

3GPP TSG RAN Meeting #93-e
Electronic Meeting, September 13 - 17, 2021

Source: ZTE, Sanechips

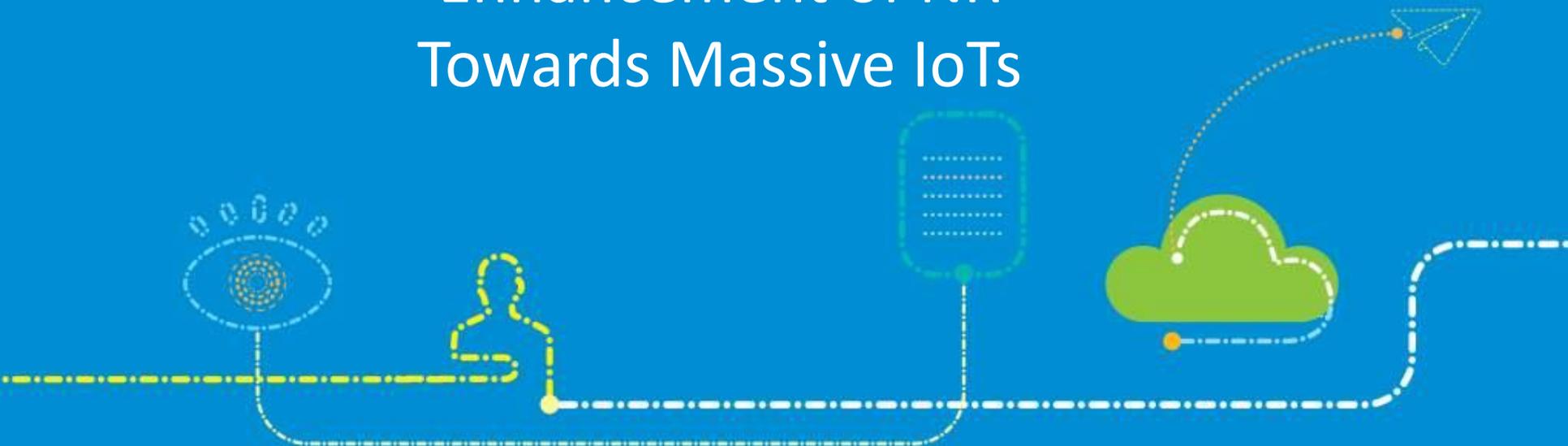
Agenda: 9.0.2

RP-212386

ZTE

Tomorrow never waits

Enhancement of NR Towards Massive IoTs



On NR based Passive IoT

- **Proposed Conclusion as the outcome of email discussion [RP-211665]:**

There is interest among many companies for a study focusing on passive IoT, but there are also multiple companies that indicate that such a study in Rel-18 is premature. In case there is further discussion on a study for other IoT enhancements/types, the following objectives that were discussed as part of this discussion can be considered:

- Study of use cases and design targets for passive IoT for power consumption, complexity, link budget (RAN1/2/4, RAN)
 - Identification of key areas to enhance to achieve design targets of passive IoT for power consumption, complexity, link budget (RAN1/2/4)
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- A SA1 proposal on **WPSCS (Wireless Power Sourcing enabled Communication Services)** is under discussion, with quite similar target use cases, e.g. Industrial Wireless Sensor Network, Smart Logistics and smart Warehousing, Smart Home Network.
 - The question is whether we should study the use cases, KPIs, and gap analysis in SA1 first, and then identify the RAN requirements.
 - From RAN perspective, the ultra-low power wake-up radio/receive can be studied first, as a common solution for both power saving and passive IoT devices

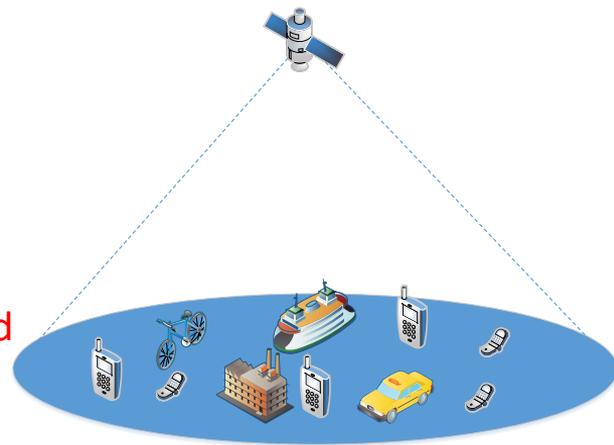
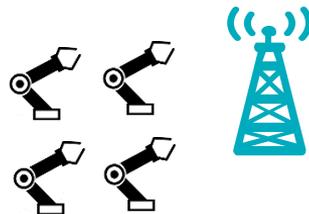
NR based massive IoTs - Motivation

- **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)

NR based massive IoTs - Motivation

- Factories of the Future (from TR22.804)
 - Support of massive connections (e.g. 1 millions per km² 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.**



Potential Enhancements for NR towards massive IoT

On massive connection and transmission efficiency

- 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 and CG-SDT (*for more efficient small data transmission*)
- Sensing based small data transmission (*e.g. LBT applied for CG-SDT*)

Thanks

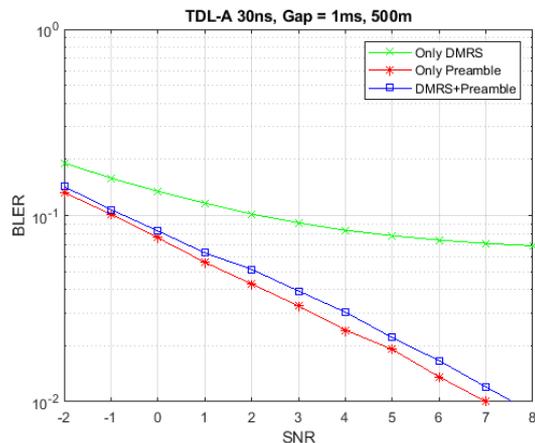


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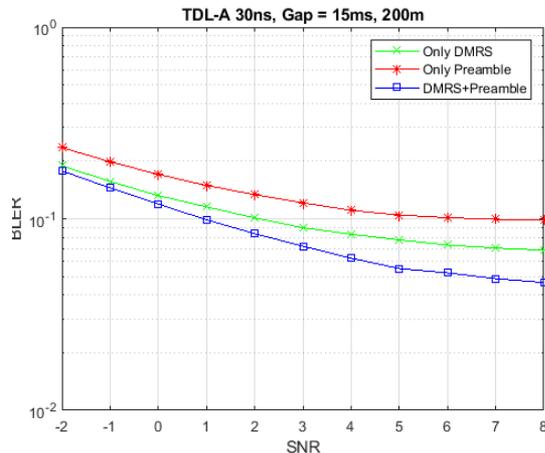


Appendix – Evaluation (1)

- 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

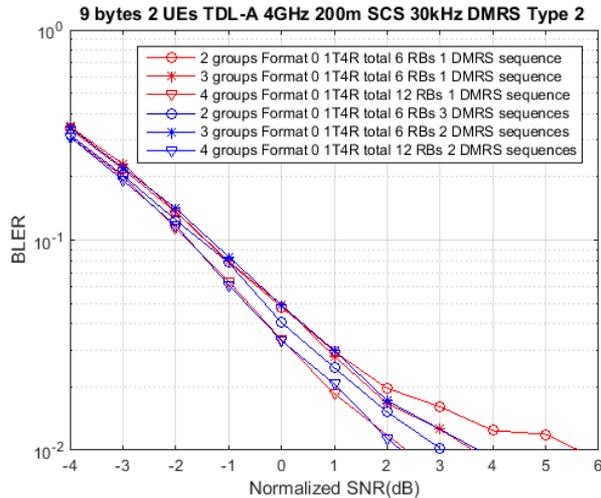
Parameter	Value
Subcarrier spacing	15 kHz
UE number	2
Collision possibility	1/64
ISD	200m, 500m
Bandwidth	12 RBs
Payload size	54 bytes
Channel estimation	Realistic
RS overhead	1/7 for Only DMRS or Only Preamble 1/4 for DMRS + Preamble

Appendix – Evaluation (2)

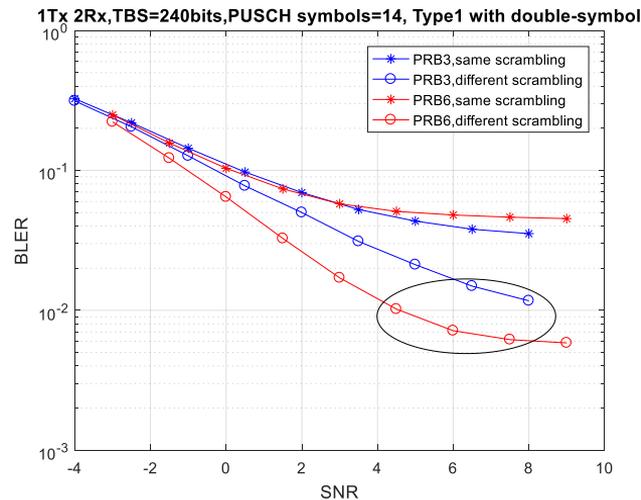
• Enhancement of DMRS capacity

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

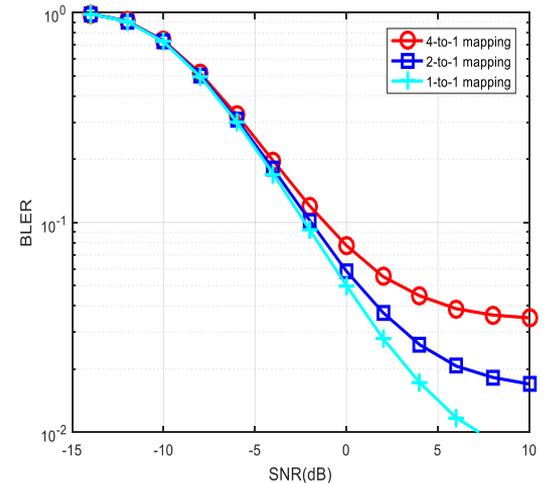
Some examples can be found as follows:



R1-190599 (ZTE)



R1-1906126 (vivo)



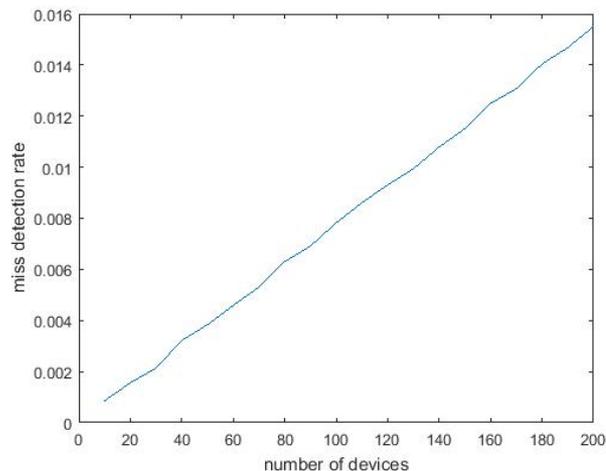
R1-1906605 (Huawei)

Appendix – Evaluation (3)

- Evaluation of connection density - PRACH collision probability

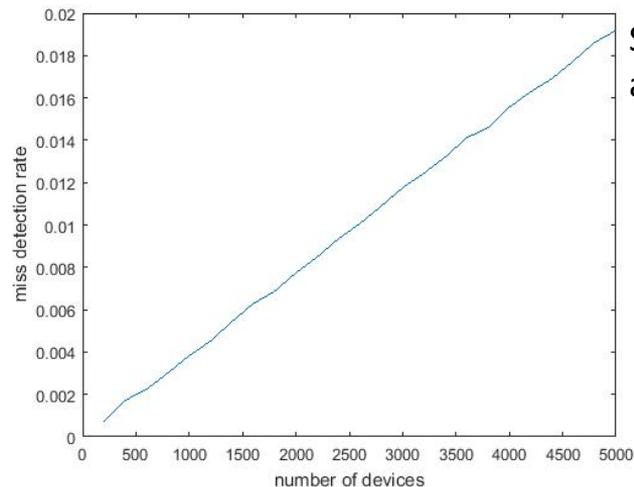
Max. number of supported devices in 1 second assuming each device perform RACH once.

(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 = $500 \times 8 \times 64$
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

Appendix – Evaluation (4)

- Sensing based transmission

21% avg. UPT gain vs. contention based SDT

11% avg. Delay reduction vs. contention based SDT

		Contention based transmission	Sensing based transmission
UL UPT CDF [Mbps]	5%	7.8140	9.6592
	50%	11.4882	13.5859
	95%	24.2202	30.9801
	Mean	13.0347	15.7241
UL Delay CDF [s]	5%	0.0040	0.0080
	50%	0.0260	0.0200
	95%	0.0750	0.0750
	Mean	0.0328	0.0293

Simulation assumptions

Parameter	Value
Layout	Indoor- office: (12 BSs per 120m X 50m)
Carrier frequency	4G
System bandwidth	10MHz
Channel model	TRP-to-UE: ITU InH; TRP-to-TRP: ITU InH; UE-to-UE: A.2.1.2 in TR36.843
Antenna:	BS/UE antenna: 2Tx/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