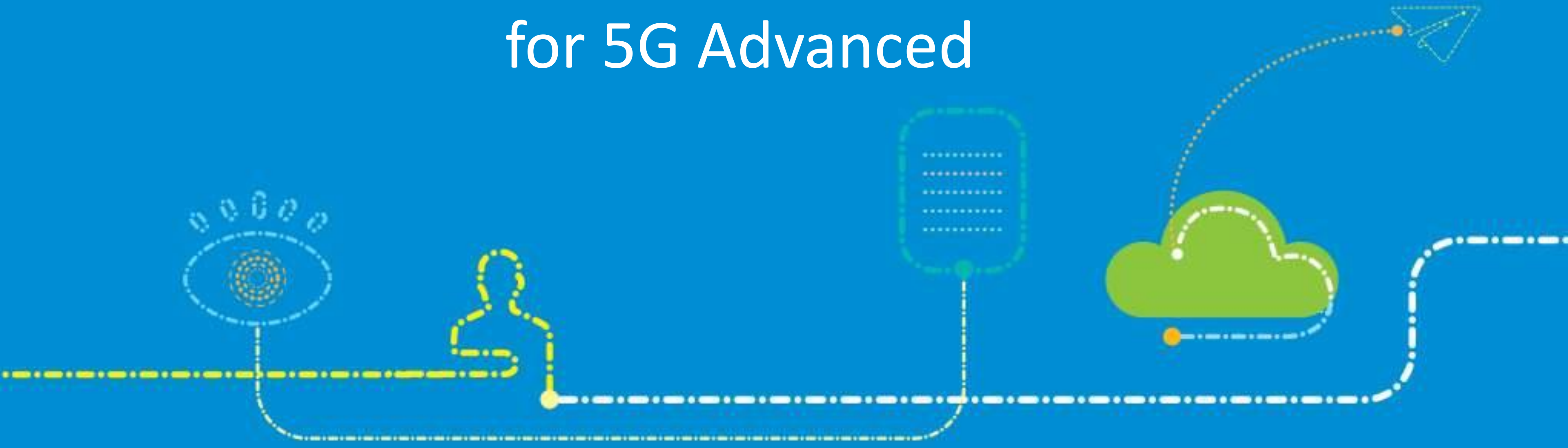
3GPP TSG RAN Rel-18 workshop
Electronic Meeting, June 28- July 2, 2021

RWS-210467

Source: ZTE, Sanechips
Agenda: 4.2

Evolution of massive NR based IoTs for 5G Advanced



NR based massive IoTs - Scenarios

- **Wide area sensor monitoring and event driven alarms [TR 22.891, 5.20]**
  - The sensor sends its information unsolicited and infrequently with no expectation of a response from the network.
  - The 3GPP System shall support efficient transfer of infrequent uplink data for low power devices which only participate in mobile-originated communication scenarios.
  - The system shall support efficient data transmission with limited resource and signalling usage.
  - The system shall support high density massive connections (e.g.1 million connections per square kilometre) in an efficient manner.
- **Advanced smart metering require both high connection density and reliability, good coverage, and decent data rate [TR 22.867, Table 5.2.6-1]**

User experienced Data rate (bps)	Latency (ms)	Reliability [%]	Connection density	coverage
UL:<2M DL:<1M	Accuracy fee control: < 100; General information data collection: <3000	>99.99	<[x]*10000/km2	<40km (city range)

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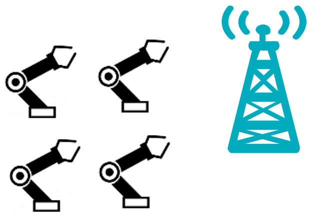
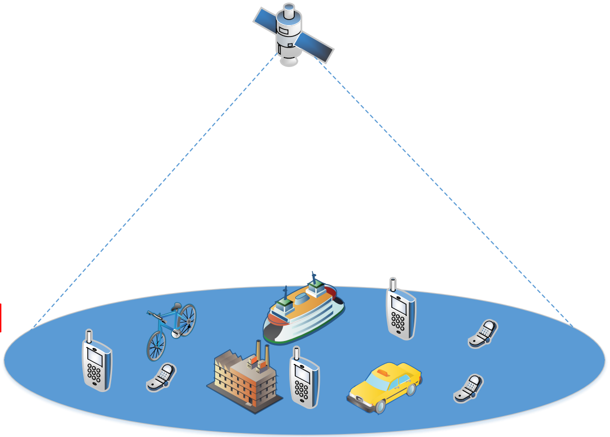
NR based massive IoTs - Scenarios

- Factories of the Future (from TR22.804)
  - Support of massive connections (e.g. 1 millions per km^2 with small data) considering certain URLLC requirements.
  - Use cases include: Condition monitoring for safety, Packaging machine, process automation, motion control, mobile robots…



- NTN scenarios (from TR 38.821)
  - For NTN, the maximum user density is one of the key for profitability. However, the user density for connected mode UE is quite limited due to the large cell size.
  - In NTN, a cell may be covered by one or multiple beams, and the footprint diameter of a beam is 200–3500 km for GEO and 100–1000 km for non-GEO.



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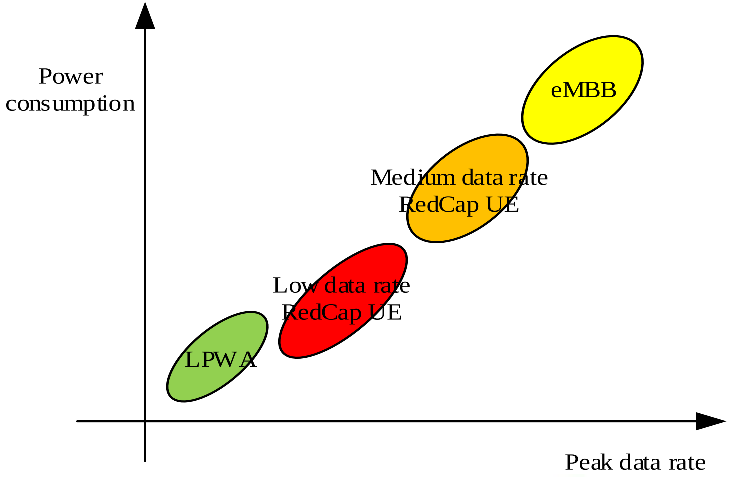
NR based massive IoTs – Evolution of RedCap UEs

Vertical industries in China have strong demand on much lower complexity UEs (compared to Rel-17 RedCap UEs)

- Low data rate Redcap UEs
  - Support of massive connections considering certain low power consumption requirement and low peak data rate requirement.
  - Use cases include: Industrial sensors, Logistic Store…



- eMBB UE: high peak data rate larger than 150Mbps
- Medium data rate RedCap UE: data rate(10~ 150Mbps) e.g smart watch, video surveillance, etc.
- Low data rate RedCap UE: data rate(1~10Mbps) e.g. sensor.
  - Normal power Redcap UE
  - Low power Redcap UE
- LPWA(Cat M1/Cat NB2): peak date rate no more than 1Mbps
- FFS
  - Whether to support even lower complexity or lower power consumption for NR (LPWA, very low power UEs, passive/battery-less UEs, ….)

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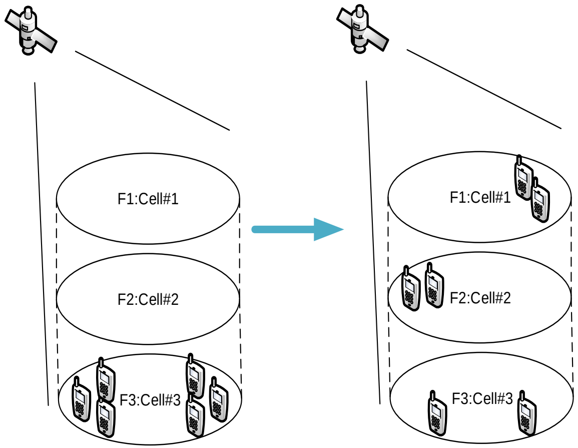
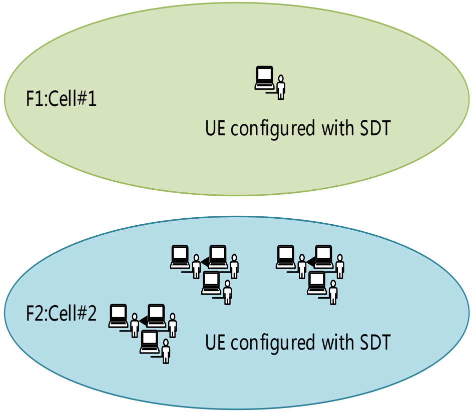
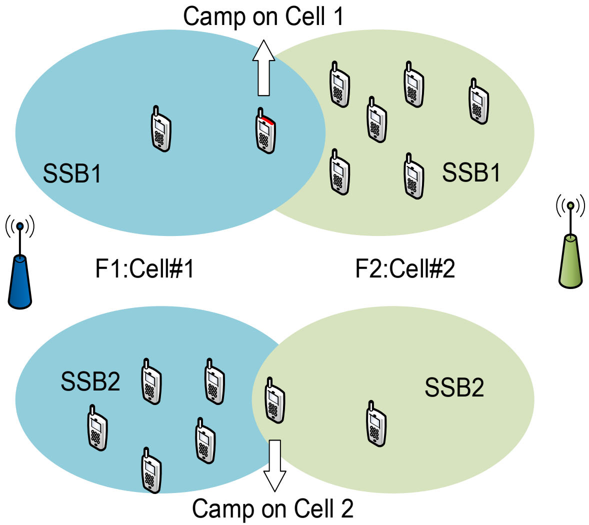
UE distribution for high user density

Distribution of idle/inactive UEs considering high user density







- More overlapping cells in frequency domain
  e.g. To increase the supported user density
- Multiple inter-frequency NTN cells can be deployed in the same area.

- Load imbalance in different SSBs
- Load distribution for small data transmission in INACTIVE state

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Motivations and Enhancements

- In Rel-16 2-step RACH WI
  - The MsgA channel structure is preamble + PUSCH in different slots
  - UP data cannot be included in MsgA PUSCH for non-RRC_CONNECTED state
- In Rel-17 small data WI
  - Small data transmission from RRC_INACITVE state is considered
  - RACH based or configured grant based procedure with RRC involved
- For Rel-18, transmission efficiency and connection density can be further enhanced, e.g.
  - Small data transmission through RACH or pre-allocated resources from idle state directly
  - Support more flexible UE distribution for high user density in IDLE/INACTIVE modes
  - Extend the number of configurable resources (e.g. preambles and RNTIs) to support huge amount of UEs in an extremely large cell size e.g. for NTN. Study the gap and identify the potential enhancements.

Note: the first two Rel-18 objectives can be considered in one item or a separate item dedicated for enhancements on IDLE/INACTIVE (RWS-210485)

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Potential Enhancements (cont')

- Enhancements on integration of preamble and DMRS functionality

(and therefore some resources can be saved to support more connections especially in small cell scenarios)

- Enhancements on PRACH/preamble including perspectives of capacity and latency

(considering differentiation of many services e.g. CovEnh, RedCap, SDT which may rely on PRACH/preamble)

- Support of multiple layer MsgA PUSCH for more efficient small data transmission
- Sensing based small data transmission *(e.g. LBT applied for CG-SDT)*

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Appendix – Evaluation (1)

Idle state small data transmission – power saving compared to inactive state

		RRC_IDLE	RRC_INACTIVE
Paging	Monitoring	The UE - Monitors Short Messages transmitted with P-RNTI over DCI - Monitors a Paging channel for CN paging using 5G-S-TMSI;	The UE - Monitors Short Messages transmitted with P-RNTI over DCI (see clause 6.5); - Monitors a Paging channel for CN paging using 5G-S-TMSI and RAN paging using fullI-RNTI;
	DRX cycle	A UE in RRC_IDLE uses the shortest of {a default cycle, a UE-specific cycle configured via NAS signalling};	A UE in RRC_INACTIVE uses the shortest of {a default cycle, a UE-specific cycle configured via NAS signalling, a UE-specific cycle configured via RRC signalling};
Area Update		None	Performs RAN-based notification area updates periodically and when moving outside the configured RAN-based notification area;

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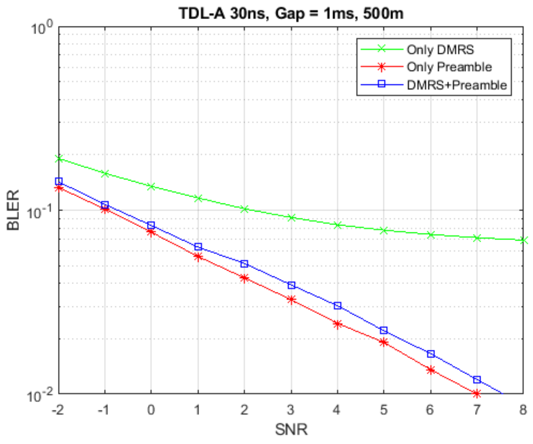
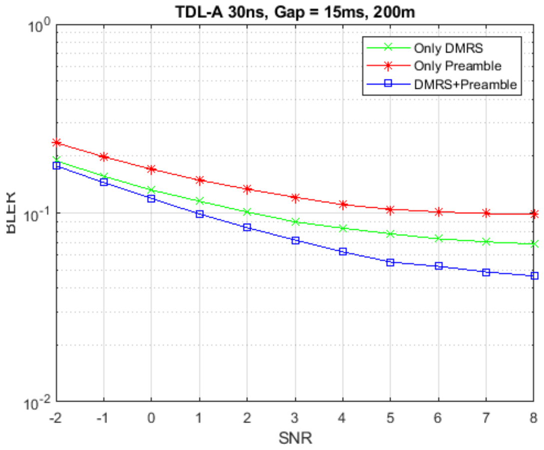
Appendix – Evaluation (2)

- Integrated preamble and DMRS for small cell
  - Case A: The performance is similar between preamble only and DMRS + preamble when the gap between preamble and PUSCH is small → DMRS can be saved
  - Case B: The performance is similar between DMRS only and DMRS + preamble when the gap between preamble and PUSCH is large → preamble can be saved (while DMRS enhancement should be further considered to alleviate collision)



(a) Case A



(b) Case B

Link level simulation assumption

Parameter	**Value**
Subcarrier spacing	15 kHz
UE number	2
Collison possibility	1/64
ISD	200m, 500m
Bandwidth	12 RBs
Payload size	54 bytes
Channel estimation	Realistic
RS overhead	1/7 for Only DMRS or Only Preamble 1/4 for DMRS + Preamble

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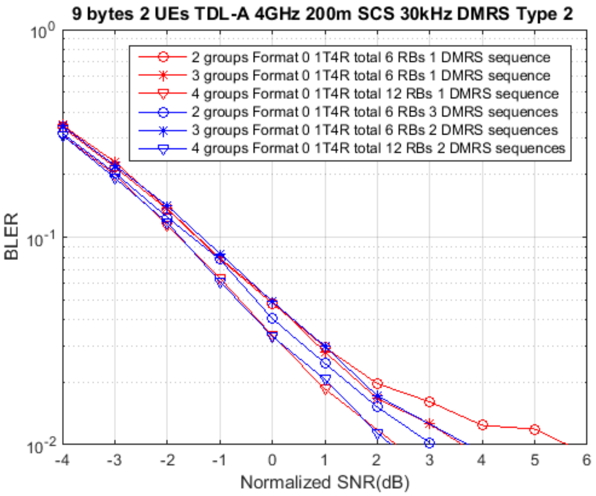
Appendix – Evaluation (3)

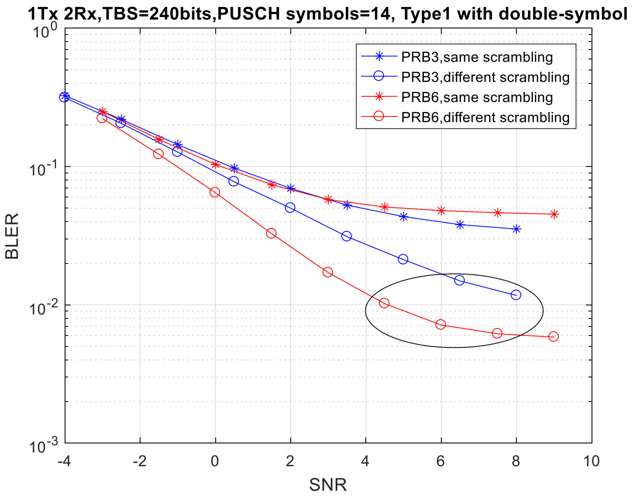
- Enhancement of DMRS capacity

Evaluations in 2-step RACH WI shown that DMRS collision would be the bottleneck on the performance of MsgA transmission, error floor can be found @BLER=0.01 if the number of DMRS resources is not enough

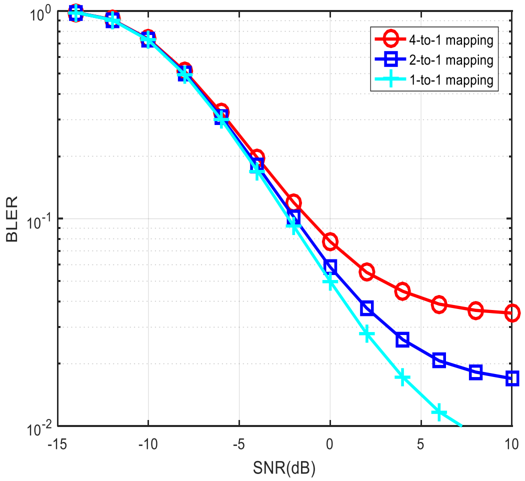
Some examples can be found as follows:



R1-190599 (ZTE)



R1-1906126 (vivo)



R1-1906605 (Huawei)

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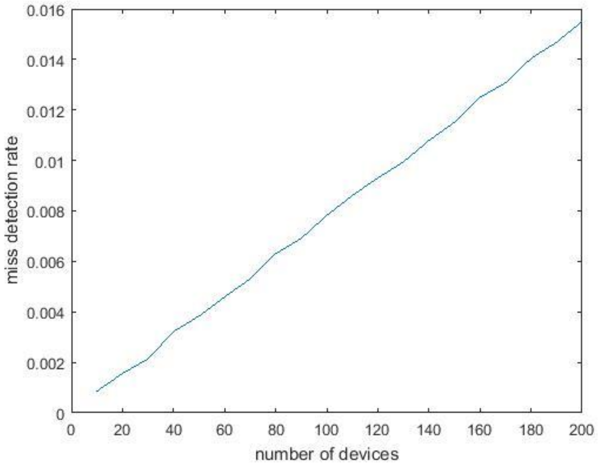
Appendix – Evaluation (4)

- Evaluation of connection density - PRACH collision probability

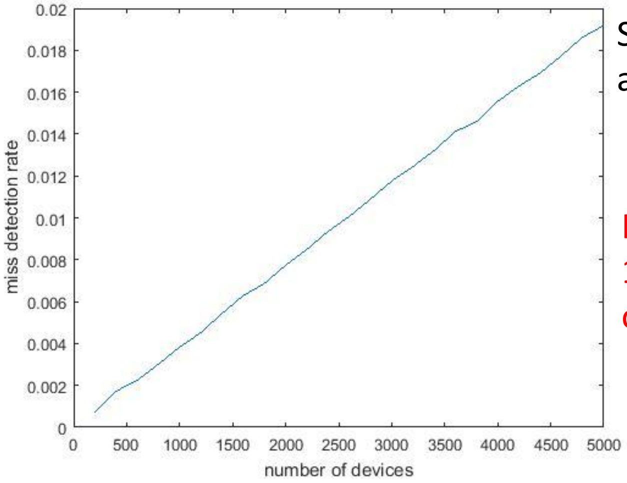
Max. number of supported devices in 1 second assuming each device perform RACH once.

(a) Typical PRACH config. index #17; # of resource = 200*64
1 TDMed and 1 FDMed ROs per slot, 2 PRACH slot per frame, and 64 preambles per RO



Support ~120 access in 1s

(b) Long preamble format; Max # of resource = 500*8*64
1 TDMed and 8 FDMed ROs per slot, 5 PRACH slots per frame (half for UL in TDD), and 64 preambles per RO



Support ~2500 access in 1s

However, it requires 10MHz and fully occupied in time!

Note 1: miss detection rate is theoretically calculated, i.e. consider preamble collision only
Note 2: for short preamble format, the capability can be increased by allocating more TDMed ROs in a subframe

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Appendix – Evaluation (5)

- Sensing based transmission

13% avg. UPT gain vs. contention based SDT
17% avg. Delay reduction vs. contention based SDT

		Contention based transmission	Sensing based transmission
UL UPT CDF [Mbps]	5%	10.466	12.765
	50%	14.938	16.930
	95%	19.773	22.679
	Mean	15.214	17.190
UL Delay CDF [s]	5%	0.008	0.008
	50%	0.021	0.014
	95%	0.071	0.068
	Mean	0.030	0.025

Simulation assumptions

Parameter	**Value**
Layout	Indoor floor: (12 BSs per 120m X 50m)
Carrier frequency	4G
System bandwidth	10MHz
Channel model	TRP-to-UE: ITU InHTRP-to-TRP: ITU InHUE-to-UE: A.2.1.2 in TR36.843
Antenna:	BS/UE antenna height:2Rx BS antenna height:3m UE antenna height:1.5m
UE number	10 UE per BS
Traffic	FTP traffic model 3 with packet size 0.03Mbytes 1 file/s
ED threshold for LBT	-82 dBm
subframe configuration	UL Only

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Thanks