3GPP RAN Workshop on 3GPP submission towards IMT-2020
October 24.-25. 2018, Brussels, Belgium
RWS-180019

Self-Evaluation: URLLC and mMTC evaluation results

Source: Nokia

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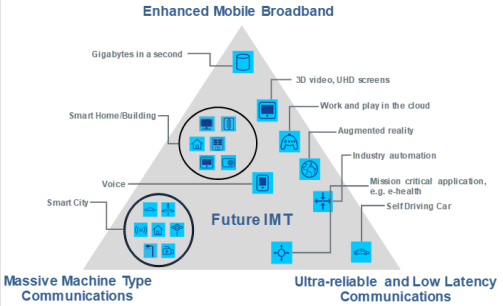
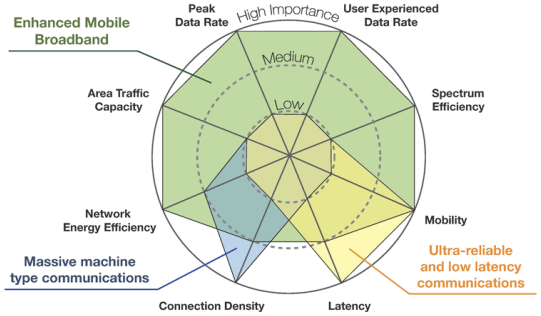
Categorization of IMT-2020 requirements

Source: 3GPP RWS-150036

ITU-R vision for IMT-2020 and beyond



Three use case categories



Eight Key Capabilities

"Framework and overall objectives of the future development of IMT for 2020 and beyond"

Source: ITU-R M.[IMT.VISION]

3GPP RAN workshop, 17.-18.September 2015

Source: ITU-R Report M.2410-0

- Peak data rate
- Peak spectral efficiency
- User experienced data rate
- 5th percentile user spectral efficiency
- Average spectral efficiency
- Area traffic capacity
- Latency
  - User plane latency
  - Control plane latency
- Connection density
- Energy efficiency
- Reliability
- Mobility
- Mobility interruption time
- Bandwidth

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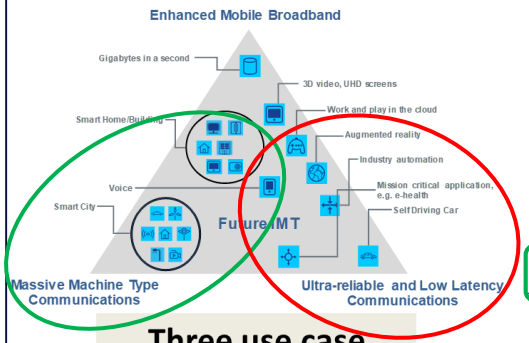
Categorization of IMT-2020 requirements – URLLC and mMTC

Source: 3GPP RWS-150036

ITU-R vision for IMT-2020 and beyond



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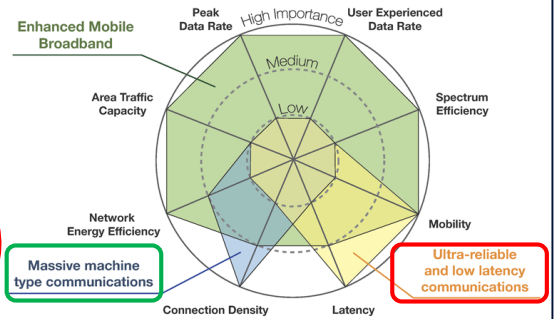

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Requirements for URLLC and mMTC

- Peak data rate
- Peak spectral efficiency
- User experienced data rate
- 5th percentile user spectral efficiency
- Average spectral efficiency
- Area traffic capacity
- Latency
  - User plane latency
  - Control plane latency
- Connection density
- Energy efficiency
- Reliability
- Mobility
- Mobility interruption time
- Bandwidth

Requirement	Required value
Latency, user plane	1 ms for URLLC
Latency, control plane	20 ms
Connection density	1 000 000 devices / km^2
Reliability	99.999% success rate within 1 ms
Mobility interruption time	0 ms

URLLC requirement
mMTC requirement

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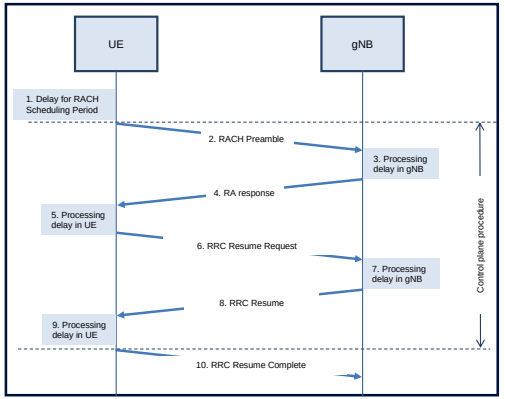
Latency, control plane (URLLC)

*"Control plane latency refers to the transition time from a most "battery efficient" state (e.g. Idle state) to the start of continuous data transfer (e.g. Active state). […] The minimum **requirement for control plane latency is 20 ms.*** [M.2410-0]



Number of configurations evaluated

	Evaluated	Passed
NR FDD	94	94
NR TDD	256	256
LTE FDD	1	1
LTE TDD	12	12

Example: 35 NR FDD configurations for 6-symbol PRACH (ms)

Control plane latency NR FDD		UE capability 1				UE capability 2		
		Subcarrier spacing				Subcarrier spacing		
Allocation		15 kHz	30 kHz	60 kHz	120 kHz	15 kHz	30 kHz	60 kHz
Mapping Type A	4 symbols	15.6	13.5	12.4	11.7	15.1	13.0	12.1
	7 symbols	15.8	13.6	12.5	11.7	15.3	13.1	12.2
Mapping Type B	2 symbols	13.7	12.3	11.9	11.4	13.4	12.0	11.7
	4 symbols	14.2	12.5	12.0	11.5	13.9	12.3	11.8
	7 symbols	15.3	13.0	12.3	11.6	14.8	12.8	12.1

Requirement of 20 ms control plane latency is met with all evaluated configurations

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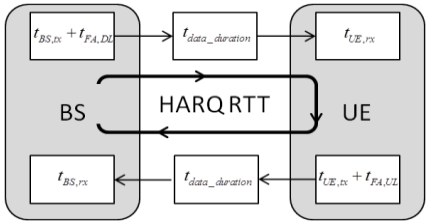
Latency, user plane (URLLC)

*"User plane latency is the contribution of the radio network to the time from when the source sends a packet to when the destination receives it (in ms). […] The minimum **requirements for user plane latency are** […] **1 ms for URLLC.*** [M.2410-0]



Number of configurations evaluated

	Downlink		Uplink	
	Evaluated	Passed	Evaluated	Passed
NR FDD	84	64	98	67
NR TDD	368	225	370	148
LTE FDD	8	5	8	5
LTE TDD	8	0	6	0

Example: 84 NR FDD DL configurations (ms)

DL user plane latency NR FDD			UE capability 1				UE capability 2		
			Subcarrier spacing				Subcarrier spacing		
Allocation		Re-Tx	15 kHz	30 kHz	60 kHz	120 kHz	15 kHz	30 kHz	60 kHz
Mapping Type A	4 symbols	p=0	1.37	0.76	0.54	0.34	1.00	0.55	0.36
		p=0.1	1.58	0.87	0.64	0.40	1.12	0.65	0.41
	7 symbols	p=0	1.49	0.82	0.57	0.36	1.12	0.61	0.39
		p=0.1	1.70	0.93	0.67	0.42	1.25	0.71	0.44
	14 symbols	p=0	2.13	1.14	0.72	0.44	1.80	0.94	0.56
		p=0.1	2.43	1.29	0.82	0.51	2.00	1.04	0.63
Mapping Type B	2 symbols	p=0	0.98	0.56	0.44	0.29	0.49	0.29	0.23
		p=0.1	1.16	0.67	0.52	0.35	0.60	0.35	0.28
	4 symbols	p=0	1.11	0.63	0.47	0.31	0.66	0.37	0.27
		p=0.1	1.30	0.74	0.56	0.36	0.78	0.45	0.32
	7 symbols	p=0	1.30	0.72	0.52	0.33	0.93	0.51	0.34
		p=0.1	1.49	0.83	0.61	0.39	1.08	0.59	0.40

Requirement of 1 ms user plane latency is met with a number of different configurations

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Reliability (URLLC)

"Reliability relates to the capability of transmitting a given amount of traffic within a predetermined time duration with high success probability. […] The minimum ***requirement for the reliability is 1-10^{-5} success probability*** *[…]* ***within 1 ms in channel quality of coverage edge****…* [M.2410-0]

"It is sufficient to fulfil the requirement in either downlink or uplink, using either NLOS or LOS channel conditions."
[M.2412-0]

Number of configurations evaluated

	Downlink		Uplink	
	Evaluated	Passed	Evaluated	Passed
NR FDD	16	16	26	26
NR TDD	-	-	1	1
LTE FDD	-	-	-	-
LTETDD	-	-	-	-

Example: 9 NR FDD DL configurations at 4 GHz (ms)

Antenna configuration	Allocation	Sub-carrier spacing	Channel	Channel model A	Channel model B
2x2 SU-MIMO	14 symbols, slot aggregation	60 kHz	NLOS	99.999899%	99.99991%
2x2 SU-MIMO	4 symbols, HARQ re-tx	30 kHz	NLOS	99.999898%	99.99995%
2x2 SU-MIMO	4 symbols, one shot	30 kHz	NLOS	99.99971%	99.99969%
2x4 SU-MIMO	7 symbols, one shot	30 kHz	NLOS	>99.9999%	>99.9999%
32x8 SU-MIMO	14 symbols, one shot	30 kHz	NLOS	99.9999%	-

Requirement of 99.999% reliability within 1 ms packet delivery is met in all evaluated configurations

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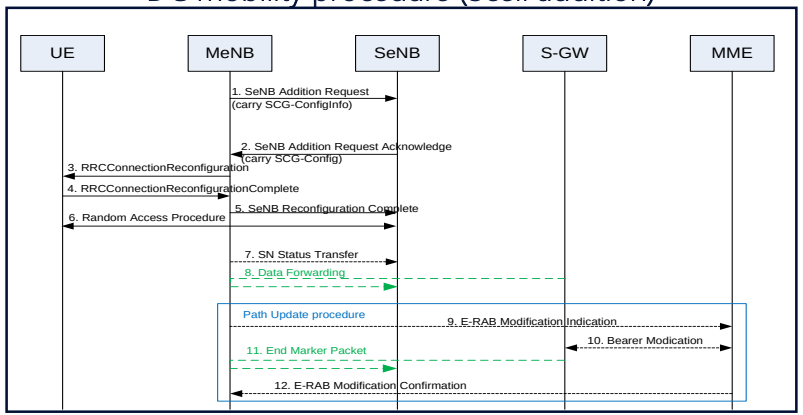
Mobility interruption time (URLLC)

*"Mobility interruption time is the shortest time duration supported by the system during which a user terminal cannot exchange user plane packets with any base station during transitions.[…]The minimum **requirement for mobility interruption time is 0 ms**."* [M.2410-0]

"The procedure of exchanging user plane packets with base stations during transitions shall be described based on the proposed technology including the functions and the timing involved." [M.2412-0]

DC mobility procedure (Scell addition)



Technical feature	Meets requirement
NR beam mobility	Yes
NR CA mobility	Yes
LTE Pcell mobility	Yes
LTE DC mobility	Yes

Requirement of zero ms mobility interruption time is met

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Connection density (mMTC)

*"Connection density is the total number of devices fulfilling a specific quality of service (QoS) per unit area (per km²). […] The minimum requirement for connection density is **1 000 000 devices per km²**."* [M.2410-0]

"The requirement is fulfilled if the 99th percentile of the delay per user D_i is less than or equal to 10s, and the connection density is greater than or equal to the connection density requirement…" [M.2412-0]

Connection density evaluation results (full buffer method)

Technical feature	ISD (m)	Scheme and antenna config.	Sub-carrier spacing	Channel model A		Channel model B	
				Connection density (device/km²)	Required bandwidth (kHz)	Connection density (device/km²)	Required bandwidth (kHz)
NR	500	1x2 SIMO OFDMA	15 kHz	35,569,150	180	35,082,937	180
	1732			1,267,406		1,529,707	
NB-IoT	500	1x2 SIMO	15 kHz	43,691,789	180	43,626,653	180
	1732			2,335,319		2,376,936	
eMTC	500	1x2 SIMO	15 kHz	35,235,516	180	34,884,438	180
	1732			1,212,909		1,511,989	

Requirement of 1 000 000 devices/km² is met in all evaluated cases

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Summary

Large number of different configurations evaluated against the URLLC and mMTC requirements

Requirement	Required value	NR	LTE
Latency, user plane	1 ms for URLLC	Meets requirement	Meets requirement
Latency, control plane	20 ms	Meets requirement	Meets requirement
Connection density	1 000 000 devices / km^2	Meets requirement	Meets requirement
Reliability	99.999% success rate within 1 ms	Meets requirement	Not evaluated
Mobility interruption time	0 ms	Meets requirement	Meets requirement

3GPP successfully completed the preliminary self evaluation on URLLC and mMTC

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