will be some interaction to adjust WP5D works with the regulatory constructs.
- Q6: The relationship between 5G and IMT-2020? End-to-end QoS should be considered.
- A6: IMT-2020 is not all of 5G. 5G is a broader term than IMT-2020.
- Q7: End-to-end QoS considering mobile and fixed-network parts is important.
- Q8: We could refer to documents about 3G and 4G for End-to-end QoS in 5G.

□ Disposition

- Noted.

3) IMT-I-005 (Chairman)

□ Discussion

- The ToR of this FG cannot be modified in FG meetings, but only in SG13 plenary meeting. However, there are no SG13 meeting during planned lifetime of this FG, so we cannot modify the ToR.(FG Chairman, SG13 chairman)

☐ Disposition: The following comment is noted.

- The radio transmission related aspect including spectrum related work is out of scope of the Focus Group.

4) IMT-I-007 (Intel / Jayne Stancavage)

☐ Discussion

- Focus group stick to its ToR.

☐ Disposition: The followings are noted.

- The Focus Group will take account of ITU-R WP5D activities in its analysis to avoid duplicative efforts.
- The radio transmission related aspect which is out of scope of the Focus Group is also including spectrum related work involving access mechanisms like dynamic spectrum access, databases, and LSA.

2.3.2 5G overview(s), status, timelines, technologies

1) IMT-I-030 (ITU/TSB / Keith Mainwaring)

☐ Discussion

- Review of 5G / IMT-2020 white papers
- The impact of 5G mobile applications on the fixed network architecture should be studied in SG13 and SG15 has an important role to play in defining specifications for optical networks.

☐ Disposition:

- Noted.

☐ Questions

- He agrees on energy consumption saving requirements, but is it possible to standardize it in ITU-T? (KT)

2) IMT-I-017 (NGMN Alliance / Luca Pesando)

☐ Discussion

- NGMN Alliance Update

☐ Disposition:

- Noted.

3) IMT-I-015 (5GMF / Aki Nakao)

☐ Discussion

- 5G Mobile Network R&D in Japan (5GMF)

- The first milestone for the network architecture and the network technology roadmap by end of June, 2015

☐ Q&A

- Application-Driven Standardization?
- Core network does application identification
- Mobile Edge Computing (Ericsson)

☐ Disposition:

- Noted.

4) IMT-I-031 (Huawei / Wen Tong)

☐ Discussion

- Again about challenging figures (delay, density, and bit rates) evolution vs revolution and time schedule.
- ITU-T could really play an important role to synchronize various activities about 5G.

☐ Q&A

- Question about spectrum-agnostic?
- KT's comment: 1ms latency requirement is not for all applications

☐ Disposition:

- Noted.

2.3.3 Views and requirements from carriers

1) IMT-I-027 (STC / Ali Amer)

☐ Discussion

- Applications should be considered importantly than any other things

☐ Q&A

- Q: What is the good approach to accelerate application development? (Nakao)
- A: Depending on Business Model/Cases
- What is the new strategy for selecting 5G driving applications? (Tunisia Telecom)
- Can the push for 5G bring cost reduction?

☐ Disposition:

- Noted.

2) IMT-I-008 (KT / Dongwook Kim)

☐ Discussion

- KT's view on IMT-2020

- ☐ Q&A
  - Integrated access: one networks/architecture
  - Gradual deployment of new technology according to needs and not a total replacement at once to protect the huge previous investments
  - Could you prioritize 5 network aspect? No - prioritization
  - Application-driven service is important, but it is not mandatory. Applications are important but it is market-driven in most cases.
- ☐ Disposition:
  - Noted.

3) <u>IMT-I-014 (TTC / Aki Nakao)</u>

- ☐ Discussion
- ☐ Q&A
  - CRAN is not only solution. We also need to consider others. (ZTE)
  - Why is energy reduction important? (STC)
  - Carbon emission reduction is required in many countries including Korea. (KT)
  - Allocation of radio resources is out of scope (FG Chair)
- ☐ Disposition:
  - Noted

4) <u>IMT-I-021 (ETRI / Namseok Ko)</u>

- ☐ Discussion
  - A view of IMT-2020 network
- ☐ Q&A
  - Q1: Can removing GTP be considered in FG?
  - A1: After analyzing more about use cases and requirements, if the architecture is not feasible to support new emerging services including IoT, we may consider to remove it.
  - Q2: Is that core network integration?
  - A2: Yes. We are considering one core networking for different access networks. Integrated gateways are located at edges.
  - Q3(comment): Distributed network architecture and simple signaling seem to be contradictory.
  - A3: At least we should consider efficient signaling to cope with the diverse different requirements.
- ☐ Disposition:

- Noted.

5) IMT-I-028 (SKT / Mingeun Yoon)

☐ Discussion

- 5G Strategy and Architecture

☐ Q&A

- Centralized or distributed orchestration? – Centralization is preferred but there can be a combination with some kind of peripheral orchestration.
- Network slice – partitioning of network devices/resource per customers or industries
- Telco IT functions? It is for implementation of network operator's own IT functions.

☐ Disposition:

- Noted.

6) IMT-I-028 (China Mobile / Yachen Wang)

☐ Discussion

- Four Principle: Flexible, Efficient, Intelligent, Openness
- 4D-Architecture: Separated, Virtualized, Modularized, Distributed.

☐ Q&A

- Q: What kind of management of mobility do you expect, do you see the devices assigned to the mobile network?
- A:
- Q: Role of the enabler in slide 13 on the side of the orchestrator? (NEC)
- A: It is a totally new thing compared to traditional networks, the enabler can open new capabilities in the network
- Q: Why is API better than signalling interfaces?

☐ Disposition:

- Noted.

2.3.4 Views and requirements from academia, SDOs

1) IMT-I-032 (PARC / Ignacio Solis)

☐ Discussion

☐ Q&A

- Security, Multicast
- Out of mandate since network stack needs to be changed in core network?
- Cisco also supporting CCNx.

- Naming of content? No strong impact on forwarding and routing part of name is signed by a global entity
- Routing for a short life packets
- Q: How to handle mobility cases?
- A: Network elements can take decisions based on the content they are going to move. Caching of data on nodes. So retransmissions can be local and faster. It is based on state of node and this allows for mobility management
- Native multicasting as it is based on common names

☐ Disposition:

- Noted

2) IMT-I-013 (Chair)

☐ Discussion

- This contribution was the liaison statement from ETSI ISG IP6 (Industry Specification Group on IPv6 Integration), and informed us that ETSI ISG IP6 was created and has successfully held the first meeting on 22-23 April, 2015. This was presented by chairman.

☐ Q&A

- None

2.3.5 Views and requirements from vendors

1) IMT-I-033 (Cisco / Michael Recchione)

☐ Discussion

- Rethinking the Mobile Core for 5G based on CCN
- Core principles
- Simplification, loose-coupling to the access network, intrinsic mobility, inherent security, and orchestration & virtualization

☐ Q&A

- Q1: Compatibility is important in supporting new concepts in 5G
  - For example, removing GTP and supporting ICN
- A1: Explained the issues of GTP : latency, mobility, etc.
- Q2: how do we maintain the backward compatibility?
- A2: Supporting ICN is not a big issue since it is already supported as overlay
- Q3: There is still an impact even if it could be supported as overlay. We need to analyze the impacts on the existing networks/mobile terminals.
- A3: The use cases that 4G cannot handle are the 5G drives.

Chairman’s comment: We are open to all technologies.

- ☐ Disposition
  - Noted

2) IMT-I-029 (Alcatel Lucent / Philip Kelley)

- ☐ Discussion
  - 5G drivers: broadband services, extreme density, innovative services, mission critical service, battery life, non-traditional devices.
  - Explained why 4G is not enough.
    - Low latency (1ms) challenges
    - LTE connection-oriented control plane to support connection density of 200,000 devices/km²
    - More consistent Quality of Experience (QoE)
    - Need to evolve the security infrastructure to handle a number of attached devices
    - Etc.
  - 5G Radio UF-OFDM
  - Also mentioned the need for parallel revolution in networking such as
    - Connectionless service
    - Flexible bearer configuration
- ☐ Q&A
  - Chairman’s comment: Radio side is not our scope.
  - Q1: Please, if possible, study how much traffic is required in fronthaul and backhaul and give us input.
  - Q2: How don’t you give some input to 3GPP RAN?
  - Q3: How do we assure that there is a two-way working relationship with 3GPP?
  - A3: The role of FG is to help you understand, and contributing to 3GPP is your job.
  - Discussed a little about how to contribute to 3GPP.
- ☐ Disposition
  - Noted.

3) IMT-I-018 (Q2/15 / Frank Effenberger)

- ☐ Discussion
  - The demands of IMT-2020, and introduction to potential Optical Access solutions
- ☐ Q&A

- Comment: CRAN should not be kept as a religious concept and we should not face the solution with brute force. Also virtualization should be considered carefully to find solutions that allow reducing the requirements on performance of the critical parts in the chain
- Comment: Taken from a radio perspective, the figures for the 64x64 MIMO solutions have sizes (1 mq) that are not compatible with extensive deployment. So we have to think of solution very carefully.
- Comment: In some cases, there are enormous bandwidth requirements on front-haul while backhaul has zero traffic (e.g. loopback traffic from the stadium)
- Conclusion: We should reconsider carefully the figures so far reported everywhere as requirements and mind what the real use cases and the real requirements are.

☐ Disposition

- Noted.

4) IMT-I-019 (Huawei / Frank Effenberger)

☐ Discussion

- NG-PON2 Technology

☐ Questions

- Comment: Why should people require services at 40G?
- Comment: CPRI transcoding makes transmission more efficient
- Comment: Error correction on fronthaul link or not? Even if no error correction, the fronthaul link has to introduce no further error (so should have error correction) …not in agreement with people from WP5D

☐ Disposition:

- Noted.

5) IMT-I-026 (Huawei / Frank Effenberger)

☐ Discussion

- Radio over Fiber (G.sup.RoF) in ITU-T Q2/15
- Requested FG to provide input to Q2/15 on the RoF application parameters to support IMT-2020

☐ Questions

- Analog over direct fiber. Then, how about error correction?
- What is the expectation for noise?
- Very high data rates could be prevented by non-linearity of laser with high power requirements

☐ Disposition:

- Noted.

6) IMT-I-025 (Huawei / James Huang)

☐ Discussion

- Low latency requirements of backhaul network for 5G
- If 1ms E2E is desired, network architecture must evolve.

☐ Q&A

- Q: 1ms requirement is right or not??
- A: Tactile internet, telemedicine, etc. require ultra-low latency.

☐ Disposition:

- Noted.

2.3.6 Contributions making concrete proposals for way forward

1) IMT-I-009 (Hyungsoo Kim / KT)

☐ Discussion

- KT Corp. proposes that the Focus Group on IMT-2020 consider conducting an in-depth study on the suggested requirements of IMT-2020 network.
- Integrated Architecture
- Standardized Network Management
- Common end-to-end QoS

☐ Q&A

- Q: Hard to achieve a single unified QoS among different operators
- A: ETSI agreed to study a single unified QoS approach
- Q: Which among three is KT more interested in?
- A: Common end-to-end QoS
- Q: Integrated network?
- A: Need to consider migration path
- Q: QoS is very important in Market (STC). Need to clearly define especially for business customers.
- Q: Integrated architecture? Integrated subscriber model?
- A: As a high-level requirement, it is needed for efficiency.
- Q: Why is this integrated architecture related to FG?
- A: Most importantly, for the efficiency of operation.

- ☐ Disposition:
  - Noted.

2) IMT-I-010 (Dongwook Kim / KT)
- ☐ Discussion
  - A Survey on QoS-related Studies and White papers for IMT-2020
- ☐ Q&A
  - Q: How would you map each flow's QoS requirements to aggregate QoS?
  - A: That is an implementation issue.
- ☐ Disposition:
  - Noted.

3) IMT-I-011 (Dongwook Kim / KT)
- ☐ Discussion
  - Gap Analysis of Different QoS Standards
- ☐ Q&A
  - Q: in 3GPP, QoS is defined in user plane as well as policy management perspectives. Are you trying to collapse transport in one single aspect?
  - A: B2B, SLA, we support mobile and wireline as well. When we design SLA document, 150ms for voice.
  - Chairman's Request: please make a concrete example to be resolved. KT: Yes. We will do.
  - Q: If we make a standard based on international voice call, it is not appropriate.
  - A: Understand his point. International call is much valuable for our business.
- ☐ Disposition:
  - Noted.

4) IMT-I-012 (Hyungsoo Kim / KT)
- ☐ Discussion
  - Baseline document-QoS framework for IMT-2020
- ☐ Q&A
  - Q: Why can't mapping approach work? Why do we have to consolidate all the different QoS?
  - A: We have our own mapping algorithm. Metro Ethernet
- ☐ Disposition

- Noted.

5) IMT-I-016 (Jian Wang / Ericsson)

☐ Discussion

- Proposal for work plan, structure and potential deliverables
- Proposed the following two documents as deliverables of FG in a single working group
  - Overview of use cases for IMT-2020 regarding the non-radio part, including the visions and service aspects for non-radio part of IMT-2020;
  - Overview of high-level requirement for non-radio part of IMT-2020, after the use cases work is substantially stable.

☐ Disposition:

- Discussed in the open discussion with the scope of FG

6) IMT-I-023 (Namseok Ko / ETRI)

☐ Discussion

- Work group proposal for Focus Group on IMT-2020
- Classify work items into two large groups: items that should be done sequentially and items that can be done in parallel

☐ Disposition:

- Discussed in the open discussion with the scope of FG

7) IMT-I-024 (Namseok Ko / ETRI)

☐ Discussion

- Problem statement of current network technologies for emerging IMT-2020 services

☐ Q&A

- Q: How could you justify that GTP signaling is a problem?
- A: We believe GTP and signaling involved in it are not appropriate to support large number of terminals in services such as IoT service.
- Comment: The current PGW traffic centering is needed for charging and etc.
- Comment: We need concrete use cases to analyze problems.
- Comment: Instead of doing some works which are duplicated with 3GPP, we need to focus more on something which are not dealt with such as virtualization, connecting functions in the cores, etc.

☐ Disposition:

- Noted.

8) IMT-I-022 (Namseok Ko / ETRI)

☐ Discussion

- Proposed a baseline document, “high-level network architecture for IMT-2020”, as one of deliverables of FG

- Q&A
  - Comment: High-level network architecture is not appropriate to deal with in Focus Group.
  - Comment: Before we talk about high-level architecture, we need to think about what the FG’s role is.
  - Comment: We need to nail down the scope first.
  - Comment: Use cases are already discussed a lot in the other white papers.

- Disposition:
  - Discussed in the open discussion with the scope of FG

2.4 Open discussion

- It was decided to select a list of possible work items choosing the most recurring topics in the presentations.
- For each entry in the list of candidate work items individuate a champion organisation
- Agreed work items and provisional champions are provided in below table.
- For those Work Items that have already been assigned a champion, activities can start with the call of meetings (conference calls) to prepare a document addressing the subject of the work item

Agreed work items and champions

#	Topic	Contribution # addressing the topic	Contributing organisation	Champion	Drivers	Group	Priority	Dependencies
1	Overview of use cases and terminology	I-030, [IMT.VISION] I-016, I-024	TSB, ETRI, Ericsson	NEC				
2	High level technology targets	I-030, I-014.1, I-14.2, I-015, [IMT.VISION]	Univ. Tokyo/TTC	[Vodafone]				
3	High level architecture	I-008, I-009, I-021, I-022, I-028	ETRI, KT, SKT	ETRI				I-022 input draft for high-level architecture
4	E2E QoS	I-009, I-010, I-011, I-012, I-028	KT, SKT	KT				I-012 input draft for work doc on QoS
5	Next generation network technology (e.g., ICN, CCNx, …)	I-032, I-033	Cisco, PARC	Cisco				
6	Network softwarization	I-028	5GMF, KT, SKT	[5GMF]				
7	Fronthaul & Backhaul (e.g., RoF)	I-018, I-019, I-026	ITU SG15/Huawei	Huawei				
	Challenges and enablers for 5G	I-025	Huawei					
	Integrated management of all segments (mobile-transport) and technology	I-14.2, I-031, I-008, I-009 I-020, I-021	TTC, Huawei , KT, China Mobile, ETRI					
	Smooth Transition Model	I-033, I-029, I-027	CISCO, ALU, STC					
	Security aspects	I-014.1	TTC					

Notes:

1 At this point, there were no champions for “challenges and enablers for 5G” and “integrated transport network” (grey highlight).

2 Two more items were added after the meeting based on information from contributions. If there is no champion, the items will be deleted later.

3 Champions in square brackets [organization] are yet to confirm their availability to lead the work on the respective work item.

Intense debate followed on whether high-level network architecture and end-to-end QoS can be dealt with or not in the Focus Group.

Some argued that these items are within the mandate of the group since the proposed work was based on gaps identified by some contributions.

Others argued that work on such topics is outside the scope of the group, as there may be existing or future work on these matters elsewhere.

The Focus Group Chair offered to seek clarification from the Chairman of the parent study group, ITU-T Study Group 13 ("Future networks including cloud computing, mobile and next-generation networks" - mandate) and the ITU-T leadership. Some clarification indicating that both items are in scope has been given on the Focus Group mailing list.

The representative of Vodafone considered the fronthaul as part of the radio access network and therefore out of scope. Other participants were of a contrary opinion.

Wrapping up the discussion the Chair reminded participants that the Focus Group was contribution driven, and that all are invited to bring technical contributions supporting their position.

The 'champions' were invited to self-organize, organize conference calls with other interested organizations (announce calls on mailing list), and to drive the work forward in-between meetings.

ITU's remote participation tools are available on request (tsbfgimt-2020@itu.int).

2.5 Outgoing Liaisons

There was no outgoing liaison statement.

3. Future Plan

The next meeting will take place from **13 to 14 July 2015 at ITU in Geneva**. Participants were invited to register for the meeting http://itu.int/reg/tmisc/3000785. Remote participation will also be possible.

The third meeting will take place from **22 to 24 September 2015 in Turin, Italy**, and the fourth meeting is *planned* for 27-29 October (Beijing, China).

4. Acknowledgements

Chairman and vice-chairmen thanked all the contributors and participants for their hard work. Also, thanks goes to Martin Adolph of ITU TSB for his support before and during the meeting.

Attachment 1 to report of first meeting of ITU-T Focus Group on IMT-2020 (IMT-O-001)
(San Diego, 8-9 June 2015)

Unedited Summary of Contributions

--- *For information only* ---

By Aaron Rose

WELCOME AND OPENING SESSION

Stephen Blust, Chairman ITU-R Working Party 5D, presented "Update on ITU-R Working Party 5D: Actions to Make 'IMT for 2020' a Reality" (see I-006att1)

5G is evolutionary and revolutionary

A key deliverable, the new Report ITU-R M.2320 "*Future technology trends of terrestrial IMT systems*" was completed in by WP 5D at end of 2014 and subsequently approved by ITU-R.

- This Report provides a broad view of future technical aspects of terrestrial IMT systems considering the time frame 2015-2020 and beyond. It includes information on technical and operational characteristics of IMT systems, including the evolution of IMT through advances in technology and spectrally-efficient techniques, and their deployment.

Draft New Recommendation ITU-R M.[IMT-Vision] "*Framework and overall objectives of the future development of IMT for 2020 and beyond*" will be completed by WP 5D in mid-June 2015 and forwarded to ITU-R Study Group 5 in July for the final steps of approval.

- This Recommendation defines the framework and overall objectives of the future development of IMT for 2020 and beyond in light of the roles that IMT could play to better serve the needs of the networked society in the future.
- In this Recommendation, the framework of the future development of IMT for 2020 and beyond, including a broad variety of capabilities associated with envisaged usage scenarios, are described in detail.
- Furthermore, this Recommendation addresses objectives of the future development of IMT for 2020 and beyond, which includes further enhancement of existing IMT and development of "IMT-2020".

Draft New Report Report ITU-R M.[IMT.ABOVE 6 GHz] "The technical feasibility of IMT in the bands above 6 GHz" will be completed by WP 5D in mid-June 2015 and forwarded to ITU-R Study Group 5 for the final steps of approval.

- This Report is to study and provide information on the technical feasibility of IMT in the bands between 6 GHz and 100 GHz.

Mr. Blust concluded his presentation with this question: How do you something in five years when it took eight years before?

Peter Ashwood-Smith of Huawei Technologies and Chair of IMT-2020 read I-005, "Terms of Reference of the Focus Group IMT-2020," in its entirety:

1. Rationale and scope

The rapid adoption of mobile broadband services and growing expectations from users for superior mobile broadband experiences are motivating industry, academia and governments to explore how to meet these demands.

In early 2012, ITU embarked on a programme on *"International Mobile Telecommunications (IMT) for 2020 and beyond"*, setting the stage for IMT-2020 research, development, and marketing activities around the world.

ITU-T Study Group 13 is mandated to study the requirements, architectures, capabilities and mechanisms of future networks including mobile. There is a desire to establish an open platform for experts representing ITU members and non-members in order to gain deep understanding of the IMT-2020 agenda and to explore if there is a **gap** to be filled by ITU-T Study Group 13 studies, from **non-radio transmission** related network perspective. Recognising activities being undertaken around the world, it is necessary to identify the specific areas for ITU-T Study Group 13, in order for ITU-T Study Group 13 to make constructive contributions to IMT-2020, together with other standardization bodies. This Focus Group will not have any radio transmission related aspect in its work scope. [Emphasis added.]

At the current early stage of IMT-2020 journey, the outcomes of this Focus Group will consist of defining the visions and objectives and performing gap analysis by focusing on use cases and high level requirements and other aspects related to IMT-2020, in order to identify goals for ITU-T Study Group 13 on IMT-2020.

2. ITU-T Focus Group on IMT-2020 (FG IMT-2020)

2.1 Objective

The objective of the Focus Group is to produce materials of gap analysis of IMT-2020 in order to identify the relevant scope of ITU-T Recommendations on the fixed network of IMT-2020. The gap analysis may be accompanied by high level technical aspects such as use cases, requirements and other aspects. The Focus Group also serves as an open platform for network architecture experts representing ITU members and non-members to move forward in the IMT-2020 direction.

2.2 Specific tasks and deliverables

Perform a gap analysis and identify necessary areas for standards on non-radio network supporting IMT-2020 by;

Collecting, categorizing and proposing high-level use cases for IMT-2020 and their requirements, and

Proposing and describing high level requirements and other aspects of non-radio network supporting IMT-2020.

2.3 Parent group

ITU-T Study Group 13 is the parent group of this Focus Group.

2.4 Relationships

The Focus Group will work in close cooperation with related ITU-T and ITU-R study groups, standards developing organizations, industry forums and consortia, research and development communities.

2.5 Leadership

See clause 2.3 of Recommendation ITU-T A.7.

2.6 Participation

See clause 3 of Recommendation ITU-T A.7. A list of participants will be maintained for reference purposes and reported to the parent group.
It is important to mention that the participation in this Focus Group has to be based on contributions and active participations.

2.7 General financing

See clauses 4 and 10.2 of Recommendation ITU-T A.7.

2.8 Administrative support

See clause 5 of Recommendation ITU-T A.7.

2.9 Meetings

The Focus Group will conduct regular meetings. Location and dates of the meetings will be determined by the Focus Group and announced by electronic means (e.g. e-mail, website, etc.) at least six weeks in advance.

The Focus Group will endeavour to utilise remote collaboration tools to the maximum extent. Focus Group meetings will be accompanied by thematic workshops as appropriate.

2.10 Duration and milestones of the Focus Group

The Focus Group lifetime is until the SG13 meeting (December 2015), but extensible if necessary by decision of the parent group.

A preliminary set of milestones includes:

- June 2015: 1st meeting;
- July 2015: 2nd meeting.

2.11 Working language

The working language is English.

2.12 Technical contributions

Contributions are to be submitted at least seven calendar days before the meeting takes place.

2.13 Intellectual property rights
See clause 9 of Recommendation ITU-T A.7.

2.14 Approval of deliverables
Approval of deliverables shall be taken by consensus.

2.15 Progress reports
See clause 11 of Recommendation ITU-T A.7.

2.16 Announcement of Focus Group formation
The formation of the Focus Group will be announced via TSB Circular to all ITU membership, via the ITU-T Newslog and other means, including communication with the other involved organizations.

2.17 Working guidelines
See clause 13 of Recommendation ITU-T A.7.

Jayne Stancavage of Intel made reference to document I-007, "Intel contribution to the first meeting of ITU-T Focus Group IMT-2020" emphasizing two key elements in these terms:

> First, in regards to the development of requirements for IMT-2020- Intel would like to highlight that WP5D, and its predecessors WP8F and TG8/1 have for nearly twenty years been responsible for developing a process and then executing on it for the development of requirements for IMT, translating those requirements into the technical specifications for IMT, and then developing further guidance to assist Administrations, operators and manufactures in its deployment. In particular the process is an iterative one that involves not only end-user requirements, but a survey and examination of technology trends to understand what new capabilities may be available, as well as participating with other working parties and groups in studies leading up to World Radio Conferences to identify potential spectrum for IMT. Therefore it is essential for the Focus Group that all of WP5D's activities are taken account of in its analysis to avoid duplicative efforts.
>
> Second, Intel would strongly emphasize that the Focus Group's terms of reference exclude radio and spectrum related work. It is important to realize that such potential work involves not only radio interface work, but Recommendations and studies that impact the use of spectrum such as techniques involving access mechanisms like dynamic spectrum access, databases, and LSA. ITU-R is the responsible entity for developing, inter alia, such Recommendations and it is critical that the work remain in the body with the relevant expertise and the global responsibility spectrum management including the efficient and timely update of the international treaty governing the use of the radio-frequency spectrum through the processes of the World and Regional Radiocommununication Conferences.

5G OVERVIEW(S), STATUS, TIMELINES, TECHNOLOGIES

Keith Mainwaring representing ITU/TSB presented aspects of I-030, "Review of 5G / IMT-2020 white papers."

Annex A. 5G White Papers

"Network Slicing"

Work on SDN, virtualisation and cloud is included in Release 13 (which is planned to conclude at the end of 1Q 2016) and continues in Releases 14 and 15 (1Q 2016 to end 2017). Releases 14 and 15 include specifications related to 5G from mid-2016.

ETSI established an Industry Specification Group (ISG) on an Open Radio Network (ORI) interface (this interface is to enable interoperability of cellular mobile network base stations) in 2010 and one on Network Function Virtualisation (NFV) in 2012.

ITU-T SG15 has defined a 100Gbps Optical Transport Unit Level 4 (OTU-4) interface specification (Recommendation G.709).

ITU-T SG13 is currently working on many of technologies relevant to fixed network support of 5G requirements such as SDN and NFV.

IEEE 802.3bs intends to produce specifications for 400Gbps Ethernet by 2017.

Luca Pesando of Telecom Italia presented an update on the NGMN alliance (see I-017att1)

NGMN 5G Vision: *"**5G** is an **end-to-end ecosystem** to enable a **fully mobile and connected society**. It empowers **value creation** towards customers and partners, through existing and **emerging use cases**, delivered with **consistent experience**, and enabled by **sustainable business models**."*

Excellent and consistent User Experience

- **Consistent** user experience across time and service footprint in a highly heterogeneous environment, dependent on use case
- **Much higher user data rates**, required to be available in at least 95% of locations (including cell-edge) for at least 95% of the time:
  - Dense urban: 300Mbps DL
  - Smart office: 1Gbps DL
  - Multi-Mbps data rates everywhere – including in stadiums, airplanes and areas currently not connected to the Internet
- **Much lower latency**: Less than 1ms E2E latency for certain car-2-car and industry automation communication needs
- **Seamless service experience** to moving users (up to 500 km/h) and also static/nomadic users/devices

[Note: Requirements are defined 'per use case category' instead of 'one-fit-for-all']

System Performance

- Connection/Traffic Density:
  - **Users in a crowd**: Several tens of Mb/s for tens of thousands of users in crowded areas
  - **Smart office**: 15Tbps/km2 traffic density for smart office
  - **Massive sensor deployments**: Up to several 100,000s simultaneous connections per km2
- **Significantly enhanced spectral efficiency** (average and cell edge, across bands) to keep number of sites reasonable
- **Enhanced resource and signaling efficiency** to minimize resource and energy consumption

Smart Devices with Growing Capabilities (HW, SW and OS)

- High degree of **programmability and configurability** of any device by the network (**OTA**)
- Flexible and dynamic **device capability handling**
- Devices to support of **multiple bands simultaneously and multiple modes** (FDD, TDD, mixed) for true **global roaming**
- Significantly increased **battery life**: at least 3 days for smartphones, up to 15 years for low-cost MTC device

Enhanced Services

Value creation towards customers and partners through capabilities enhancing today's overall service delivery

- **Seamless** and always-best-experience connection without user intervention, across existing, new and ***non-3GPP RATs***
- **Unnoticeable mobility** across existing, new and non-3GPP RATs
- **Network based positioning** with accuracy from 10 m to <1 m outdoor and <1m indoor, in real time
- **Strengthened security** for services and network in highly heterogeneous environments, working also when user is roaming.
- **Protection of users' trusted information**
- **Ultra-high reliability** rate of ≥ 99.999% for specific use cases

New Business Models

Expansion of current and creating opportunities for new business models within the 5G eco-system

- Partner Service Provider, XaaS Asset Provider:
  Configure and manage services e.g. via Open API – exposing NW capabilities in a flexible, configurable and programmable manner
- Connectivity provider:
  Connectivity delivered using only necessary NW functions – **provisioning and configuration on demand** and in a programmable manner

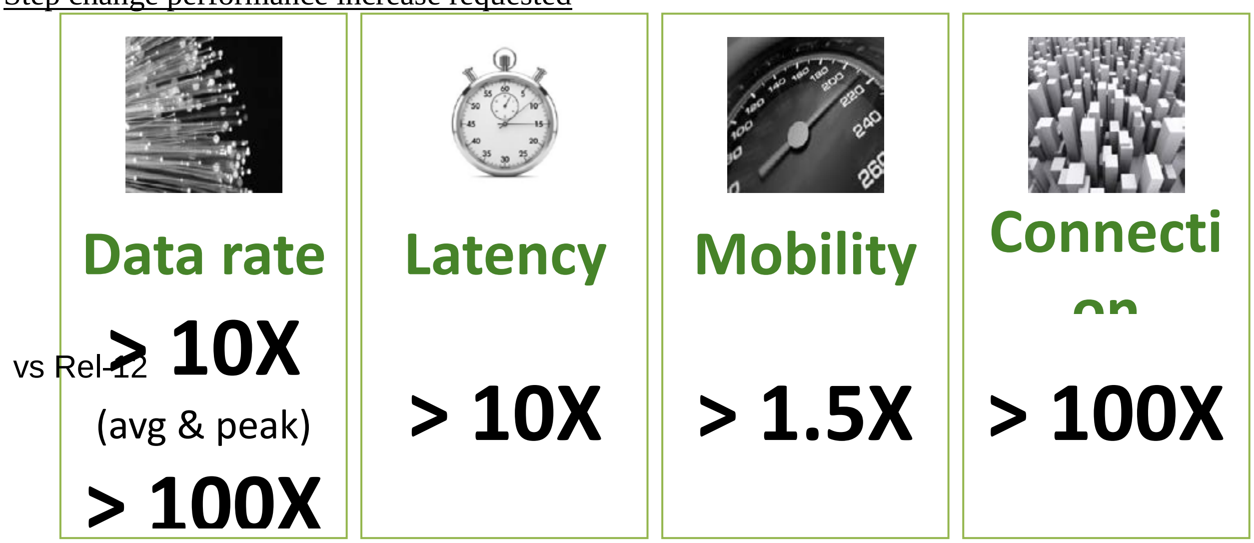
- Network Sharing Model:
  Enabling various sharing schemes to **maximise overall synergies of sharing agreements** and to allow for flexible / rapidly changing models and relationships

<u>Highly Efficient Network Operation</u>

High efficiency in cost, energy, innovation, deployment and O&M while minimizing Total Cost of Ownership

- Half of total network **energy consumption** for 1000x traffic growth
- Significant **reduction of O&M** complexity and cost
- **Ultra low cost** for very low-ARPU areas and/or MTC services
- **Flexible and fast introduction** of new services and technologies
- **Ease of deployment**: Plug&Play, Self-configuration/heal etc.
- **Flexibility and scalability**: Openness and multivendor capability at all levels, modular provisioning, functional split of Core/RAN network domains / elements, decouple HW and SW
- **Fixed-mobile convergence**, for seamless user experience and unified subscriber management

<u>Step change performance increase requested</u>



- Not a single solution will satisfy all extreme requirements at the same time
- However, several use cases to be active concurrently: High degree of flexibility and scalability of the network required

<u>Design Principles</u>

Radio

- ***Leverage spectrum***
  - Exploit higher frequencies and unlicensed spectrum
  - C/U-path split, UL/DL split, multiple connectivity
- ***Enable cost-effective dense deployments***
  - Integrate third-party/user deployments

    - Automate configuration, optimization and healing
    - Enhance multi-RAT coordination
    - Support multi-operator/shared infrastructure
- ***Coordinate and cancel interference***
    - Build-in massive MIMO and CoMP
    - Exploit controlled non-orthogonal interference
- ***Support dynamic radio topology***
    - Moving cells, relays, hubs, C-RAN, D-RAN
    - D2D (e.g., for latency, disaster relief)

Network

- ***Create common composable core***
    - Minimize number of entities and functionalities
    - C/U-function split, lean protocol stack
    - No mandatory U-plane functions
    - Minimize legacy interworking
    - RAT-agnostic core, fixed and mobile integration

Operations & management

- ***Simplify operations and management***
    - Automation and self-healing
    - Probeless monitoring
    - Collaborative management
    - Integrated OAM functionality
    - Carrier-grade network cloud orchestration

Embrace flexible functions and capabilities

- Network slicing, per user/service differentiation
- Function variance
- Flexible function/service/application allocation
- Leverage NFV/SDN
- State-disintegrated functions
- Graceful degradation

Support new value creation

- Exploit big data and context awareness
- Expose radio and network APIs
- Facilitate XaaS

Build in security and privacy

- Extend C-plane security (e.g., HetNets)
- Ensure location privacy and identity protection from (unlawful) disclosure

Aki Nakao of The University of Tokyo presented "5G Mobile Network R&D in Japan" (see I-015att1)

Presentation focused on the non-radio part of 5G Mobile Network. This is based on the study which is being done by The Fifth Generation Mobile Communications Promotion Forum (5GMF), Japan.

Tokyo to host summer Olympics in 2020. Established 5GMF Project in 2014. 5G Mobile Verification Field Experiment in 2017 and beyond.

Japan is focusing on four areas: Network Softwarization ((Deep) Programmability, Application Driven), Management/Orchestration (Automation, Autonomy, Intelligence, Analytics), Fronthaul/Backhaul (Multi-Tenancy, Data Isolation), and Mobile Edge Computing (Knowledge, Edge Security).

Mobile Edge Computing

- Scope
    - Human perceptual interactive services & applications (Advanced 5G applications)
- Challenges
    - Delivery for high quality contents by big data analysis for better user experience
    - Achieve end to end ultra-low latency for delay-critical real-time services
    - Mobility, security, and resiliency
- Approaches
    - Information Centric Networks for intelligent access to content
    - Use of local edge networks with computing and storage resources
    - Network control and management for the delay minimization anywhere and no single point of failure

Summary

- 5GMF Network Architecture Committee has been studying overall network architecture for 5G mobile
- Challenges, requirements and technologies for network infrastructure has been discussed to create the Network Technology Roadmap
- The first milestone for the network architecture and the network technology roadmap by end of June, 2015.
- Outcome of the committee will be included in 5GMF white paper, which will be released in Autumn, 2015.

Wen Tong of Huawei made a presentation, "5G: True Single Network" (see I-031att1)

Diversified Challenges and Gaps to Reach 5G including:

- Latency
- Throughput
- Connections
- Mobility
- Network Architecture

5G Timetable
Revolution (5G) vs. Evolution (4G or 4.5G)

- 5G -> 4G (5G applications will be applied to 4G)
- 4G-5G (4G will stimulate the emergence of new applications for 5G)

Key Enablers for Reaching 5G

- Spectrum (aggregate all available bands)
- New Air Interface (flexibility & spectrum efficiency)
- New Architecture & Operation (one physical network multiple industries)

5G Will Aggregate Sub 6GHz and the Bands >6GHz

5G for All Spectrum Access Unified Design Across Spectrum Bands and Types

- Below 1GHz (Longer Range, Massive MTC)
- Below 6GHz (Mobile Broadband, Mission Critical MTC)
- Above 6GHz (Integrated Access and Backhaul Short Range)

Dual Non-Orthogonality for Air Interface (Departure from LTE global orthogonality)

- Inter-block non-orthogonalilty
  - Enabled by f-OFDM
    - filtered-OFDM
  - Allow co-existence of different WF numerology in different sub-band within same carrier
  - Different CP, sub-carrier spacing, TTI
- Intra-block non-orthogonality
  - Enabled by SCMA
    - Sparse-Code Multiple Access
  - Allow over-dimension and over-loading

A Docker Style for Radio Resource

UE Centric “no-Cell” Radio Access

- New UE and network transmit node association mechanism enabled by “Hyper cell ID” and “Dedicated UE connection ID”
- CRAN and D2D enabled UE centric TP cooperation and device cooperation to eliminate “cell edge”
- New UE state supports massive connected devices with low signaling overhead and energy consumption

VIEWS AND REQUIREMENTS FROM CARRIERS

Dr. Ali Amer of Saudi Telecom Company presented I-027, “Paving the way towards 5G.”

5G networks will face significant design challenges to simultaneously meet all of the above service requirements. The challenges are built around the technology and spectrum, where they are the core elements to fulfill the above requirements which include but not limited to the following:

- **Extreme densification**: to increase the overall system capacity of a mobile network significantly. 5G networks are likely to consist of the several layers of connectivity that Hetnets are currently suggesting: a macro layer for lower data speed connectivity, a very granular layer for very high data speeds, and many layers in between. Network deployment and coordination are major challenges to be addressed here, as they increase exponentially with the number of network layers.
- **Multi-network association**: Several networks are currently providing connectivity for end-user devices: cellular, Wi-Fi, mm-wave, and device-to-device are a few examples. 5G systems are likely to tightly coordinate the integration of these domains to provide an uninterrupted user experience. However, bringing these different domains together has proven to be a considerable challenge. Hotspot 2.0 and Next Generation Hotspot are perhaps the first examples of cellular/Wi-Fi integration. Whether a 5G device will be able to connect to several connectivity domains remains to be seen, and a major challenge is the ability to successfully switch from one to another
- **Full duplex**: All existing mobile communication networks rely on a duplex mode to manage the uplink and downlink. There are frequency duplex or FDD schemes (such as LTE, where uplink and downlink are separated in frequency) and time duplex or TDD schemes (where the transmitter and receiver transmit at different points in time, as in TD-LTE). This approach would entail major technology challenges – requiring what is essentially self-interference cancellation, and major changes in both networks and devices.
- **Massive MIMO**: Massive MIMO refers to the network, where the base station employs a much higher number of antennas that create localized beams around each connected device. MIMO has been deployed in LTE-Advanced networks, where the base station and end-user device uses more than a single antenna to increase link efficiency.
- **Mm-wave**: Lower-frequency spectrum (450MHz–2.6GHz) which is currently relevant for mobile communications is almost fully congested. Massive amounts of spectrum are available in the higher spectral bands, which may reach up to 300GHz. Mm-wave could be used by indoor small cells (in line with the extreme densification principle outlined above), which would provide very-high-speed connectivity in confined areas.
- **Software control, Virtualization, and cloud architectures**: A parallel evolutionary trend to 5G is software and cloud, where the network is driven by a distributed set of data centers that provide service agility, centralized control, and software upgrades. SDN, NFV, cloud, and open ecosystems are likely to be the foundations of 5G, and discussion continues about how to take advantage of these architectures. Although they are not new, these concepts are necessary to provide the increased capacity and connectivity of billions of devices that 5G specifications promise.
- **The Spectrum impact**: freeing up additional spectrum will also be required to support thousand-fold capacity increases by 2020, and even higher increases looking forward to 2040 and beyond. But while a global consensus is forming that 500MHz to 1GHz bandwidth of additional mobile spectrum is needed. Spectrum bands availability by region and the local laws that govern their usage will need to be harmonized, and the global circulation and economies-of-scale for mobile devices are not negatively impacted. Table 2 outlines some options for the 5G spectrum that can be considered.

Hyungsoo Kim of KT Corporation presented "KT's view on IMT-2020" (see I-008att1)

Current Network Architecture

- Wireline and wireless networks are independently deployed and operated

Planned Network Architecture for IMT-2020

- Unified Network integrating access and core of wireless and wireline networks

Technical Requirements for IMT-2020: Advanced Radio Technology
Advanced technologies to enhance radio performance

- Massive MIMO
  - Massive Antenna and 3D Beamforming
  - Extending Coverage & Boosting Cell Capacity
- New RATs
  - Multiple Access
  - Duplexing
  - New Waveform
  - Modulation
- mmWave Cellular
  - Ultra-wideband transmission (> 400MHz)
- Massive Aggregation
  - LTE+WiFi+5G Aggregation

Technical Requirements for IMT-2020: Small Cell
Cost-effective coverage of traffic intensive regions

- Dual Connectivity
  - Increase capacity by carrier aggregation
  - Reduce small cell load (minimize small cell signalling)

Technical Requirements for IMT-2020: Access Integration
Integration of wireline and wireless access networks

- Fiber-based Access Integration
  - Fiber provides high-speed link
  - Both wireline and wireless connectivity is provided via single medium

Technical Requirements for IMT-2020: Flat & Distributed Architecture
Distributed wireless core network for extremely low latency services

- Layer simplification (3 layers → 1 layer)
- Distributed core network system

Technical Requirements for IMT-2020: Intelligent Management
Unified operation & management

- Flexible operation with active small cell (automatic tilting, throughput)
- Open standard M&C (monitoring and control) interface

Technical Requirements for IMT-2020: Support the future of hyper-connectivity and IoT (Internet of Things)

- LTE M2M
  - Low cost, low power connectivity based on narrow bandwidth
  - Massive connections
- D2D (Device-to-Device)
  - Direct communication between devices (vehicles)
  - Low latency connectivity for mission-critical IoT services

Aki Nakao of The University of Tokyo presented "TTC Ad-hoc Group on Future Mobile Networking" (see I-014att2)

Extreme Increase in Load of C-plane

- Advancement of diversified types of service such as IoT/M2M
  - Expecting 100 times more terminals (compared with 2012) need to be accommodated, issues on shortage of ID space for terminal identification and re-defining terminal identification be addressed.
  - Increase of C-plane processing due to cell small-sizing (connection, hand-over, paging) and increase of time and location dependency

Namseok Ko of ETRI presented "A View on IMT-2020 Network" (see I-021att1)

Issues in Current Mobile Network (physical convergence of fixed & mobile networks is needed)

- CAPEX/OPEX increases
- Operation/management complexity increases
- Radio resources cannot be utilized efficiently
- Ineffective network architecture with high traffic concentration (Distributed Network Architecture is needed to resolve traffic concentration problem)
  - GTP-based circuit-like service on packet-based network
  - PGW is an anchor point of all traffic
- Inefficient mobility architecture (efficient mobility needs to be supported on a distributed network architecture)
  - Non-optimal traffic route arises from hierarchical structure (mobility anchor point)
  - IP session reestablishment is required in inter-RAT mobility
  - Additional delay occurs from authentication process per access network
  - Interworking solution (ePDG) between untrusted network (WiFi) and trusted network
  - (3GPP) is rarely deployed

Similar view as NGMN

- System design should move away from the 4G monolithic design optimized for mobile broadband
  - To support the diversity of use cases and requirements in a cost-effective manner
  - In this regard, a rethink of models such as bearers, APNs, extensive tunnel aggregation and gateways is needed
- Minimization of Interworking

    - To provide further simplification, legacy interworking must also be minimized, for example towards circuit switched domain in the 2G and 3G networks.
- Converged access-agnostic core
    - identity, mobility, security, etc. are decoupled from the access technology
    - integrates fixed and mobile core on an IP basis

Similar view as 4G America

- Tunneling Overhead
    - For local offloading, 4G requires a separate mobile packet gateway (PGW) deployed locally largely because mobile-network-specific tunneling is employed for all traffic.
    - 3GPP handling of mobility entails significant RAN and core network signaling overhead that is unnecessary for devices and applications that are primarily static or nomadic.
    - Because the tunneling encapsulation and de-encapsulation can occur only at special router nodes designed to handle the associated signaling messages, packets cannot always be routed using the shortest path.
- Signaling Overhead
    - The devices have only a small amount of data to send but nevertheless have to go through a full signaling procedure to transmit the data.
- Inefficient Traffic Handling
    - The network cannot alter whether a users' video should be sent over Wi-Fi versus over cellular as a function of network conditions and steer traffic accordingly.

Unified Network for Wireless & Wireline Access

- Distributed & flat architecture
- Unified and lightweight signaling
- New mobility architecture on distributed and flat architecture

MinGeun Yoon of SK Telecom's perspective of 5G (see I-028att1)

4G/LTE is mature with respect to the market and technology, respectively.

- Top 8 countries by LTE penetration
    - Korea, South – 64.29%
    - Japan – 42.64%
    - United States – 40.19%
    - Singapore – 35.4%
    - Australia – 34.41%
    - Canada – 29.22%
    - Sweden – 29.2%
    - UK – 24%
- 4G/LTE evolution by SK Telecom
    - LTE (75 Mbps, July 2011)
    - Multi-carrier (75 Mbps, July 2012)
    - LTE-A (150 Mbps, June 2013)
    - LTE-A (225 Mbps, June 2014)

    - LTE-A (300 Mbps, December 2014)
- SK Telecom’s Market share is 50.1%
- LTE penetration is 57.1%

Is 5G just a faster network?

- Change people’s lifestyle
- Enrich society
- “Hyper Mobile connected Society”
- 5G (~10,000 Mbps)
- 4G/LTE-A (450 Mbps)
- 3G (14.4 Mbps)
- 2G (384 Kbsp)
- 1G

Key values expecting from 5G

- Customer Experience Enhancement
    - High resolution video in communication, entertainment & work
    - 3D, Hologram, AR/VR
- New Business Opportunity
    - Support different types of customers
    - Software oriented characteristic
    - Differentiated network functions
    - Massive IoT, Mission-critical IoT
- Efficient and Intelligent Operation
    - Cost reduction
    - Network usage optimization
    - Automation
    - Analytics

All-IT Infrastructure

- 5G networks running on the top of virtualized IT infrastructure intelligently managed by central orchestrator
- 4G Legacy Infrastructure
    - Dedicated H/W
    - Static
    - Simple policy
- 5G All-IT Infrastructure (NFV/SDN)
    - Virtualized (Open-source S/W, COTS H/W)
    - Programmable
    - Intelligent

5G will support lots of emerging use cases with its high performance attribute

- Virtual Experience, Anywhere, Anytime
- Mission-Critical Internet-of-Things (IoT)
- Massive Internet-of-Things (IoT)

Key Strategic Direction

1. Biz Enabling Platform
   - Providing network services and platforms meeting different requirements in new business, e.g. IoT, Big Data
2. Guaranteed Service Delivery
   - Managing QoE in end-to-end networks to provide the optimum user experience for different services
3. Smart Operation
   - Enhancing operational intelligence with big data analytics and IT infra technologies

Yachen Wang of China Mobile presented "5G view and work of China Mobile" (see I-020att1)

5G has high requirement on data rate, connection density, latency, mobility, cost and efficiency——Trigger New Network Architecture

Mapping of Architecture

- More Flat Architecture
- Fast content delivery
- Flexible network orchestration
- Simple mobility management
- Efficient resource management
- Secured system design

5G is hot all over the world, requirement and scenario is the focus previously, network architecture is not clear yet

NFV & SDN Enables New Architecture Design

- NFV decouples software and hardware. More importantly, NFV enables network element orchestration, leading to great flexibility and O&AM efficiency
- SDN is an open network architecture and can schedule the whole network resource
- SDN network architecture has 3 layer
  - forwarding, control, application
- SDN VS. traditional IP network
- Traditional IP Net: distributed routing computing, good for scalability and reliability, lack of global scheduling
- SDN: Centralized routing computing, global optimization

Five Key Problems on 5G Network Architecture

1. Centralized global optimization or distributed coordination?
   - Debate on centralization and distribution always exist
2. Access network topology?
   - Variant architecture: C-RAN, D-RAN, Wireless Mesh, D2D, Multi-RAT
3. Variant node: Macro, Nanocell, Relay, WLAN

4. To what extend NFV and SDN impact?
    - NFV dramatic change network element: network function becomes programmable
    - SDN changes network design model, network becomes programmable
5. RAN and CN convergence?
    - RAN+CN——Traditional Mobile Network
    - Convergence appears in LIPA, Relay, C-RAN
6. Evolution or Revolution?

Four Architecture Design Principles

1. Flexible: service oriented (super reliable, supper low latency) user oriented networking (user, enterprise, M2M) fast time to market
2. Efficient: low data transmission cost, easy scalability, simplified state & signaling
3. Intelligent: network resource auto-configuration, self-adaptation, self-optimization
4. Openness: open platform for network element, network capability openness for the 3rd part bring new profitable opportunities

Feature——4D-Architecture

1. Separated: C/U separation of access, control and forwarding separation
2. Virtualized: logical cell dynamic configuration, network function virtualization
3. Modularized: function atomization, modularization, composition per demand
4. Distributed: distributed access, deployment, processing and data delivery

5G Network Architecture Prototype

Main Feature: Flexible Access, Intelligent and opened Control, efficient and cost efficient forwarding

- Access: C/U separation, radio resource coordination, multiple scenario(centralize, distribute, mesh), flexible function and topology;
- Control: centralized network controller, function virtualization, software oriented, signaling handling and management;
- Forwarding: content and forwarding close to user, service capability enabler to control cloud.

5G Network Architecture - the Platform View

- Platform View: Platform and orchestration becomes part of the architecture
- Logical View: Traditional network logical architecture is for further study

Control plane technologies

- Redesign network element
    - Fully converge
    - Application based vertical converge
    - Function based horizon redesign
- Redesign Interface
    - Connections are between network functions, not network entities.
    - Network function interact with others with API instead of signaling interface
- Connection management
    - Simplified QoSand connection management.

- SDN based mobility management
    - Centralized control, no-tunnel, no-anchor, support multiple access, routing optimization
- Forwarding plane technologies
    - Service chain for traffic steering: network policy + new routing mechanism for service, network, user on-demand data forwarding
        - Real-time traffic monitoring: statistics of network bandwidth, traffic visualization
        - QoS per demand
        - Intelligent steering: per network load, traffic type
    - Hierarchical content delivery: layered content in terminal, access, core network with policy based coordination, improve QoS

Network Capability Openness
- A new Network Capability Layer: with resource orchestration, enabler and openness capabilities
    - OTT is booming and traffic profit is decreasing, 5G shall consider new business model and opportunities.
    - Network work together with the 3rd party, improve user experience and benefit the industry
- Network capability openness will incorporate with new architecture from access to the network side

Standardization work
- ITU-R: Submit 5G “flower diagram” to WP5D Recommendation M.[IMT.Vision]Propose 9 key capabilities, 8 of which were accepted. Released Future tech trends. Report together with other company and propose candidate technologies.
- ITU-T: Actively participated in the initiation of IMT-2020 focus group and take the work of vice chairman. Have been doing the research of soft architecture of mobile, multi-connection, etc, which are recognized as the candidate technique in IMT-2020 network.
- NGMN: Produced and published NGMN 5G white paper together with other operators, including 5G vision, high-level requirements, architecture and spectrum, etc. Will continue to lead 5G requirement work in future and take an active part in the network architecture and spectrum research.

Suggestion to future work of IMT-2020 FG
- Suggest that ITU-T do not need to repeat the work such as high level requirements, scenarios, architectures which have been done by multiple SDOs such as ITU-R and NGMN.
- New strategy such as mobility management, connection management, function design and API may be the candidate research point in ITU-T.

VIEWS AND REQUIREMENTS FROM ACADEMIA, SDOS

Nacho Solis of Palo Alto Research Center (PARC) presented “CCNx Overview” (see I-032att1)

The future Internet architecture

- We have a proposal that
  - Is secure
  - Provides high availability
  - Transfers data independent of location
  - Takes advantage of storage and processing
- It does this by
  - Naming all data, securing all data and communicating based on name

CCNx (Content-Centric Networks) is a secure communications architecture based on transferring named information objects

The CCNx communication architecture

- Applications
  - User facing programs
- Services
  - Base services required for network operation
- APIs
  - Abstractions for interacting with the network
- Transport
  - Structured and secure "end-to-end" communication
- Messaging
  - Name-based, network wide communication using CCNx messages
- Framing
  - Transport for messages over layer 2

The CCNx project

- Specifications
  - Description of protocols and algorithms
- Software
  - Reference software implementation
- Hardware
  - Hardware prototypes (big and small)
- Commercial community
  - Commercial companies developing CCNx
- Research community
  - Researchers, faculty and students working on the CCNx technology
- Developer community
  - Application developers (big and small) using CCNx

Peter Ashwood-Smith of Huawei Technologies and Chair of IMT-2020, noted that a Liaison Statement was submitted by ETSI (see I-013)

ETSI "has successfully held the first meeting of their newly created Industry Specification Group on IPv6 Integration on 22-23 April, 2015.

The ETSI "IPv6 integration" Industry Specification Group (IP6 ISG) is a working group to focus on IPv6-based best practices, deployment guidelines and success showcases identifying thereby what and where consensus and harmonization could be reached. But overall, IP6 ISG will focus on integrating the IPv6 protocol into the next generation of mobile telecommunications, 5G systems, looking at the complete wireless network and the full spectrum of mobile wireless technologies.

We invite all interested parties from your organization or others to join in. Participation in the ISG IP6 is subject to signature of an ISG IP6 Agreement you can find at https://portal.etsi.org/tb.aspx?tbid=827&SubTB=827. Explanation about those agreements is also available from the same location.

JUNE 9, 2015

VIEWS AND REQUIREMENTS FROM VENDORS

Michael Recchione of Cisco presented "Rethinking the Mobile Core for 5G" (see I-033att1)

The 5G core should enable a new economic framework to support applications and use cases that are beyond the reach of 4G (technology and economics) and its evolution.

While 5G may be available by 2020, may not see wide adoption until well past 2020.

Insights from the NGMN and 4G Americas White Papers

- The current mobile core network architecture specifies many entities to supports its functions making it challenging to deploy and manage
- Complexity: network becomes expensive and costly to scale with growing traffic volume and growing number of devices.
- Opacity – lack of inbuilt monitoring tools --> external probes tunnels add to monitoring complexity
- Need for enablers for improved business agility
- Planning should consider all major technology advances on road to 5G
- Rethinking the Mobile Core architecture can address these concerns

5G Core Network – Guiding Principles
The core is the convergence point of all use cases:

- Simplification
- Loose-coupling to the access network
- Intrinsic mobility – fundamentally converging fixed and mobile at the network layer
- Inherent security
- Orchestration & virtualization as fundamental, enabling implementation technologies

Information Centric Networking (eg NDN, CCNx): Ideas for a new foundation for 5G

- New communication model addressing modern Internet usage
- Builds on the latest "Future-Internet" architecture research

- New networking paradigm:
    - Mobility – eliminate need for special mobility overlays
    - Security – guarantee the integrity of every data object
    - Storage – dynamic placement of information anywhere in the network

Philip Kelley of Alcatel-Lucent presented "5G is coming" (see I-029att1)

What's driving 5G?
Consumers' ever increasing expectations

- Better end-to-end performance
- Better support for innovative applications
- Better battery life

Anywhere anytime communications with excellent QOE

What's driving 5G?

- Broadband
    - Massive traffic capacity
    - Reduce Cost
    - Spectrum efficiency
    - Access new spectrum
- Innovative Services
    - Flexible bearer design 3rd party policy
- Extreme density
    - Massive user density
    - User content
- Mission Critical
    - Very low latency
    - High reliability
    - High availability
    - Security
- Battery Life
    - Signaling reduction
    - Energy optimization
- Non-Traditional Devices
    - Short packet
    - Sporadic access
    - More devices and more device types

5G should focus on solving these issues

Generations arrive every 10 years and take about 10 years from early research to deployment
5G will most likely be available from 2020

LTE evolution offers most of the key foundation technologies for 5G

Why is 4G not enough?

- 4G LTE will continue to evolve and will play a significant role even after 5G service launch
- But key 5G use cases are not economically or technically achievable with the evolution of 4G
    - Low latency (1ms) challenges LTE framework and the hybrid retransmission approach
    - Connection density (200,000 devices / km^2) pressures LTE connection-oriented control plane
    - More consistent Quality of Experience (QoE) pushes need for a more flexible optimization
    - Simultaneous support for wider range of use cases drives need for a more adaptable network
    - High density zones will eventually exceed LTE spectrum bands forces need for new radio access technologies for new spectrum bands above 20 GHz.
    - Need to evolve the security infrastructure to handle a number of attached devices

5G Radio: High band to add massive capacity

5G Radio: UF-OFDM – a New waveform derived from OFDM
- Designed to meet new requirements
    - Contention based access for connection-less services
    - In-band optimization to devices and services
    - Higher capacity
- Universal Filtered OFDM (UF-OFDM)
    - New filter stage applied per sub-band
    - Cyclic prefix replaced by filter time response
    - More tolerant to power and timing errors
    - Reduced guard band requirements
    - May re-apply huge knowledge base of LTE processing

5G Radio: Macro and Small Cell layers, low and high bands plus LTE and WLAN

Timing: LTE Evolves and 5G is coming
- LTE
    - Evolution continues well after 5G launch
- 5G
    - Low band deployed from 2020 first on macro cell then on small cells
    - High band on small cell follows as 5G capacity needed

5G deployment
- Starting point
    - LTE with carrier aggregation and dual-connectivity to small cell layer
- Service starts with deployment of new 5G carrier on macro layer
    - Wide area coverage for new services, improved efficiency and 5G control
    - Combined with existing LTE carriers on macro and small cell for capacity
- Coverage extended indoor on small cell

- Capacity then built out for massive capacity
  - Additional 5G carriers above 20 GHz on small cells
- …plus
  - Additional 5G carriers in cellular bands on macro and small cells
- Parallel revolution needed in networking
  - Connectionless service
  - Flexible bearer configuration

Frank Effenberger of Huawei Technologies presented "The demands of IMT-2020, and introduction to potential Optical Access solutions" (see I-018)

Bandwidth is the important parameter

- Bandwidth cannot be compressed

Conclusion
Wireless front haul is certainly a transformative new service, which could have major impacts to the optical transport and access industry. Its extreme bandwidth demands certainly stretch conventional systems to their breaking point, motivating new approaches. This may be the time where various new WDM-PON and analog RoF systems finally make economic and practical sense. Certainly they need further research to optimize and select the best approach, and to complete their standardization. Q2/15 wishes to play an active role in finding these solutions, and looks forward to a robust cooperative effort with the Focus Group.

Frank Effenberger of Huawei Technologies presented "NG PON2 for Fronthaul" (see I-019att1)

Bandwidth Growth Promotes NG PON Development

So it's a PON over DWDM, so what?

- Activation in multi-wavelength, multi-operator, multi-vendor case is non-trivial
  - No link engineering allowed
  - Worst-worst-worst case assumed
  - Interoperable specs required
- If ONU is not calibrated, how can it learn without jamming others?
  - Synchronized ranging windows?
  - Very weak "photon ranging"?
- PON is different from DWDM
  - No mux on the ONU side
  - Extreme dynamic range
  - ONU's must have high spectral purity
- The system to support DWBA?
  - Downstream tuning is slow
  - Upstream tuning medium
  - TDMA is very fast
- Burst mode tunable lasers
- Power -> Temperature -> Wavelength

TWDM-PON Prototype System Mark II
Innovations

1. Tunable ONU with low-cost SFP transceiver;
2. 4x10G OLT transceiver with integrated EDFA
3. Integrated TOSA/ROSA on PLC platform
4. ONU wavelength control based on G.Multi standard

Achievements

1. Leading TWDM PON standard at FSAN/ITU-T
2. Award-winning research deliverables
3. FSAN Shanghai demo; Lab test at many Tier 1
4. ECOC PDP paper: World First TWDM PON Tcvr

Implications of Timing Requirements

- Frequency: Combination of low latency and low timing jitter/wander
    - Packet-based clock not possible: It would require a very long synchronizer buffer
    - Line clocking must be used
- Line clocking is fine when 1 client = 1 wavelength (or fiber)
    - But, feeding multiple independent CPRI clients over a common system is not possible
- TDMA turns off all endpoints during ranging
    - Imposes a 0.2ms delay for 20km of fiber
    - Thus, the TDMA system in NG-PON2 is not recommended for fronthaul
- Phase: Good news – PON already has robust solutions for ToD
    - The transmission delay in fiber is quite constant
    - All OAN's use a single fiber (duplex mode) – so no cable skew
    - Accuracy in the 10's of ns, and even better stability have been demonstrated

PtP WDM-PON is included in NG-PON2 standard
Summary: in order to meet the full service access (FTTH, enterprise, mobile back/fronthaul) requirements after XG-PON, NG-PON2 include two parts: TWDM-PON and PtP WDM-PON. And TWDM-PON is the primary solution.

4G LTE Fronthaul Test in China Telecom

- CPRI 3(20M, 2T2R);
- Ultra low round trip processing delay:<6us;
- Frequency jitter: <1.1ppb.
- The service test result(VoD, upload/dowload, FTP, and etc.) show it achieve the same performance as the one of fronthaul solution based on PtP fiber direction connection(refer to OFC 2015 paper)

Frank Effenberger of Huawei Technologies presented "Radio Over Fiber" (see I-026att1)

Radio over Fiber in Q2/15

- For 18 months, a project has been gathering technology descriptions for publication as a supplement of the G series

    - Supplements are informative documents that lay out a particular technology, system of calculation or measurement, or other non-normative matters
- This month G.sup.RoF will be submitted for Agreement at the SG15 plenary
    - As the text is very stable, Agreement is very likely
- Most likely, a new Recommendation project will be started at the same meeting
    - The Rec. will describe the particular technical parameters of 1 or more types of RoF links

Boosting channel efficiency: SCM
- Subcarrier multiplexing is naturally very effective
    - Fiber has a wide bandwidth, limited mostly by the electronics used
    - However, creating the SCM signal might require a lot of analog electronics

Digital Channel Aggregation
- Digitized RoF signals are aggregated, then transmitted in analog

Boosting channel efficiency: WDM
- Wavelength multiplexing is also possible
    - Fiber has significant channel capacity (40~80 channels)
    - However, the cost of all these O/E and E/O components add up

Summary
- G.sup.RoF goes into far more detail that these slides: we invite all to review it
- This is a perfect time for the FG to help provide input on the RoF application parameters of interest to IMT2020
    - These can be the drivers for rapid standardization of RoF in Q2/15

James Huang of Huawei Technologies presented “Low Latency Requirements of backhaul network for 5G” (see I-025att1)

Latency Requirements
- NGMN 5G White Paper
    - 10 ms E2E latency in general
    - 1 ms E2E latency for the use cases which require extremely low latency
- METIS
    - Generally 5time reduced E2E latency; less than 10ms
    - 10ms E2E for realtime remote computing
    - 8ms E2E for smart grid
    - 5ms E2E latency for V2V

Calc based on assumptions below:
- Total fiber length of S1 is 100km, propagation delay is 500us
- Total hops of S1 is 15
- In each device
    - 20us delay if no congestion happens
    - 120us delay if congestion happens, with strict priority scheduling

- 5ms delay if congestion happens, with WFQ

	Total delay	Propagation delay	Device delay
No congestion	0.8ms	0.5ms	0.3ms
Congestion SP schedule	2.3	0.5ms	1.8ms
Congestion WFQ	75.5	0.5ms	75

If there is congestion, the delay can meet 5G requirements
The analysis assumes the 5G network topology is similar to LTE (may not correct); D2D scenario is complex

Conclusion

- If there is no congestion, 5ms or 10ms RTT delay is possible
- If there is congestion, SP (Strict Priority) scheduling must be applied, and delay of high priority traffic can be guaranteed
- If 1ms E2E is desired, network architecture must evolve.

Possible Solutions

- Guarantee low network load, avoid ANY congestion
- EPC move to a lower position; less network nodes, shorter fiber length
- Resource reservation and planning to avoid congestion
  - RSVP, TSN in IEEE, DETNET in IETF, Others potential solutions

OPEN DISCUSSIONS AND WAY FORWARD

Hyungsoo Kim of KT Corporation presented "Proposal of Study Issue for FG on IMT-2020" (see I-009)

Spectrum is a scarce resource its utilization as a medium for connectivity is reaching its optimal level of efficiency today. With the ever-growing demand for speed and bandwidth, and an ever-increasing number of mobile devices requiring access to the network, the networks will need to be near ubiquitous and adapted to everyday objects. The solution lies in a new generation of high-speed hybrid networks increasingly based on robust wireline infrastructure. The necessity of the high-speed hybrid networks is evident from the Seoul Communique (ITU CJK CTO Consultation meeting: Apr. 14th, 2015).

The today's network, however, consists of networks with different functions and standards (e.g., 3G, 4G, and Wireline Network) and it is difficult to meet the ever-growing demand cost-effectively and operation-excellently. It is therefore necessary to achieve the attributes listed below to develop the next generation high-speed hybrid network for IMT 2020 network. This document will devote a section for each attribute to describe the requirements of IMT 2020 network.

- Integrated Architecture (Wireline & Wireless)
- Standardized Network Management
- Common end-to-end QoS

KT Corp. proposes that the Focus Group on IMT-2020 consider conducting an in-depth study on the suggested requirements of IMT-2020 network.

- Integrated Architecture
- Standardized Network Management
- Common end-to-end QoS

Hyungsoo Kim of KT Corporation presented "A Survey on QoS-related Studies and White papers for IMT-2020" (see I-010)

As noted in "Proposal of Study Issue for FG on IMT-2020" document, IMT-2020 network needs to support single common end-to-end QoS (Quality of Service) standard. The first step in establishing a common framework would be to identify the current status of QoS-related views and descriptions in relevant studies and white papers. This document therefore provides a survey on IMT-2020 QoS-related studies and white papers of the following organizations:

- International Organizations: NGMN, GSMA
- Regional Organizations: Horizon 2020, NetWorld2020, RAS Future Networks Cluster, 4G Americas
- Local Organizations: ARIB, Future Mobile Communication Forum of China, IMT-2020 Promotion Group, Huawei, ZTE, Nokia, Qualcomm, Ericsson, Samsung, NTT DoCoMo, Datang Telecom Technology & Industry Group

Conclusion

The differing and access-centric view of IMT-2020 QoS calls for a systematic and integrated approach to establish a common framework for end-to-end QoS. KT Corp. therefore proposes that the Focus Group on IMT-2020 consider the standardization of common QoS framework.

Hyungsoo Kim of KT Corporation presented "Gap Analysis of Different QoS Standards" (see I-011)

Definition of "End-to-End" in different standards

3GPP's concept of "end-to-end" comprehensively covers the whole network from a user's device to another user's device. However, its UMTS bearer concept is limited to an interval starting from user's device to PDN gateway (a gateway in wireless core network) for the sake of practicality (i.e., a network operator can influence only its network and its radio interface). (3GPP TS 23.107 Rel.12)

ITU-T, on the other hand, attempts to identify network QoS from end user to end user by defining UNI (User Network Interface) to UNI objectives in Y.1541. The concept, however, is usually applied to wireline IP-based services without any specific discretion on technologies of lower layers.

Layered Approach for QoS Management

The all-IP nature of IMT-2020 network allows data to be transported without connection on IP layer. With a given pair of source and destination IP address, IP packets are transferred from an end to another. The performance of an IP service, however, also depends on the performance of other layers (both upper and lower layers) and it is important to identify/acknowledge the relationship between performances of different layers.

ITU-T's Y.1540 standard provides a layered model of performance of IP service to illustrate the point aforementioned. The lower layers do not have end-to-end significance (i.e., it transfers packet from a point to another) but the type of technology employed (e.g., Ethernet-based leased lines) may affect the performance. Higher layers may also affect performance. 3GPP's bearer acknowledges the effect of various layers on IP services, but defines the bearer on layer 1 and 2 for the use of higher layers (3GPP TS 23.107 Rel. 12). Nevertheless, both acknowledge that the framework must take into account the impact from performance of layer 1 and 2 in both wireline and wireless media.

Conclusion and Topics for Further Study

The scope and the content of the existing standards are not sufficient to provide a common single end-to-end QoS standard. KT Corp. therefore proposes an in-depth study to further investigate/analyze different QoS standards and to develop a common single end-to-end QoS standard for IMT-2020 as follows:

- Definition and Terminologies
- Scope of "End-to-End"
- Classification and its objectives, etc.

Hyungsoo Kim of KT Corporation presented "Baseline document- QoS framework for IMT-2020" (see I-012)

Scope

This deliverable describes QoS-related general aspects and terminologies that are used to develop the commonly used terms in the study and management for QoS of IMT-2020. And guidance for relative parameters, classes of network QoS with objectives and allocation over multiple connectivity is indicated to be used in specifying and assessing the performance of IMT-2020 network and services.

This deliverable can be used by service providers in the planning, development and assessment of IMT-2020 service that meets user's quality needs; by equipment manufacturers as quality information that will affect equipment design; and by end users in evaluation of IMT-2020 service quality.

Network performance, Quality of Service and Quality of Experience

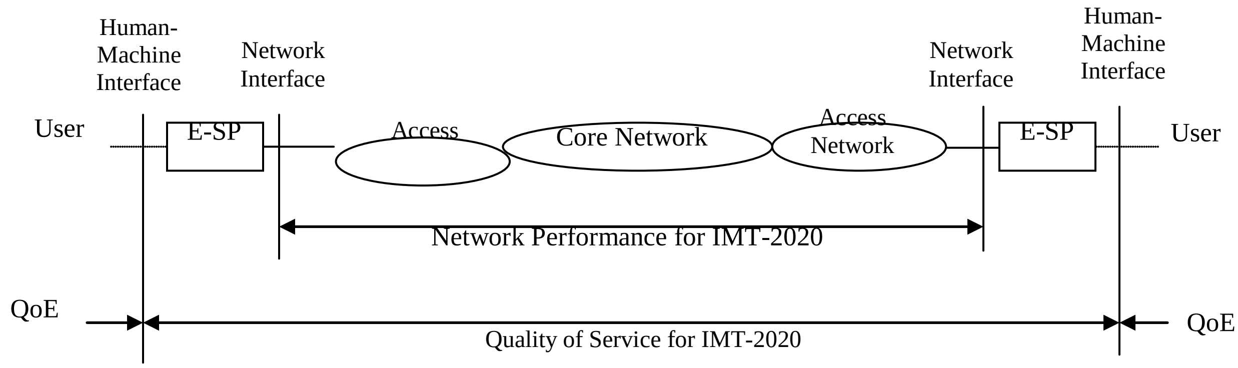
QoS is defined in Recommendation E.800 as follows: “Collective effect of service performance which determine the degree of satisfaction of a user of the service”.

The definition of QoS in Recommendation E.800 is comprehensive and encompasses many areas of work, including subjective user satisfaction. However, within this document the aspects of QoS that are covered are restricted to the identification of parameters that can be directly observed and measured at the point at which the service is accessed by the user.

Recommendation I.350 defines Network Performance as follows: “NP is measured in terms of parameters which are meaningful to the network provider and are used for the purpose of system design, configuration, operation and maintenance. NP is defined independently of terminal performance and user actions.”

QoE is defined as the overall acceptability of an application or service, as perceived subjectively by the end-user. Quality of Experience includes the complete end-to-end system effects. Overall acceptability should be influenced by user expectations and context.

Figure 1 illustrates how the concepts of QoS, NP and QoE can be applied in IMT-2020.



- ESP : End-Service Platform (i.e., Mobile/smart phone, data server, appliances, TV, etc.)

Figure 1. General reference configuration for QoS, NP and QoE

Editor’s Note 1: User-to-user communication is the basic consideration in this figure. In order to cover the IMT-2020 in broader perspective, the connectivity of IMT-2020 should facilitate Machine-to-machine/Device-to-device interfaces as well. This is for further study.

Editor’s Note 2: The above definitions and configuration are derived from existing general telecommunication terminologies. Based on the study result of new architecture for IMT-2020, those definitions and configuration (i.e., the coverage or location of wireless interface) may be changed. This is for further study.

QoS, NP and QoE are related concepts with different focus and scope.

QoS provides a valuable framework for network provider, but it is not necessarily usable in specifying performance requirements for particular network technologies (i.e. ATM, IP, MPLS, etc.). Similarly, NP ultimately determines the (user observed) QoS, but it does not necessarily describe that quality in a way that is meaningful to users.

QoE is subjective in nature, i.e. depend upon user actions and subjective opinions.

The definition of QoS, NP and QoE should make mapping clear in cases where there is not a simple one-to-one relationship among them.

Table 1 shows some of the characteristics which distinguish QoS, NP and QoE.

Table 1. Distinction between quality of experience, quality of service and network performance

Quality of Experience	Quality of Service	Network Performance
User oriented		Provider oriented
User behaviour attribute	Service attribute	Connection/Flow element attribute
Focus on user-expected effects	Focus on user-observable effects	Focus on planning, development (design), operations and maintenance
User subject	Between (at) service access points	End-to-end or network elements capabilities

The separation of QoS, NP and QoE indicates that development of corresponding parameters should take into account the following general points:

- the definition of QoS parameters should be clearly based on events and states observable at service access points and independent of the network processes and events which support the service;
- the definition of NP parameters should be clearly based on events and states observable at network element boundaries, e.g. protocol specific interface;
- the definition of QoE parameters is for further study.

Recommendation I.350 defines 3x3 matrix for QoS parameters with each row representing one of the three basic and distinct communication functions (access,[1] user information transfer[2] and disengagement[3]) and each column representing one of the three mutually exclusive outcomes possible when a function is attempted (speed[4], accuracy[5] and dependability[6]). Table 2 shows the defined 3x3 matrix for QoS parameters. The parameters are then mapped onto the matrix with outage thresholds defined.

QoS classes and their performance objectives

[1] Issuance of an access request signal or its implied equivalent at the interface between a user and the communication network

[2] Begins on completion of the access function and ends when the “disengagement request” is issued. It includes all formatting, transmission, storage, error control and media conversion operations performed on the user information during this period

[3] Issuance of a disengagement request signal

[4] Describes the time interval that is used to perform the function or the rate at which the function is performed

[5] Describes the degree of correctness with which the function is performed

[6] Describes the degree of certainty (or surety) with which the function is performed regardless of speed or accuracy

QoS requirements of the applications/services for IMT-2020 can be identified by an extremely wide range from best effort to very stringent level.

These various levels should be classified as follows:

1. Based on end-to-end user expectation of impairments and is therefore not dependent on any specific technology (network as well as application) for its validity. But the classification should be easily applied to network technologies for the purpose of implementation and operation.
2. Shows how the performance parameters (delay, delay variation, loss, etc.) and their objectives can be grouped appropriately, with implying that one class may "better" than another.

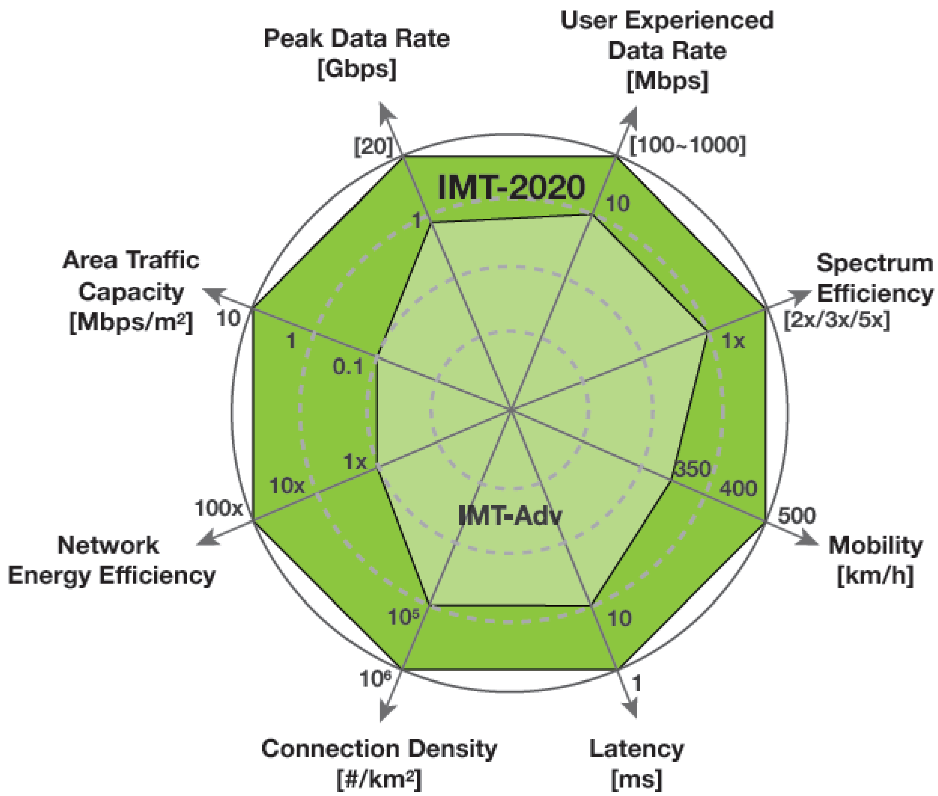
Specific QoS classes and their performance objectives for IMT-2020 are for further study.

Jian Wang of Ericsson presented "Proposal for work plan, structure and potential deliverables" (see I-016)

In order to perform the gap analysis, a survey of the relevant work will be needed, and by benchmarking upon it with our understanding we can discern the gaps to be filled. Therefore the task is twofold: survey the landscape of existing works which are pertinent to IMT-2020, and apply our knowledge to the survey so that we can find the areas to be further worked on in ITU-T. For the first part, fortunately there is already considerable work existing, which can provide us abundant useful material to compare and analyse, such as the work from NGMN, GSMA, 5G-PPP, METIS 2020 and activities from many countries.

Another very important input and source for the gap analysis is ITU-R, which is the key defining force of IMT-2020 and will have wide and profound impact on the non-radio part of IMT-2020. It is impossible to define the non-radio part of IMT-2020, without a clear understanding of its radio capabilities and characteristics.

Currently ITU-R WP 5D is working on the vision document (Preliminary Draft New Recommendation ITU-R M.[IMT.VISION] : IMT Vision – "Framework and overall objectives of the future development of IMT for 2020 and beyond") which will define the key technical parameters of IMT-2020 radio technology with their corresponding values, as illustrated below:



ITU-R WP 5D plans to finalise this vision document in the next meeting (10-18 June), right after our first FG meeting. So we will have a glimpse of the globally harmonized IMT-2020 vision before our second FG meeting. The latest draft can be found at Attachment 3.11 of 5D/929.

Based on the above observations, it is believed that we would need primarily two documents as deliverables. The first document would be an overview of use cases envisioned in the time frame of IMT-2020. The use cases are not necessarily all taken from the existing work in other organization; new use cases may be proposed as far as it is justified. The point is we can save effort by reviewing the work done by others and apply this accordingly to the scope of the FG.

The second document would be an overview of high-level requirement of non-radio part of IMT-2020, which in principle derives from the use cases. Here too we can learn from what is done by others, while at the same time we may add new requirements wherever it is deemed necessary.

Regarding the working structure, it is our belief that working in a single group, at least at the beginning, will create the biggest synergy and efficiency for the FG work. It may be tempting to split the meeting and create several working groups (such as one for use cases and one for high-level requirement etc.), but since we are still at the early stage of IMT-2020, the fundamental thing therefore would be to build up consensus and common understanding of IMT-2020 and the path it shall take. Besides, the work we are doing is highly inter-dependent and incremental, so working in a single thread will not only generate cohesion but also avoid discrepancy and diversion which would have to be remedied later with more energy.

Proposal
To fulfil the task of the FG, it's proposed to have the following documents as the primary deliverables:

- Overview of use cases for IMT-2020 regarding the non-radio part, including the visions and service aspects for non-radio part of IMT-2020;
- Overview of high-level requirement for non-radio part of IMT-2020, after the use cases work is substantially stable.

It is proposed to closely follow up the IMT-2020 work in ITU-R and other organizations, for example, by reviewing ITU-R IMT-2020 recommendations.

It is proposed to work together within one group, especially at the beginning of the FG lifetime, in order to form momentum and build up consensus and since the nature of our work is incremental.

Namseok Ko of ETRI presented "Work Group Proposal for IMT-2020" (see I-023)

Proposed structure of the FG on 5G
It is proposed that the FG organizes itself in working groups to work sequentially and in parallel depending on the characteristics on the study items:

1. Working Group 1: network architecture dependent (or closely coupled) working group
   - Service scenarios and requirements
   - Problem statements of existing networks
   - arkHigh-level network architecture
2. Working Group 2: network architecture independent (or loosely coupled) working group
   - QoS
   - Network management
   - Other works which do not have too much of dependency on network architecture

Namseok Ko of ETRI presented "Problem statement of current network technologies for emerging IMT-2020 services" (see I-024)

Network architecture with traffic centralization
A UE is connected to PDN through PGW in order to receive IP connectivity service in current 4G network. The connection is provisioned through hierarchical GTP tunnels between UE and PGW. Therefore, content servers or cloud are located in PDN, not inside EPC, and all the traffic has to pass through PGW. This traffic centralization causes the increase in load in a specific node and network resources are unnecessarily used in some cases.

Unoptimized traffic path
The issues from traffic centralization can be addressed partly by distributed PGW as in the study about decentralized EPC in FP7's Mobile Cloud Network project. However, protocol is not defined for the mobility between multiple PGWs in 3GPP yet, the PGW which a UE is attached first becomes the anchor for the traffic. The anchoring of traffic also causes the centralization of

traffic into a node and an unoptimized traffic path resulting in unnecessary use of network resources.

Network architecture which is not appropriate for low-latency service
Figure 8 compares the latency requirements of LTE and 5G (IMT-2020), which is given in GSMA white paper. The latency of existing network comes from the complexity of core network include GTP tunnelling and the location of servers outside of core network. In this kind of network architecture which has 20 ms of latency, tactile service cannot be realized.

Long latency from complex signalling
Aside from the signalling in radio access network, 4G has NAS and GTP-C signalling, which are complex and optimized for only existing mobile terminals, as well. This kind of intrinsic latency in control plane can be an obstacle to Tactile Internet as well.

Namseok Ko of ETRI presented "Baseline document – high-level network architecture for IMT-2020" (see I-022)

While there are several white papers and related works from other SDOs, industry groups, forums, etc, they are lack of describing the requirements and problems from the fixed network perspective. We propose that FG on IMT-2020 creates a new document to fill the gap while also considering the existing documents not to have unnecessary duplication.

After we identify the use cases, requirements, and issues in current network architectures, we finally need to propose a high-level network architecture based on the identifications, which will be given as an input for more detailed network architecture in our standardization process later on. Since these works – works on use cases, requirements, problem statements, and high-level network architecture – are closely related to each other, we propose that we work these in one document sequentially. By the way, if there is other works which does not have too much of dependency on the architecture and can be done separately for efficiency purposes, we agree on the approach as well.

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