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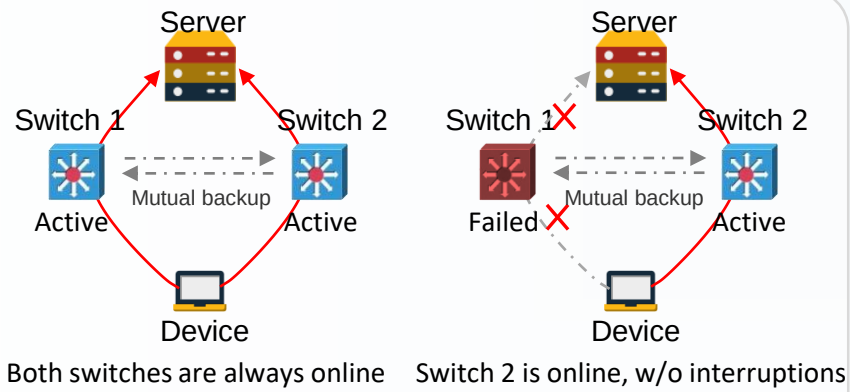
**3GPP TSG RAN Rel-19 workshop** **RP-231914**

**Bangalore, India, September 11th – 15th , 2023**

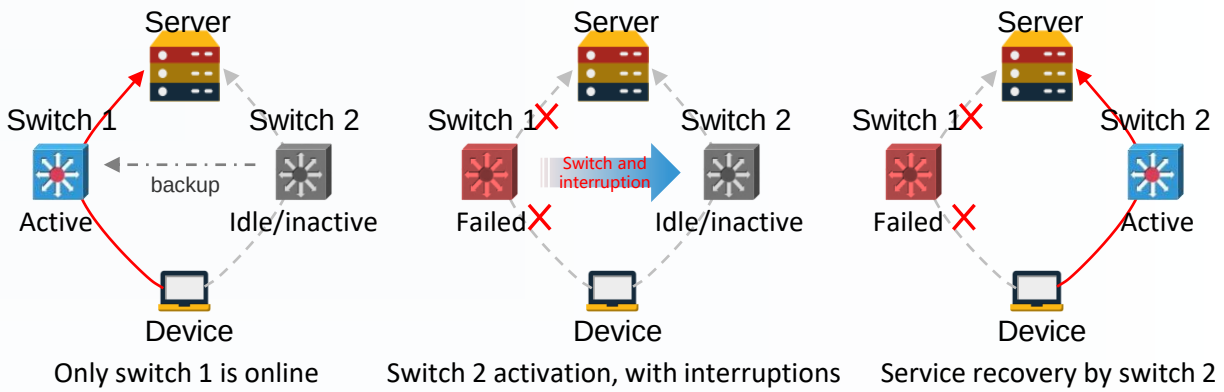
| | |
|---|---|
| **Agenda Item:** | **8A.2.13.6** |
| **Source:** | **Spreadtrum Communications, CEPRI, China Southern Power Grid, CAICT, China Telecom** |
| **Title:** | **UL SFN for UE backup in Rel-19** |
| **Document for:** | **Discussion and decision** |

# Industrial backup description

- **Backup from Collins Dictionary**
  - If you have something such as a second/third… piece of equipment or set of plans as backup, you have arranged for them to be available for use in case the first one does not work.
- **Hot backup & cold backup**
  - Hot-backup:  real-time and always online backup, and switching does not affect service.
  - Cold-backup: when a switch occurs, service data is not the latest or may be lost.




Example of hot backup

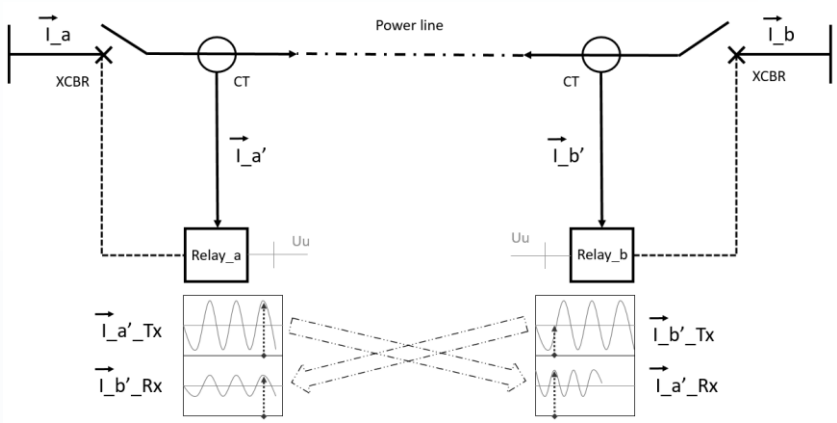



Example of Cold backup

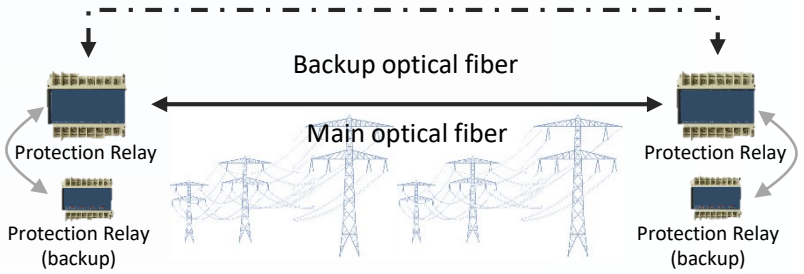
- **End to end backup industrial requirement for 5G application**
  - 5G cellular backup: Transmission line, terminal device.
  - Industrial data network: backup channels with multiple connections, software  and devices backup.
  - Hot-backup.

# Use cases for wireless backup (1/2)

- **Differential protection(DP) in smart grid**
  - DP is used to protect the power line from being burnt down and any secondary damages.
    - DP is usually in an 1+1（even 1+N） backup mode to guarantee the reliability.
  - Traditional DP backup by optical fiber brings high cost and faces construction difficulty.
  - KPIs of line current differential protection*[1].




Line Current Differential Protection by two protection relays*[1]




Traditional backup for differential protection

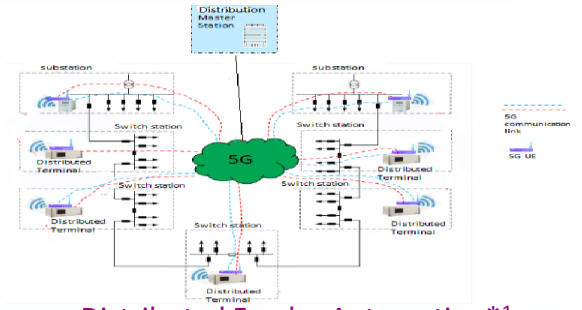
| Communication service availability | End-to-end latency: maximum (note) | Time synchronization accuracy | Service bitrate: user experienced data rate | Message size [byte] | UE speed | UE density [#/km²)] |
|---|---|---|---|---|---|---|
| > 99.999 % | ≤10ms | <10us | 2.5 Mbit/s | < 245 | Stationary | ≤ 100/km² |
| Note: UE-to-UE communication | | | | | | |

1. TR 22.867, Study on 5G Smart Energy and Infrastructure_v18.1.0, (Release 18), 2021-09.

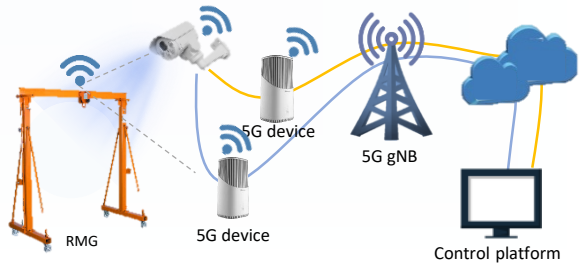
# Use cases for wireless backup (2/2)

- **Other wireless backup in smart grid*1**
  - Distributed Energy Storage
    - The communications between Distributed Energy Storage Management Platform (DESMP) and Distributed Energy Devices (DED) should be supported by multiple connections and backup each other.
  - Distributed Feeder Automation
    - According to the distribution network reliability configuration principle, one backup is required.
  - Distributed Energy Resources and Micro-Grids
    - A certain level of redundancy is required in the system, e.g., backup channels, software components and devices, etc.
  - Coordination for Energy Recovery
    - Cellular routers that enable remote access to the assets have dual cellular configuration in order to provide an extra level of redundancy and availability.
- **Backup in other industrial services**
  - Remote control of automated Rail-Mounted Gantry (RMG) crane*2
    - E2E latency: 10~20 ms; High reliability: 99,999%. Real time data processing.
    - Backup is required to ensure the high reliability.

Distributed Energy Storage*1




Distributed Feeder Automation*1

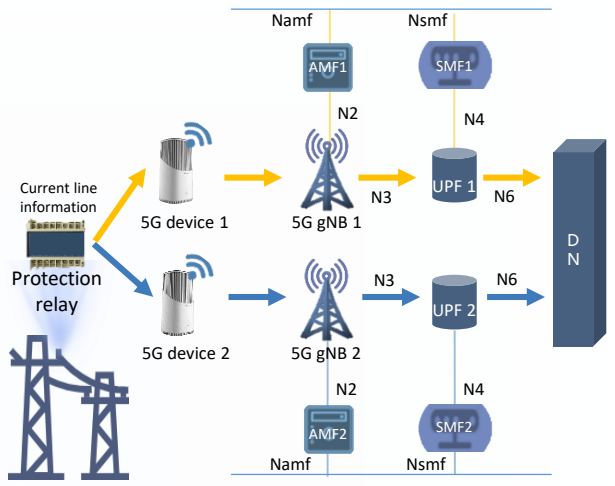



RMG crane*2

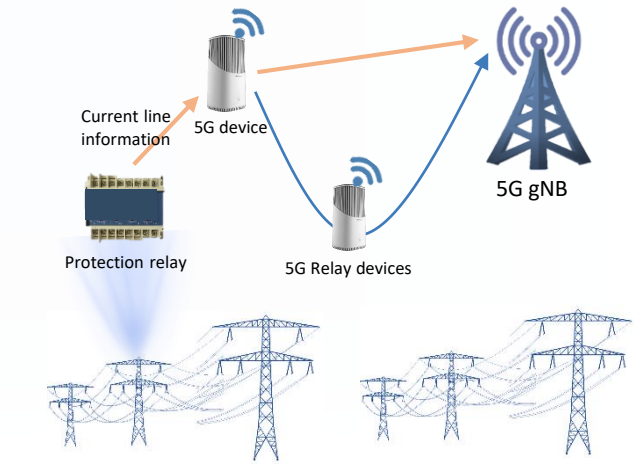
1. TR 22.867, Study on 5G Smart Energy and Infrastructure_v18.1.0, (Release 18), 2021-09. 2. 5G E2E Technology to Support Verticals URLLC Requirements, ngmn, 2020.

# Current potential 5G solutions for wireless backup

- **SA based solution: “Redundant user plane paths”**
  - As illustrated by the figure, this solution results in high cost on radio resource, transport resource, processing resource and redundant signalling/data overhead.
- **Implementation based solution**
  - UE1 acquire C-RNTI and security keys from gNB, then the protection relay transfer the C-RNTI and keys from UE1 to UE2 via application layer.
  - It will cause vendor lock issue and security risks.
- **Relay based lower layer aggregation**
  - It can improve the UL resource efficiency and throughput.
  - May not suitable for hot-backup. When the remote UE is down, all connections will be failed.
- **Hardware aggregation of different devices or UL MU-MIMO**
  - Aggregation on RF part, and single baseband is assumed.
  - It can not achieve hot-backup function, if baseband is down.




Redundant user plane paths




Relay based lower layer aggregation

# UL SFN solution for wireless backup

- **Definitions for UL SFN solution**
  - Similar to DL SFN, UL SFN means that the UL radio resources used for the same service from different UEs (e.g., all the UE(s)) are the same.
  - Two or more UEs are always online for the same service. The UEs are back-up to each other.
  - The registrations and the link management of these UEs are independent.

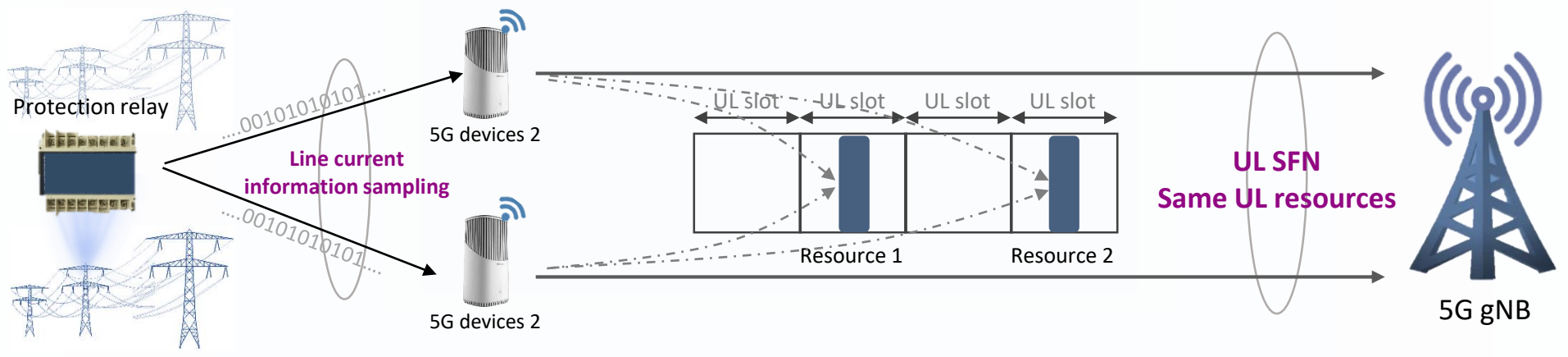


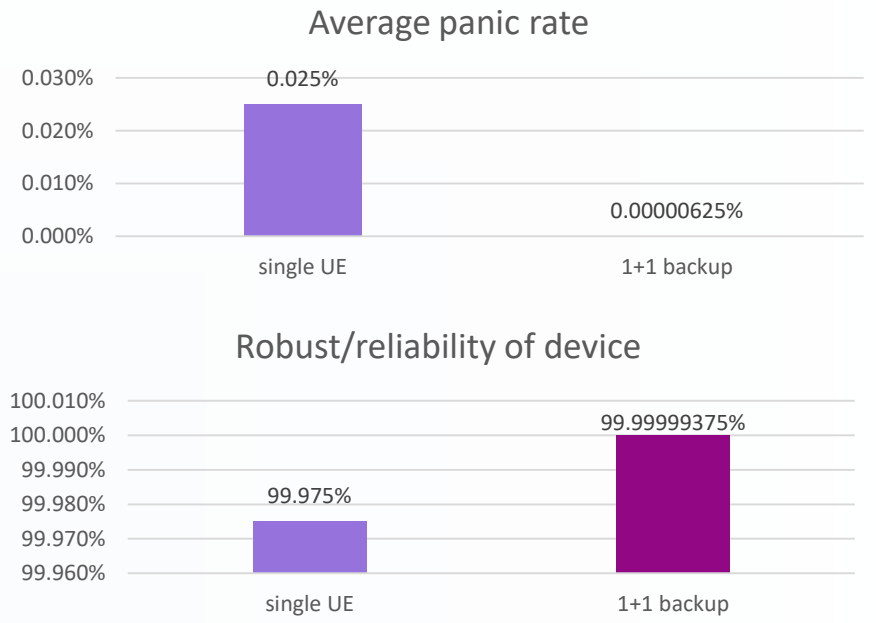

Illustration of UL SFN

- **Advantages for UL SFN solution**
  - UEs are independent and always online, which is suitable for hot-backup.
  - Save the radio/transport/processing resource and redundant signalling/data overhead.
  - It will not cause vendor lock issues.

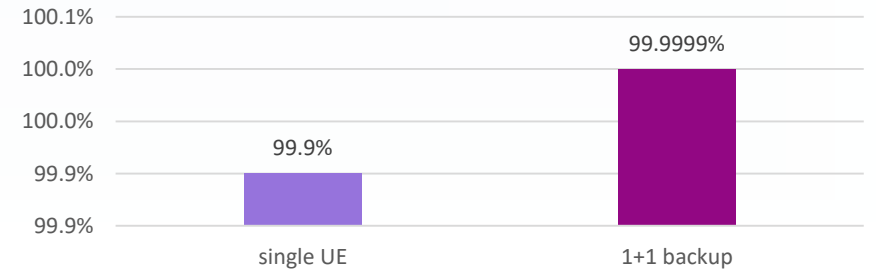
# Evaluations of UL SFN – Robust/availability

- **Robust/availability requirements**
  - The communication service availability for many vertical cases (e.g., DP) is 99.999%.
- **Device reliability from software/hardware perspective**
  - The average panic rate of single 5G device may around 0.025%[*1], the corresponding availability is 99.975%, which is smaller than the requirements.
  - With 1+1 backup, the probability that two UEs fail simultaneously is extremely low, i.e., 0.00000625%.
- **Device reliability from software/hardware and environment impacts perspective**
  - For the (annual) damage rate of a 5G vertical device, caused by software/hardware and environment factors (e.g., weather, animals, etc.), is around 0.1%[*1].
  - With 1+1 backup, the average annual failure rate can be reduced to 0.0001%, i.e., the robust/reliability is increased to 99.9999%.

**Reliability from software/hardware perspective**



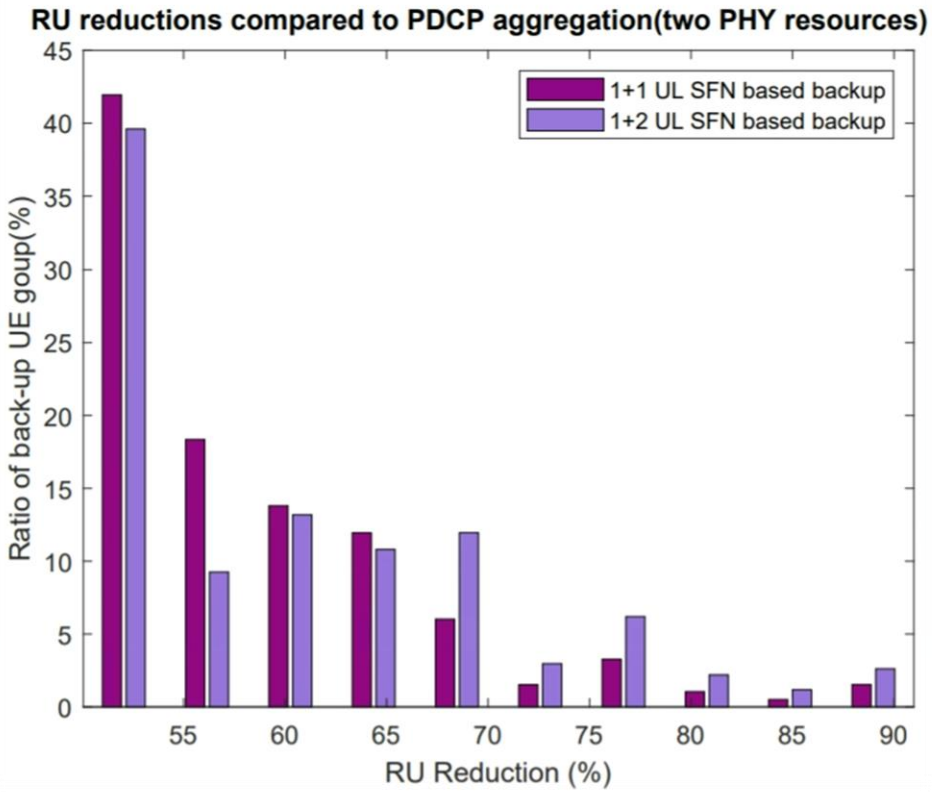

**Reliability from software/hardware and environment perspective**



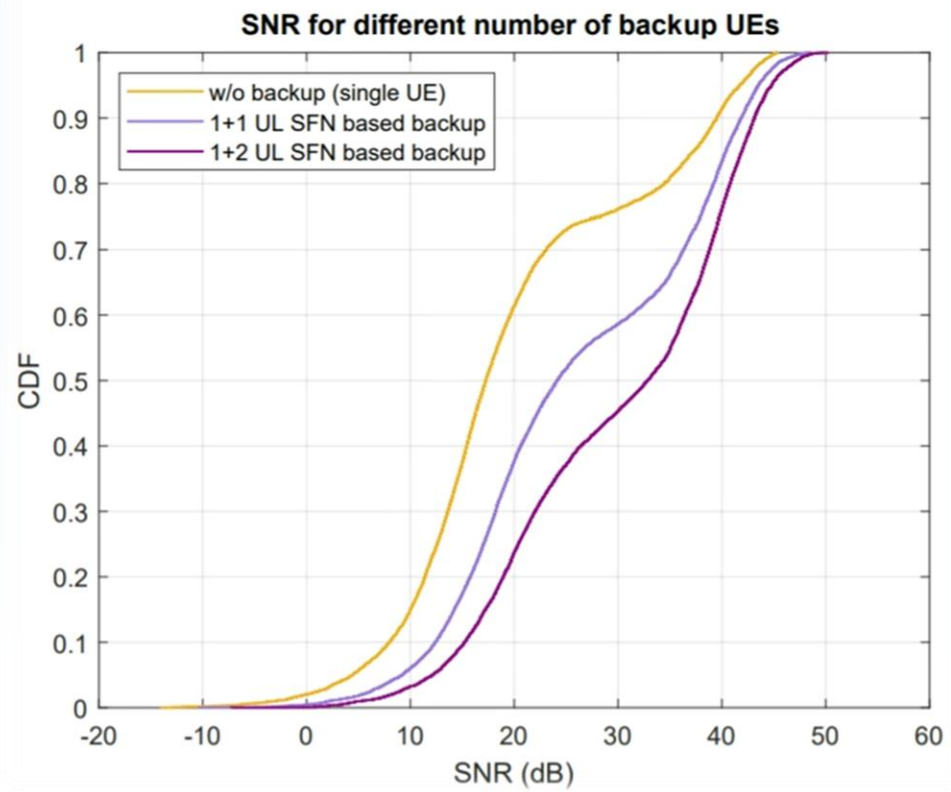

1. These data are come from our customers.

# Simulations of UL SFN – Resources and performance

- **Significant PHY resource saving**
  - Compared to PDCP aggregation(i.e., two separate UL PHY resources), the resource utilization can be reduced by more than **57%** (average) via SFN based backup.
  - The resource utilization can be further reduced, if the number of SFN based backup UEs is increased.

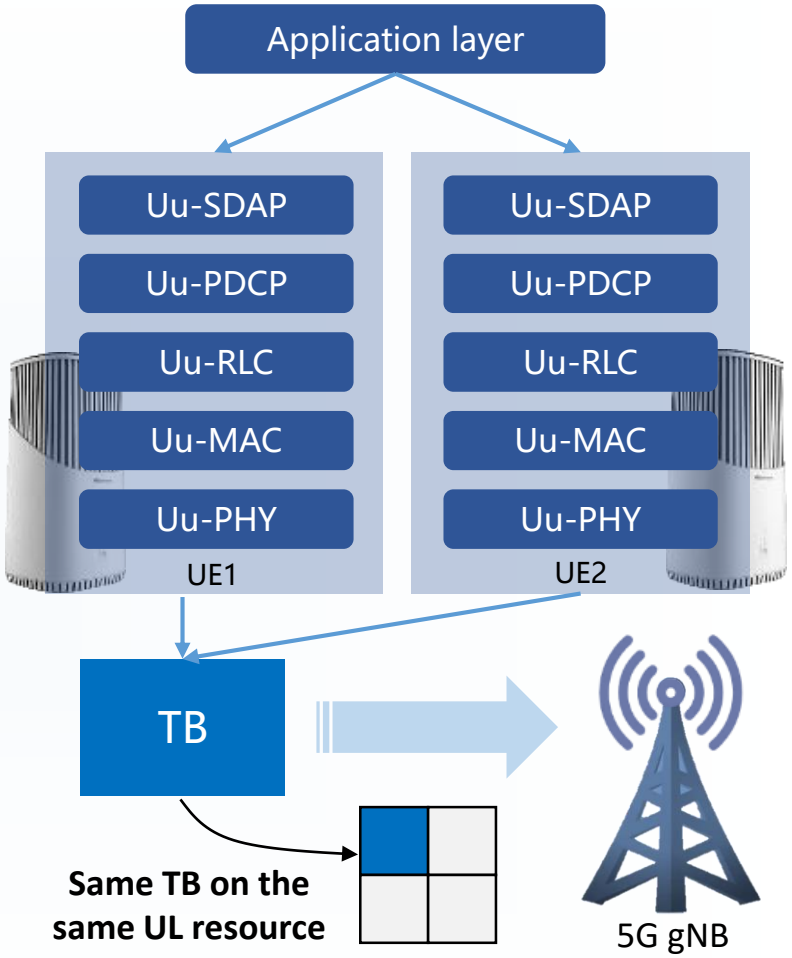



- **Improved UL SNR performance**
  - Compared to single UE(without backup), UL SFN based 1+1 and 1+2 backup can provide **~3dB** and **~5dB** SNR gain@90%, respectively.
  - Higher SNR performance can theoretically bring lower latency and higher throughput.



# RAN2 aspects for UL SFN

- **High layer protocol stack architecture**
  - E.g., Independent TB (illustrated by the figure).
- **Synchronization**
  - The synchronization between UEs can be achieved by the implementation via the interface between UEs.
  - The time synchronization in TSN can also be applied.
- **Security**
  - Service based Security mechanism is applied for one service for these associated UEs.
- **Group management**
  - The relationship between the associated UEs should be informed to RAN and CN for security and group scheduling.



# RAN1 aspects for UL SFN

- **UL SFN by group scheduling**
  - CG based group scheduling
    - Group CG configuration and resource allocation.
      - Group activation and deactivation.
  - Dynamic group scheduling
    - RNTI for UL SFN scheduling, e.g., Group RNTI.
    - DCI format for UL SFN scheduling, e.g., Group DCI.
- **Reuse or simplified function**
  - Reuse the current mechanisms as much as possible, e.g., resource allocation types/granularities, power control, etc.

# Summary and proposals

- **Summary**
  - Backup, especially hot backup is important and urgent for serval vertical use cases.
  - The current potential 5G solutions cannot meet the hot backup requirements or results in high cost on radio resource, transport resource and so on.
  - UL SFN solution not only provides hot back-up function but also improves UL performance, thereby achieving robustness and better radio resources efficiency.
  - The expected spec. impacts and standardization workload are small.
- **Proposal**
  - Introduce UL SFN function in R19.

# Objectives for UL SFN

## Objectives for UL SFN

**The objective is to specify support for SFN in UL:**

- Study and specify a group scheduling mechanism to allow multiple UEs to transmit same data on the same UL resource. [RAN2, RAN1]
  - Package alignment between UEs via standardized or non-standardized UE-UE interconnection.

# Thanks

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# References


- TR 22.867, Study on 5G Smart Energy and Infrastructure_v18.1.0, (Release 18), 2021-09.
- 5G E2E Technology to Support Verticals URLLC Requirements, ngmn, 2020.
- RP-213211, Smart grid differential protection backup requirement for Rel.18. Spreadtrum Communications, CEPRI, China Southern Power Grid, H3C, Xiaomi, RAN#94e, December 6 - 17, 2021.
- RP-213243, Motivation on smart grid differential protection backup for Rel.18. CEPRI, China Southern Power Grid, CMCC, China Telecom, Spreadtrum Communications. RAN#94e, December 6 - 17, 2021.

# Simulation parameters/assumptions

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- **Parameters/assumptions**

| Items | Values |
|---|---|
| Scenario | UMa |
| Frequency | 2GHz |
| Bandwidth | 10MHz per UE |
| Subcarrier spacing | 15KHz |
| Base station configurations | [4,  4, 2, 1, 1] |
| UE antenna configurations | [1, 1, 1, 1, 1] |
| UE Tx power | 26dBm |
| WhiteNoise | -174dBm/Hz |
| Distance between backup UEs | 10m |
| Drop number | 10000 |