LTE evolution and 5G

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Introduction

- 3GPP continues to expand the LTE platform to new services, while improving its efficiency to meet the increasing mobile broadband demand

- At the same time 3GPP has started to work on the standardization of next generation cellular technology, aka 5G, to address the expanded connectivity needs of the future

- This presentation discusses the main features being defined for the evolution of LTE, and the initial plans for 5G

LTE evolution

Focus on areas significantly expanding LTE platform capability and opportunities

Offload to unlicensed spectrum

- Licensed spectrum remains 3GPP operators' top priority to deliver advanced services and user experience
- Opportunistic use of unlicensed spectrum will be an important complement to meet the growing traffic demand
- Moving forward 3GPP operators will have two options to offload traffic to unlicensed spectrum:

1. Wi-Fi (via **LTE/Wi-Fi interworking**)
2. **Licensed Assisted Access** to unlicensed spectrum, aka **LAA**

LTE/Wi-Fi interworking

- Framework developed since the first release of LTE
  - With tighter and tighter forms of interworking added in subsequent releases

- To cater to operators' demand, in Release-13 3GPP defined a number of new interworking features:
  - LTE-WLAN Aggregation (**LWA**)
    - Allows aggregating LTE and WLAN downlink radio links
    - LWA is controlled by LTE eNB, based on UE measurement reporting; no interaction with LTE Core Network
    - Key drivers: performance, mobility, eliminating need for WLAN-specific Core Network nodes
  - LTE WLAN Radio Level Integration with IPsec Tunnel (**LWIP**)
    - Tight radio-level interworking allowing an LTE eNB to quickly toggle between the two radio links
    - LWIP is controlled by LTE eNB, based on UE measurement reporting; WLAN is hidden from CN (except for authentication)
    - UE uses WLAN via IPsec tunnel between eNB and UE
    - Key drivers: fast time to market, use of legacy WLAN infrastructure

- For Release 14 3GPP is working on
  - Enhanced LWA (eLWA): uplink support, enhanced mobility, optimizations for high data rate 802.11 techs
  - Enhanced LWIP (eLWIP): flow control, measurement support over Xw

LAA

- Modified LTE radio to operate in unlicensed spectrum (5GHz)
  - Includes features such as Listen-Before-Talk (LBT), Discontinuous TX, Dynamic Frequency Selection, Carrier selection, Transmit Power Control…
  - Key objective: fair coexistence between LTE and Wi-Fi as well as between LTE operators
- License-Assisted Access operation, aggregating
  - A primary cell operating in licensed spectrum to deliver critical information and guaranteed Quality of Service
  - A secondary cell operating in unlicensed spectrum to opportunistically boost datarates
- In Release 13 3GPP defined downlink LAA operation
  - Feature design is essentially frozen, where only essential corrections are allowed (based on consensus)
  - 3GPP is now defining a set of tests to check LAA coexistence performance
- LAA Uplink support likely to follow in Release 14
- Extensive and fruitful dialog with other industry stakeholders, including IEEE and WFA

Cellular IoT

- In Release-13 3GPP made a major effort to address the IoT market by defining:

1. **eMTC** Further LTE enhancements for Machine Type Communications
2. **NB-IOT** New radio added to the LTE platform optimized for the low end of the market
3. **EC-GSM-IoT** EGPRS enhancements which make GSM/EDGE markets prepared for IoT

- In Release-14 3GPP is enhancing the above technologies
  - Positioning enhancements [*eMTC, NB-IOT, EC-GSM-IOT*]
  - Multicast, mobility enhancements for [*eMTC, NB-IOT*]
  - New power classes, access/paging enhancements [*NB-IOT*]
  - Higher data rates and VoLTE support for [*eMTC*]

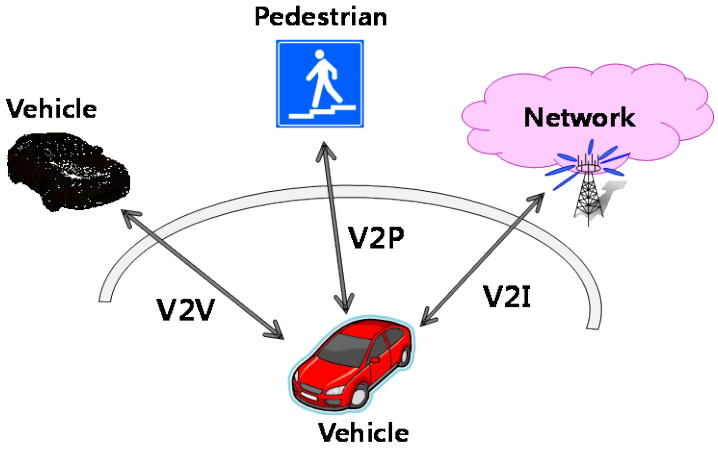
Rel-13 eMTC, NB-IOT and EC-GSM-IoT

	eMTC (LTE Cat M1)	NB-IOT	EC-GSM-IoT
Deployment	In-band LTE	In-band & Guard-band LTE, standalone	In-band GSM
Coverage*	155.7 dB	164 dB for standalone, FFS others	164 dB, with 33dBm power class 154 dB, with 23dBm power class
Downlink	OFDMA, 15 KHz tone spacing, Turbo Code, 16 QAM, 1 Rx	OFDMA, 15 KHz tone spacing, TBCC, 1 Rx	TDMA/FDMA, GMSK and 8PSK (optional), 1 Rx
Uplink	SC-FDMA, 15 KHz tone spacing Turbo code, 16 QAM	Single tone, 15 KHz and 3.75 KHz spacing SC-FDMA, 15 KHz tone spacing, Turbo code	TDMA/FDMA, GMSK and 8PSK (optional)
Bandwidth	1.08 MHz	180 KHz	200kHz per channel. Typical system bandwidth of 2.4MHz. 600 kHz considered feasible for static, small data applications
Peak rate (DL/UL)	1 Mbps for DL and UL	DL: ~60 kbps UL: ~50kpbs (multi-tone), ~20 kbps (single tone)	For DL and UL (using 4 timeslots): ~70 kbps (GMSK), ~240kbps (8PSK)
Duplexing	FD & HD (type B), FDD & TDD	HD (type B), FDD	HD, FDD
Power saving	PSM, ext. I-DRX, C-DRX	PSM, ext. I-DRX, C-DRX	PSM, ext. I-DRX
Power class	23 dBm, 20 dBm	23 dBm, others TBD	33 dBm, 23 dBm

** In terms of MCL target. Targets for different technologies are based on somewhat different link budget assumptions (see TR 36.888/45.820 for more information).*

LTE-based V2X

- In Release 14 3GPP is expanding the LTE platform to support V2X applications
- V2X will include two complementary transmission modes
  - Direct communication:
    - Building upon LTE D2D with enhancements for high speeds, high density, improved synchronization and low latency
  - Network communication:
    - Enabling broadcast of messages from a V2X server to vehicles and beyond; Vehicles can send messages to server via unicast
- The initial features needed to support V2V safety applications were finalized in September 2016
- The broader V2X framework will be finalized in March 2017



Low latency LTE

- 3GPP is working on a major enhancement to the LTE air interface to shorten latency over-the-air
- The goal is to improve performance and user experience of existing services as well as to enable new delay critical services
- Target enhancements:
  - Shortened processing time to be completed by March 2017
  - Shortened TTI operation (2-symbol, 4-symbol, and 1-slot) to be completed by June 2017

Others: a lot more going on…

- Work Items
  - RP-160680, Downlink Multiuser Superposition Transmission for LTE
  - RP-160623, Enhancements on FD-MIMO for LTE
  - RP-160675, eMBMS enhancements in LTE
  - RP-160664, Uplink Capacity Enhancements for LTE
  - RP-160676, SRS Carrier Based Switching for LTE
  - RP-160667, L2 latency reduction techniques for LTE
  - RP-160540, Signalling reduction to enable light connection for LTE
  - RP-160636, Mobility enhancement in LTE
  - RP-160538, Further Indoor Positioning enhancements for UTRA and LTE WI
  - RP-161856, Voice and Video enhancement for LTE
  - RP-161896, Flexible eNB-ID and Cell-ID in E-UTRAN

- Study Items
  - RP-160665, Further enhancements to CoMP operation
  - RP-160633, Study on Context Aware Service Delivery in RAN
  - RP-160571, Study on HSPA and LTE Joint Operation
  - RP-161181, SON for eCoMP for LTE

5G

3GPP submission to IMT-2020

- 3GPP submission to IMT 2020 (aka 5G) will include
  - “New Radio of 5G”, aka NR
  - LTE

- It is for later discussion whether this will be done in a single or two RITs (formal submissions) and how the evaluation process will be organized
  - This will also depend on the criteria defined by WP5D for IMT-2020 technologies

- NR shall eventually address all identified requirements and use cases

Timeline & phasing

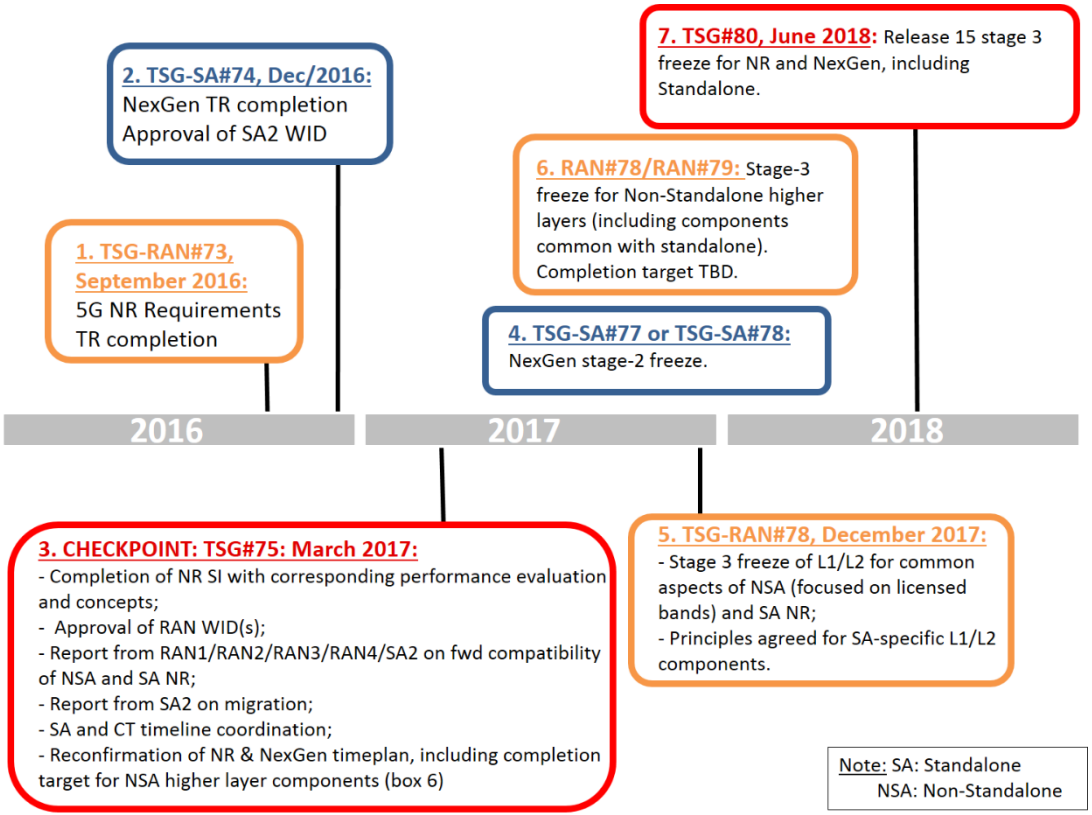
- There will be **two phases** for the normative work
  - The first release of the 5G specification will be completed by Sep. 2018/Release-15, addressing the more urgent subset of the commercial needs
  - The second release of the 5G specification to be completed by Mar. 2020/Release-16, for the IMT 2020 submission and to address all identified use cases & requirements

- With the following, tentative, release timing

Note: dates above refer to official 3GPP release freeze (ANS.1 freeze)

- Key requirement: NR design should be **forward compatible** at its core so that features can be added in later releases in an optimal way

Release-15 workplan



Release-15 targets

- Two main deployment scenarios:
  - Non-Standalone (NSA) NR deployment
  - Standalone (SA) NR deployment

  NSA NR in this context implies using LTE as control plane anchor. SA NR implies full control plane capability for NR

- Different architecture options being evaluated
  - Decisions as to which option will be standardized will be taken in Dec. 2016 or Mar. 2017

- Use cases
  - Enhanced Mobile Broadband
  - Some Low Latency and High Reliability capabilities

- Frequency ranges below 6GHz and above 6GHz

- **Forward compatibility** between scenarios

5G studies in TSG RAN (Radio)

- Scenarios and Requirements for Next Generation Access Technologies
  - Target completion on Dec. 2016
  - Latest progress in TR 38. 913
- Channel model for frequency spectrum above 6 GHz
  - *Completed on Jun. 2016*
  - New channel model described in TR 38.900
- New Radio Access Technology
  - Target completion on Jun. 2017
  - Working Groups have started evaluating technology solutions for NR

5G studies in TSG SA (System Aspects)

- SMARTER (New Services and Markets Technology Enabler)
  - Study concluded on Jun. 2016
  - Service requirements defined in:
    - TR 22.861 for the Massive Internet of Things use case
    - TR 22.862 for the Critical Communications use case
    - TR 22.863 for the Enhanced Mobile Broadband use case
    - TR 22.864 for the Network Operation uses case
  - Normative work targeting completion in Mar. 2017

- Architecture and Security for Next Generation System
  - Target completion on Sep. 2016
  - Latest progress in TR 23.799 (*draft*)

Thanks