5G Standardization
From New Services and Markets Technology Enablers to Next Generation System Architecture and Next Generation New Radio Access Technology

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September 9, 2016
Outline

• 3GPP Overview
• TSG Plenary Status for 5G
• New Services and Markets Technology Enablers
• Architecture for Next Generation System
• Next Generation Radio Access Technology
• TSG Plenary Status for LTE-Advanced Pro
• References
3GPP Overview
The role of 3GPP

- GSM, GPRS, W-CDMA, UMTS, EDGE, HSPA and LTE are all RAN Technologies specified by 3GPP
- Core network and Systems architecture evolution have kept pace
- Backward compatibility is a key element of each new 3GPP Release

The 3GPP Organizational Partners are

- Regional and National Standards Bodies;
- Companies participate through their membership of one of these 6 Partners

Source: 3GPP
Relationship between 3GPP and other SDOs

- **ITU-R/T**: Developing Recommendations (contributed by individual members)
- **Developing Wireless LAN/MAN specs**
- **IEEE**: Cross reference of specs
- **3GPP Partners**: Referring to 3GPP specs for the local specs
- **Organisational Partners**: Referring to 3GPP specs (contributed by individual members)
- **Developing Mobile application specs**
- **Developing internet protocol specs**
- **MRP**: Requirements
- **Terminal Certification based on 3GPP specs**

**Source**: 3GPP
4 Technical Specification Groups (TSG) which control their Working Groups (WGs)
TSGs meet 4 times/year, WGs in 1 or 2 times (for 1 week) between TSGs
WGs have up to 350 participants & handle up to 1300 Technical Documents per week
results are TSG approved Change Requests (CR) to modify Technical Specifications

Source: 3GPP
Scope of 3GPP TSG

TSG–SA
Service & System Aspects

TSG–RAN
Radio Access Networks

E-UTRAN
UTRAN
cNB

Node–B
RNC

TSG–CT
Core Network & Terminals

UE

LMSC
GMSC

CN

PS
Domain

SGW
PDG

CS
Domain

SGSN

GGSN

PSTN

Internet

Source: NEC
Evolution from 1G to 5G

1G (AMPS)  2G (GSM)  3G (384K)  3GPP R99  3.5G (42M)  4G (1Gps)  5G (10Gps, expect)

- Analog
- Digital
- Voice/SMS Service
- App/SNS Service
- Data/PS 3GPP R99

- 1980’s
- 1990’s
- 2000’s
- 2010’s
- 2020’s

Cloud/Big Data Service
- 100X 4G provide VRI Service + IoT
- Wearable Device Service
- RIT, R15/R16
- 5G (Phase 1)
- 5G (Phase 2)

- ITU-R M.1457 IMT-2000 Recommendation
- Release 9 (2009)
- Release 10 (2010)
- Release 11 (2011)
- Release 12 (2012)
- Release 13
- Release 14
- Release 15
- Release 16

- HSPA, R5
- HSDPA
- LCR TDD
- LTE
- LTE-Advanced
- LTE-A
- LTE-A, R10

- 1G (1Gps)
- 3.9G (300M)
- 3.5G (42M)
- 4G (1Gps)
- 5G = 1000X3G + IoT + VRI

- 1G
- 2G
- 3G
- 3.9G

- ITU

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• Rel-13 complete (including CIoT)
• Rel-14
  – completed (SA1),
  – under way (SA2, SA3, SA4, SA5, SA6).
  – Exceptions for stage 2 may arise.
• Rel-15 stage 1 will start in SA1 under TSG

Source: RP-160708 (SA Chair)
Next Generation

- Further progress on NR scope & workplan
  - Endorsed plan in RP-161253 (see also timeline in the next slide)

- Good progress on requirements & deployment scenarios
  - Next version of the TR will be available in RP-160810 (under email approval)
  - SI will be closed and TR will be approved in RAN#73.
    - In RAN#73 the approved TR will be sent to ITU-R WP5D

- Closed SI on channel modelling for frequencies above 6 GHz
  - Approved TR in RP-161301, sent to ITU-R WP5D in LS RP-161314

- Endorsed tasks for the WGs (RP-161269):
  - SA2 should deliver options 2, 4, 5 and 7 in line with the timeplan in 1253*
    - By March 17 we should understand if SA2 can deliver option 2,4,5 and 7
  - RAN2/3 should continue to work on option 3 (together with the other options)
    - Table in slide 10 of RP-161266 is confirmed (removes options 6 and 8)
  - R1/R2/R3/R4/S2 to ensure availability of forward compatibility and report to RAN#75
    - Forward compatibility between NSA and SA
    - Forward compatibility between scenarios

Source: SP-160482 (RAN Chair)
Release planning

• **Rel-13:**
  - Stage 1: completed in 09/2014,
  - Stage 2: completed June-December 2015
  - Stage 3: being completed since December 2015
  - ASN.1 freeze: Target date Mar 2016

• **Rel-14:**
  - Stage 1: Confirmed freezing date March 2016
  - Stage 2: Target date September 2016
  - Stage 3: Target date March 2017
  - ASN.1 freeze: Target date June 2017

• **Rel-15 (aka "5G phase 1"):**
  - Stage 1 freeze: June 2017
  - Stage 2 freeze: December 2017
  - Stage 3 freeze: June 2018
  - ASN-1 freeze: Sept 2018?

• **Rel-16 (aka "5G phase 2"):**
  - Stage 1 freeze: Dec 2018
  - Stage 2 freeze: June 2019
  - Stage 3 freeze: Dec 2019
  - ASN-1 freeze: Mar 2020?

Source: SP-160136 (MCC)
TSG Plenary Status for 5G

Release 14 ~ Release 15
## TSG Plenary Status for 5G

<table>
<thead>
<tr>
<th>3GPP Study/Work Item</th>
<th>Meeting</th>
<th>Release</th>
<th>Date</th>
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<tbody>
<tr>
<td>New Services and Markets Technology Enablers</td>
<td>SA#72</td>
<td>Rel-15</td>
<td>MAR 2016 ~ MAR 2017</td>
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<tr>
<td>Study on New Services and Markets Technology Enablers</td>
<td>SA#67</td>
<td>Rel-14</td>
<td>MAR 2015 ~ MAR 2016</td>
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<td>Study on Enhancement of 3GPP support for V2X service</td>
<td>SA#72</td>
<td>Rel-15</td>
<td>MAR 2016 ~ MAR 2017</td>
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<tr>
<td>FS_SMARTER - Massive Internet of Things</td>
<td>SA#70</td>
<td>Rel-14</td>
<td>DEC 2015 ~ JUN 2016</td>
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<tr>
<td>FS_SMARTER - Critical Communications</td>
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<td>FS_SMARTER - Network Operation</td>
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<tr>
<td>Study on Architecture for Next Generation System</td>
<td>SA#70</td>
<td>Rel-14</td>
<td>DEC 2015 ~ DEC 2016</td>
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<tr>
<td>Study on Channel model for frequency spectrum above 6 GHz</td>
<td>RAN#69</td>
<td>Rel-14</td>
<td>SEP 2015 ~ JUN 2016</td>
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<tr>
<td>Study on Scenarios and Requirements for Next Generation Access Technologies</td>
<td>RAN#70</td>
<td>Rel-14</td>
<td>DEC 2015 ~ SEP 2016</td>
</tr>
<tr>
<td>Study on Next Generation New Radio Access Technology</td>
<td>RAN#71</td>
<td>Rel-14</td>
<td>MAR 2016 ~ MAR 2017</td>
</tr>
</tbody>
</table>
The study aims

- to identify the market segments and verticals whose needs 3GPP should focus on meeting,
- to develop the use cases and requirements that the 3GPP eco-system would need to support in the future.

The focus of this work is on the use cases and requirements that cannot be met with EPS. The work is likely to span a number of 3GPP releases.

The use cases and high-level requirements can be sourced from existing work such as

4G Americas’ Recommendations on 5G Requirements and Solutions

Chinese IMT-2020 (5G) Promotion Association 5G white paper

ITU-R WP5Ds IMT Vision – Framework

The 5G Forum of Korea’s 5G White Paper

The NGMN 5G White Paper

The future development of IMT for 2020 and beyond

Develop several use cases covering various scenarios and identify the related high-level potential requirements

Identify and group together use cases with common characteristics

Select a few use cases (or groups of use cases with common characteristics) for further development

Start new individual building block study items for each use case or group of use cases identified in the previous step to further develop the use cases and their potential requirements, and capture desired system requirements and capabilities that apply across the different verticals. This is essentially a horizontal view of the potential requirements to complement the vertical use cases.

On completion of study items in the previous step, review and consolidate the resulting potential requirements from all of them

Target for Phase 1: Sep. 2015

Target for Phase 2: Mar. 2016

Source: S1-150300 (Vodafone)
Study on Architecture for Next Generation System

The study shall consider scenarios of migration to the new architecture. The expected work will include:

- Investigation of high-level architectural requirements.
- Definition of the terminology to be used as common language for architecture discussions.
- Definition of the high-level system architecture as the collection of required capabilities, and high level functions with their interactions between each other.

The architecture should be developed with the following non-exhaustive list of operational efficiency and optimization characteristics:

1. Ability to handle the rapid growth in mobile data traffic/device numbers in a scalable manner.
2. Allow independent evolution of core and radio networks
3. Support techniques (e.g. Network Function Virtualization and Software Defined Networking) to reduce total cost of ownership, improve operational efficiency, energy efficiency, and simplicity in and flexibility for offering new services.

Source: S2-153703 (China Mobile & Nokia)
Higher opportunities for wide-contiguous spectrum (Spectrum ranges allocated to MS by ITU Radio Regulation)

Frequency ranges supported by regional preparatory groups (toward WRC-19)

Source: RP-151373 & RP-151606 (Samsung)
Scenarios and Requirements for Next Generation Access Technologies

• The study item aims to develop deployment scenarios and requirements of next generation access technologies, and to provide guidance to the technical work to be performed in RAN WGs. In order to achieve this, the study item should fulfil the following objectives:
  – Identify the typical deployment scenarios associated with attributes such as carrier frequency, inter-site distance, user density, maximum mobility speed, etc.
  – For each usage scenario, develop specific requirements for next generation access technologies for the identified deployment scenarios.

Source: RP-152211 & RP-152257 (CMCC & NTT DoCoMo)
Next Generation New Radio Access Technology

1) Target a single technical framework addressing all usage scenarios, requirements and deployment scenarios defined in TR38.913 including
   - Enhanced mobile broadband
   - Massive machine-type-communications
   - Ultra reliable and low latency communications

2) The new RAT shall be inherently forward compatible
   - It is assumed that the normative specification would occur in two phases: Phase I (to be completed in June 2018) and Phase II (to be completed in December 2019)
   - Phase I specification of the new RAT must be forward compatible (in terms of efficient co-cell/site/cARRIER operation) with Phase II specification and beyond, and backward compatibility to LTE is not required
   - Phase II specification of the new RAT builds on the foundation of Phase I specification, and meets all the set requirements for the new RAT.
   - Smooth future evolution beyond Phase II needs to be ensured to support later advanced features and to enable support of service requirements identified later than Phase II specification.

Source: RP-160671 (NTT DoCoMo)
New Services and Markets Technology Enablers
“SMARTER” introduction

• Study on New Services and Markets Technology Enablers, 3GPP SA1 Study Item for Rel-14

• Objective to develop high-level use cases and identify the related high-level potential requirements for 5G

  - Use cases from TR 22.891 are grouped in 4 BB TRs
  - Normative requirements to follow in Release 15
Radio Interface Technology (RIT) definition

- The current definition of RAT in 21.905 is
  - Radio Access Technology: Type of technology used for radio access, for instance E-UTRA, UTRA, GSM, CDMA2000 1xEV-DO (HRPD) or CDMA2000 1x (1xRTT).

- In order to accommodate a wide range of use cases as described by the NGMN white paper, 5G air interface technologies will allow for more flexible operation and support a variety of communication purposes
  - Radio Interface Technology (RIT): Type of technology used for radio communication between two or more devices, without limitation to the functional capability or the purpose of the communication. A RIT may be used to provide a traditional access function, a backhaul function, a direct device-to-device (D2D) function between peers, or multiple such functions. A RIT may also support a variety of different communication modes (e.g., unicast, multicast, broadcast) and/or topologies (e.g., point-to-point, star, tree, or mesh).

Source: TR 22891v1.3.2
Four New Building Block Study Items for 5G

SA1 propose the following building block study items in the separated documents:
- Enhanced Mobile Broadband
- Massive Internet of Things
- Critical Machine Communications (ultra-reliable and low latency)
- Network operation (including Migration and Interworking)

<table>
<thead>
<tr>
<th>Company</th>
<th>New Services and Markets Technology Enablers</th>
<th>TR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Huawei</td>
<td>New Services and Markets Technology Enablers</td>
<td>TR 22.863</td>
</tr>
<tr>
<td></td>
<td>- Enhanced Mobile Broadband (eMBB)</td>
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<tr>
<td>Vodafone</td>
<td>New Services and Markets Technology Enablers</td>
<td>TR 22.861</td>
</tr>
<tr>
<td></td>
<td>- Massive Internet of Things (mIoT)</td>
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<tr>
<td>Nokia Networks</td>
<td>New Services and Markets Technology Enablers</td>
<td>TR 22.862</td>
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<tr>
<td></td>
<td>- Critical Communications (CriC)</td>
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<tr>
<td>China Mobile</td>
<td>New Services and Markets Technology Enablers</td>
<td>TR 22.864</td>
</tr>
<tr>
<td></td>
<td>- Network Operation (NeO)</td>
<td></td>
</tr>
</tbody>
</table>
The proposed use cases can be largely classified into five categories as below.

1) **Enhanced Mobile Broadband**: e.g. Mobile Broadband, UHD / Hologram, High-mobility, Virtual Presence

2) **Critical Communications**: e.g. Interactive Game / Sports, Industrial Control, Drone / Robot / Vehicle, Emergency

3) **Massive Machine Type Communications**: e.g. Subway / Stadium Service, eHealth, Wearables, Inventory Control

4) **Network Operation**: e.g. Network Slicing, Routing, Migration and Interworking, Energy Saving

5) **Enhancement of Vehicle-to-Everything**: e.g. Autonomous Driving, safety and non-safety aspects associated with vehicle

Source: TR 22891v14
### enhanced Mobile Broadband (eMBB) use case

#### Higher Data Rates
- 5.5 Mobile broadband for indoor scenario
- 5.6 Mobile broadband for hotspots scenario
- 5.56 Broadcasting Support
- 5.71 Wireless Local Loop

#### Deployment and Coverage
- 5.5 Mobile broadband for indoor scenario
- 5.10 Mobile broadband services with seamless wide-area coverage
- 5.11 Virtual presence
- 5.30 Connectivity Everywhere
- 5.66 Broadband Direct Air to Ground Communications (DA2GC)
- 5.71 Wireless Local Loop
- 5.72 5G Connectivity Using Satellites

#### Higher User Mobility
- 5.6 Mobile broadband for hotspots scenario
- 5.10 Mobile broadband services with seamless wide-area coverage
- 5.29 Higher User Mobility
- 5.53 Vehicular Internet & Infotainment
- 5.66 Broadband Direct Air to Ground Communications (DA2GC)

#### Higher Density
- 5.5 Mobile broadband for indoor scenario
- 5.6 Mobile broadband for hotspots scenario
- 5.7 On-demand networking
- 5.32 Improvement of network capabilities for vehicular case
## Critical communications (CriC) use case

### Higher reliability and lower latency

- 5.1 Ultra-reliable communications
- 5.11 Virtual presence
- 5.18 Remote control
- 5.44 Cloud Robotics
- 5.45 Industrial Factory Automation
- 5.46 Industrial Process Automation
- 5.50 Low-delay speech coding
- 5.54 Local UAV Collaboration
- 5.68 Telemmedicine Support

### Higher accuracy positioning

- 5.12 Connectivity for drones
- 5.18 Remote control
- 5.43 Materials and inventory management and location tracking
- 5.54 Local UAV Collaboration
- 5.55 High Accuracy Enhanced Positioning (ePositioning)

### Higher availability

- 5.72 5G Connectivity Using Satellites

### Mission critical services

- 5.1 Ultra-reliable communications
- 5.2 Network Slicing
- 5.3 Lifeline communications / natural disaster
- 5.12 Connectivity for drones
- 5.31 Temporary Service for Users of Other Operators in Emergency Case
- 5.54 Local UAV collaboration
- 5.65 Moving ambulance and bio-connectivity
- 5.66 Mobile ambulance and bio-connectivity
- 5.72 5G Connectivity Using Satellites

### Very low latency

- 5.14 Tactile internet
- 5.15 Localized real-time control
- 5.17 Extreme real-time communications and the tactile Internet

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# massive Internet of Things (mIoT) use case

## Operational Aspects
- 5.19 Light weight device configuration
- 5.21 IoT Device Initialization
- 5.22 Subscription security credentials update
- 5.24 Bio-connectivity
- 5.25 Wearable Device Communication
- 5.40 Devices with variable data
- 5.41 Domestic Home Monitoring
- 5.59 Massive Internet of Things M2M and device identification
- 5.63 Diversified Connectivity
- 5.67 Wearable Device Charging

## Connectivity Aspects
- 5.24 Bio-connectivity
- 5.25 Wearable Device Communication

## Resource Efficiency Aspects
- 5.20 Wide area monitoring and event driven alarms
- 5.24 Bio-connectivity
- 5.25 Wearable Device Communication
- 5.40 Devices with variable data
- 5.41 Domestic Home Monitoring
- 5.42 Low mobility devices
- 5.43 Materials and inventory management and location tracking
- 5.60 Light weight device communication
Network Operation (NEO) use case

System flexibility

5.2 Network slicing
5.8 Flexible application traffic routing
5.37 Routing path optimization when server changes
5.48 Provision of essential services for very low-ARPU areas
5.49 Network capability exposure
5.56 Broadcasting Support
5.57 Ad-Hoc Broadcasting
5.64 User Multi-Connectivity across operators
5.69 Network Slicing – Roaming
5.70 Broadcast/Multicast Services using a Dedicated Radio Carrier
5.74 Priority, QoS and Policy Control

Scalability

5.7 On-demand networking
5.9 Flexibility and scalability
5.35 Context Awareness to support network elasticity
5.51 Network enhancements to support scalability and automation

Mobility support

5.34 Mobility on demand
5.42 Low mobility devices
5.47 SMARTER Service Continuity

Security

5.62 Device Theft Preventions / Stolen Device Recovery

Efficient content delivery

5.36 In-network & device caching
5.38 ICN Based Content Retrieval
5.39 Wireless Briefcase

Self-backhauling

5.6 Mobile broadband for hotspots scenario
5.52 Wireless Self-Backhauling
5.61 Fronthaul/Backhaul Network Sharing

Access

5.3 Lifeline communications / natural disaster
5.23 Access from less trusted networks
5.26 Best Connection per Traffic Type
5.27 Multi Access network integration
5.28 Multiple RAT connectivity and RAT selection
5.31 Temporary Service for Users of Other Operators in Emergency Case
5.55 High Accuracy Enhanced Positioning (ePositioning)
5.58 Green Radio
5.71 Wireless Local Loop
5.72 5G Connectivity Using Satellites

Migration and interworking

5.4 Migration of services from earlier generations
5.16 Coexistence with legacy systems

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eV2X use case and Timeline

5.10 Mobile broadband services with seamless wide-area coverage

5.32 Improvement of network capabilities for vehicular case

5.33 Connected vehicles
Capabilities of Future IMT systems

Source: Output from SA1 SMARTER ad-hoc meeting
Time Delay Scenarios and Analysis

There are several cases for the E2E delay definition in the local communication scenario (e.g. with ultra-low latency requirement) as shown in Figure x1. Note that the numbers in the figure indicate the component links of a communication path, for example, 1 refers to the link from a UE to an eNB.

a) via 1, 8 (in red): RTT (round-trip-time) for Uu interface
b) via 1, 6, 7, 8 (in blue): E2E communication. Normally it doubles the time delay in case a).

c) via 1, 2, 3, 4, 5, 8 (in yellow): from UE to the APP Server

Source: S1-152728 (Huawei, Vodafone)
Time Delay Scenarios and Analysis

There are several cases for the E2E delay definition in the remote scenario (e.g. with low latency requirement) as shown in Figure x2 below:

a) via 1, 2, 5, 8, 9, 10, 11, 12, 13, 14 (in blue): E2E communication via different EPCs in remote cities.

b) via 1, 2, 3’, 4’, 13, 14 (in yellow): from UE to APP Server (Client-Server). In this case but the APP Server is far away from EPC1.

The E2E time delay will be longer if we consider the process delay in each nodes.

Source: S1-152728 (Huawei, Vodafone)
Physical Limit for E2E Time Delay

The propagation delay is limited by physics, i.e. the **speed of light** (299 792 458 meters per second) in air and 2/3 of the speed of light in fibre connection. With these limits, 1ms one way transmission latency can be mapped to 300 km air propagation or 200 km for fiber based transmission as shown in left Figure.

### A.3 Conclusions

1. **Local Communication:**
   - E2E time delay can not be less than **1ms**.

2. **Remote Communication:**
   - E2E time delay can not be less than **10ms**.

Source: 3GPP TR 22.891 v.1.1.0
SA Statue Summary

• SA1 start **four building block study item** for the identified use case group:
  – to identify and document the key families of use cases and their consolidated potential requirements
  – to capture desired system requirements and capabilities

• The target for the completion of **building block study item** is **March 2016**.

• Work on 5G (**the next generation system architecture**) has started in SA2 and the approval of the Study Item has triggered discussion via the SA2 email reflector (as well as offline) on SA2 work planning.

• TSG SA endorses that work on the next generation system architecture shall be allowed to be **run in parallel** to other topics without scheduling restrictions.
Architecture for Next Generation System
Architecture options in the light of 5G

- Two radio technologies have to be considered in the 5G discussions
  - LTE (in its Rel-15 version)
  - Next generation Radio (NR)
- Plus radio level aggregation of both radio technologies
- Two Core Network concepts have to be considered in the 5G discussions
  - EPC (with potential evolutions)
  - Next Generation Core (NGCN)
- This results in 8 options

Source: SP-160455 (T-Mobile)
5G scenarios in 3GPP NR & NextGenCore (1/4)

1) Standalone LTE, EPC connected - legacy

2) Standalone NR, NGCN connected

Source: SP-160455 (T-Mobile)
5G scenarios in 3GPP NR & NextGenCore (2/4)

3) Non-Standalone/"LTE assisted", EPC connected

Source: SP-160455 (T-Mobile)
5G scenarios in 3GPP NR & NextGenCore (3/4)

4) Non-Standalone/”NR assisted”, NGCN connected

Source: SP-160455 (T-Mobile)
5G scenarios in 3GPP NR & NextGenCore (4/4)

7) Non-Standalone/"LTE assisted", NGCN connected

7a) Non-Standalone/"LTE assisted", NGCN connected

Source: SP-160455 (T-Mobile)
Key Migration Paths

• **Option 1 → Option 7 → Option 2 / Option 4**
  – This is the likely migration path for operators who are interested in upgrading their current LTE RAN infrastructure to connect to NextGen Core. With eLTE not being a legacy technology, and due to potential significant coverage differences dependent upon spectrum availability, it is possible that this intermediate step may exist over a long period of time.

• **Option 1 → Option 3 → Option 2 / Option 4**
  – This is the likely migration path for operators who want to reuse their existing LTE RAN and core. Moving from Option 3 to Option 2 maybe as significant a step as moving from LTE/EPC directly to Option 2.

• **Option 1 → Option 3 → Option 7 → Option 2 / Option 4**
  – For those operators wanting to start with Option 3, it is not clear how long Option 3’s intermediate step can last and if it will require migrating to Option 7 or can go straight to Option 2/ Option 4. Some further analysis of migrating from Option 3 to Option 7 should be done as part of this work to determine its viability.

• **Option 1 → Option 2 / Option 4**
  – This is the likely migration path for operators who do have spectrum availability to allow wide area coverage of NR in standalone mode.

Source: S2-164017 (AT&T)
Architecture(s) for the Next Generation System

- MM Control Function (MMCF)
- Authentication Function (AUF)
- Subscriber Database (SDM)
- SM Control Function (SMCF)
- Policy Function (PF)
- Application Function (AF)

Interconnection & Routing Function (IRF)

UE → (R)AN → Interconnection & Routing Function (IRF)

NG1 → NG2 → NG3 → NG4 → NG5 → NG6 → NG7 → NG8 → NG9 → NG10

Source: TR 23.799-070
5G RAN and Core: Network Function Virtualization

Source: NETMANIAS TECH-BLOG (E2E Network Slicing - Key 5G technology)
Network slicing between Edge and Core clouds

Source: NETMANIAS TECH-BLOG
Next Generation Radio Access Technology
Use Cases & Services

• Three emerging high level use cases for Next Generation Radio Technology (also from IMT 2020 discussion):
  1. Enhanced Mobile Broadband
  2. Massive Machine Type Communications
  3. Ultra-reliable and Low Latency Communications

• Wide agreement that the Next Generation Radio Technology should be able to support a variety of new services
  – Automotive, Health, Energy, Manufacturing …
  – Some of these new services are being described by SA1 in the SMARTER project

Source: RWS150073 (RAN Chair)
New radio

- Emerging consensus that there will be a **new, non-backward compatible, radio** as part of Next Generation Radio Technology
  - Strong **LTE evolution continued in parallel**
- The requirements and scope of the new radio will be established by RAN in the **Rel-14 SI starting in December**
  - WGs will then proceed with the evaluation of technology solutions in the SI starting in March

Source: RWS150073 (RAN Chair)
Interworking & System Architecture

- There seems to be a need to also rethink the **System Architecture** for “5G”
  - This will be debated under the **new SI to be approved by SA Plenary**

- The level of **interworking of the new radio with the legacy systems** needs to be discussed more in detail – different opinion & nuances seems to exist
  - This discussion will be done in cooperation with **SA group**
    (for this it may be also useful the joint workshop tentatively planned for **H2-16**)

Source: RWS150073 (RAN Chair)
Emerging consensus that there should be two phases for the normative work

- **Phase 1 to be completed by H2 2018** to address a more urgent subset of the commercial needs (to be agreed)
- **Phase 2 to be completed by Dec 2019** for the IMT 2020 submission and to address all identified usecases & requirements

The above implies the following, tentative, release timing

NOTE: Dates above refer to “stage-3 functional freeze” of specs (what matters for the ITU-R submission). ASN.1 freeze is typically one quarter after that.

Source: RP-151660 (RAN Chair)
RAN Statue Summary

• RAN to confirm SA tentative planning, with following tentative release (stage-3) freeze dates:
  – Rel-14 stage-3 freeze in March 2017
  – Rel-15 stage-3 freeze in June 2018
  – Rel-16 stage-3 freeze in Dec 2019 → basis for the submission to ITU-R

• ITU-R AH to prepare for RAN#71 a living document with a plan for the whole interaction with ITU-R on IMT 2020

• WG Chairs should start planning to accommodate after March a track for the work on the new radio, in addition to the existing WG capacity that will continue to be dedicated to the LTE evolution (and HSPA enhancements)

Source: RP-151660 (RAN Chair)
Timeline for NR and NexGen

1. TSG-RAN#73, September 2016:
   5G NR Requirements TR completion

2. TSG-SA#74, Dec/2016:
   NexGen TR completion Approval of SA2 WID

3. CHECKPOINT: TSG#75: March 2017:
   - Completion of NR SI with corresponding performance evaluation and concepts;
   - Approval of RAN WID(s);
   - Report from RAN1/RAN2/RAN3/RAN4/SA2 on fwd compatibility of NSA and SA NR;
   - Report from SA2 on migration;
   - SA and CT timeline coordination;
   - Reconfirmation of NR & NexGen timeplan, including completion target for NSA higher layer components (box 6)

4. TSG-SA#77 or TSG-SA#78:
   NexGen stage-2 freeze.

5. TSG-RAN#78, December 2017:
   - Stage-3 freeze for Non-Standalone higher layers (including components common with standalone). Completion target TBD.

6. RAN#78/RAN#79:
   Stage-3 freeze for Non-Standalone higher layers (including components common with standalone). Completion target TBD.

7. TSG#80, June 2018:
   Release 15 stage 3 freeze for NR and NexGen, including Standalone.

Note: SA: Standalone
NSA: Non-Standalone
TSG Plenary Status for LTE-Advanced Pro

Release-13 ~ Release-14
Following the successful choice by the PCG of new nomenclature for LTE to take effect from Release 13 onwards, Rel-13 and later 3GPP Specs will carry a new logo, replacing the LTE Advanced logo.

The original LTE logo will continue to be applied to Rel-8 and -9 Specs, and the LTE Advanced logo to Rel-10, -11 and -12.

Releases 8, 9

Releases 10, 11, 12

Releases 13, 14, …

Source: SP-150769_RP-151645_CP-150853 (MCGC)
<table>
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<td>Architecture enhancements of cellular systems for ultra low complexity and low throughput Internet of Things</td>
<td>SA#70</td>
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<td>JUN 2016 ~ SEP 2017</td>
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</table>
Narrow Band IOT (NB-IOT)

- The new technology will provide **improved indoor coverage**, support of **massive number** of **low throughput devices**, **low delay sensitivity**, **ultra-low device cost**, **low device power consumption** and **optimized network architecture**.

- The technology can be deployed “**in-band**”, utilizing resource blocks within a normal LTE carrier, or in the unused resource blocks within a LTE carrier’s **guard-band**, or “**standalone**” for deployments in dedicated spectrum.

- Single-tone transmission support is a mandatory part of the NB-IoT UE category
  - Both subcarrier spacings, 3.75 kHz and 15 kHz, are mandatory components of the NB-IoT UE category
  - Provide an IOT bit to indicate whether UE supports 15 kHz multi-tone transmission.

Source: RP-151621
LTE enhancements for Machine-Type Communications

The key objective of the work is to define a new low complexity UE category type that supports **reduced bandwidth**, **reduced transmit power**, **reduced support for downlink transmission modes**, **ultra-long battery life** via power consumption reduction techniques and **extended coverage** operation.

- **Reduced bandwidth**: to specify **1.4 MHz operation** at the terminal within any LTE system bandwidth, allowing operators to multiplex reduced bandwidth MTC devices and regular devices in their existing LTE deployments.

- **Extended coverage**: to improve by **15dB** the coverage of delay-tolerant MTC devices, allowing operators to reach MTC devices in poor coverage conditions e.g. meters located in basements.

Source: RP-141645 (Ericsson)
An essential component of the study is to ensure **coexistence between LTE with WiFi** and to provide a fair opportunity in accessing the unlicensed spectrum.

In terms of deployment scenarios, the focus will be on Licensed-Assisted Aggregation (LAA) operation to aggregate a **primary cell** - using **licensed spectrum** - to deliver critical information and guaranteed Quality of Service, and a **secondary cell** - using **unlicensed spectrum** - to opportunistically boost data rate.

The secondary cell operating in unlicensed spectrum could be configured either as **downlink-only cell** or contain both **uplink and downlink**.

Source: RP-141615 & RP-141664 (Ericsson & Huawei)
Further Enhancements to LTE Device to Device

• D2D transmission using NB-IoT uplink waveform
  – Changes needed for multi-tone transmissions are likely small
  – Single tone transmission requires more changes
  – Some signaling & procedure changes maybe needed

• MTC: No major changes needed
  – No waveform incompatibility between D2D and MTC
  – Some signaling & procedure changes maybe needed

• Unidirectional relays do not suffer from half duplex issue on D2D
  – Enables a single relay to relay larger number of remote UEs
  – Each household is expected to have a large number of MTC devices

Source: RP-160268 & RP-160677 (Qualcomm)
Further Enhancements to LTE Device to Device

**IoT**

- Single modem solution for proximal and cellular communication
- Operator controlled proximal communication
- Deep coverage operation (MCL 165dB)
- Large amount of bundling needed – power impact
- Relaying can reduce the power consumption

**Wearable**

- Wearables getting increasingly complex
- Moving towards independent operation with full LTE modem
- D2D advantages: range, security, power, throughput, & device cost
- Example: lower end device with lower max transmit power and throughput capability

Source: RP-160268 & RP-160677 (Qualcomm)
ELIOT

Enhancing Location Capabilities for Indoor and Outdoor Emergency Communications

The topics covered includes, but not limited to developing or enhancing existing emergency location service requirements arising from the Roadmap and the Fourth Report and Order:

1. **Reporting vertical location requirements for emergency calls** which may be based on measurements of physical and environmental conditions (e.g. compensated barometric pressure) or other positioning technologies

2. Supporting and delivering a dispatchable address (civic address with detail to floor/room/suite number) of a **mobile caller's location** to the PSAP for **emergency calls**

3. Defining **emergency location performance metrics** including those based on physical and environmental properties

4. Support technology alternatives demonstrating **indoor location accuracy improvements** (e.g. A-GPS, TBS, multi-lateration)

Source: SP-150044 & S1-150065 (Sprint)
The Indoor Positioning study will first determine the performance of already specified positioning methods in indoor environments and later evaluate potential improvements to the existing methods, or new methods, in order to achieve improved positioning accuracy.

While initially driven by the FCC request to improve the positioning accuracy in indoor environments for emergency calls, the work can further expand the capability of the LTE platform - allowing operators to address the growing market of indoor positioning.

Source: RP-140967 & RP-141003 (NextNav)
The goal is to study enhancements for **LTE to operate in unlicensed spectrum**. While licensed spectrum remains operators’ top priority to deliver advanced services and user experience, the opportunistic use of unlicensed spectrum is becoming an important complement to meet the growing traffic demand.

Source: RP-141615 & RP-141664 (Ericsson & Huawei)
LTE support for V2X service

- The vehicular communication in this study, referred to as Vehicle-to-Everything (V2X), contains the following three different types:
  - **Vehicle-to-Vehicle (V2V) Communications**
  - **Vehicle-to-Infrastructure (V2I) Communications**
  - **Vehicle-to-Pedestrian (V2P) Communications**

- Introduction of V2X applications (use cases)
  - V2V use cases
    - e.g. Forward car collision warning, ...
  - V2I use case
    - e.g. advanced navigation/telematics, cloud services, ...
  - V2P use case
    - e.g. Pedestrian protection (threat alert) from car collision, ...

Source: SP 150165 & S1-150284 (LG)
LTE-based V2X Services

- RAN WGs are ready for WI on PC5-based V2V.
  - Early completion of the corresponding specifications will enable fast preparation for device implementation and network deployment
- A WI is proposed with the following objective:
  - Core part
    - To specify enhancement to sidelink physical layer structure necessary for V2V services
    - To specify enhancement to sidelink synchronization procedure necessary for V2V services
    - To specify necessary sidelink resource allocation enhancement option(s) for V2V services
    - To specify necessary radio protocols and RRC signaling
    - To specify UE Tx and Rx RF requirement covering operations at up to 6 GHz carrier
    - To specify RRM core requirement
  - Performance part
    - To specify demodulation requirements and RRM performance for the UE

Example of V2V use cases (Forward Collision Warning)
Example of V2P use case (Pedestrian Collision Warning)

Source: RP-151109 & RP-150777 & RP-151942 (LG)
References
3GPP FTP Server (Regular)

SA – http://www.3gpp.org/ftp/tsg_sa/TSG_SA/
SA1 – http://www.3gpp.org/ftp/tsg_sa/WG1_Serv/
SA2 – http://www.3gpp.org/ftp/tsg_sa/WG2_Arch/
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SA6 – http://www.3gpp.org/ftp/tsg_sa/WG6_MissionCritical/

RAN – http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/
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RAN3 – http://www.3gpp.org/ftp/tsg_ran/WG3_Iu/
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GERAN1 – http://www.3gpp.org/ftp/tsg_geran/Wg1_Radio_Aspects/
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Thank You

Winning works of 2013 III Photography Competition