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Initial Views on 5G Technologies

- from Terminal Perspectives

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3GPP RAN Workshop on 5G

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Outline

- Coolpad's Views on 5G Terminals & Potential Radio Technologies
- Considerations on Potential Technologies
  - T-SC
  - IoT aggregation
  - UDN
  - D2D evolution

Coolpad's Views on 5G Terminals & Potential Radio Technologies

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Coolpad's view of 4G terminals: PMCC

➢Personal, Mobile, Cloud, Computer

Coolpad's views on 5G Terminals & Potential (Radio) Technologies

➢**Faster access**

- **Ultra dense network**, **large scale antenna array**, new multiple access and full spectrum access =>Terminal's transmission will be faster.

➢**More flexibility**

- **Direct link** between terminals (**more advanced D2D**) will be applied in commercial scenarios.
- Less dependency on network infrastructure for communications.

➢**Terminal evolution**

- Terminal has part of base station functions which can provide radio access and **aggregation of IoT** services as **Terminal-Small Cell(T-SC).**

➢**More security needs (not only related to radio)**

- Open hardware and software platform brings more security needs.
- Not only for the mobile terminal itself, but also for other aggregated devices.

➢**Tighter collaboration (not only related to radio)**

- Cloud is not only cloud and terminal is not only terminal.
- Function collaboration and migration between mobile terminal and cloud for different purposes such as power saving, load reduction and security endurance.

Terminal Small Cell (T-SC)

- Challenges and Opportunities of using crowdsourcing to build 5G RAN

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■ **Challenges** on mismatch between fast increasing traffic load and operator's income

➢ According to some statistics in 2014, 184% traffic increase only brought around 51.6% income increase .

➢Operator's income from Voice + Message decreases due to some reasons such as free chat APPs via smart phone.

➢Data traffic increasing doesn't mean more income.

➢Income from other services such as cloud are less than 1%.

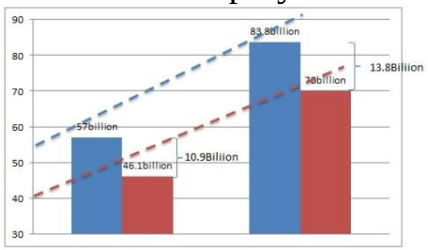
■ **Challenges** of 5G radio access network deployment

➢According to some statistics about 4G network deployment, mobile network occupies 50% of operator's cost while the access network takes over 36%.

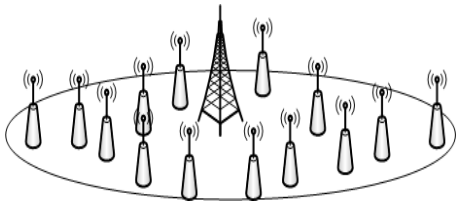
➢In 5G networks, the number of small cells rises due to ultra dense deployment, e.g., hundreds of small cells per square kilometers.

➢Price of small cell is not sufficient low (it is estimated as 7~8 000 CHY), thus cost of small cell deployment may be even more than macro cell. There are also other difficulties to deploy small cells such as backhaul.

Mismatch between traffic and income



Increasing NW deployment cost



Dense deployment of 5G small cells

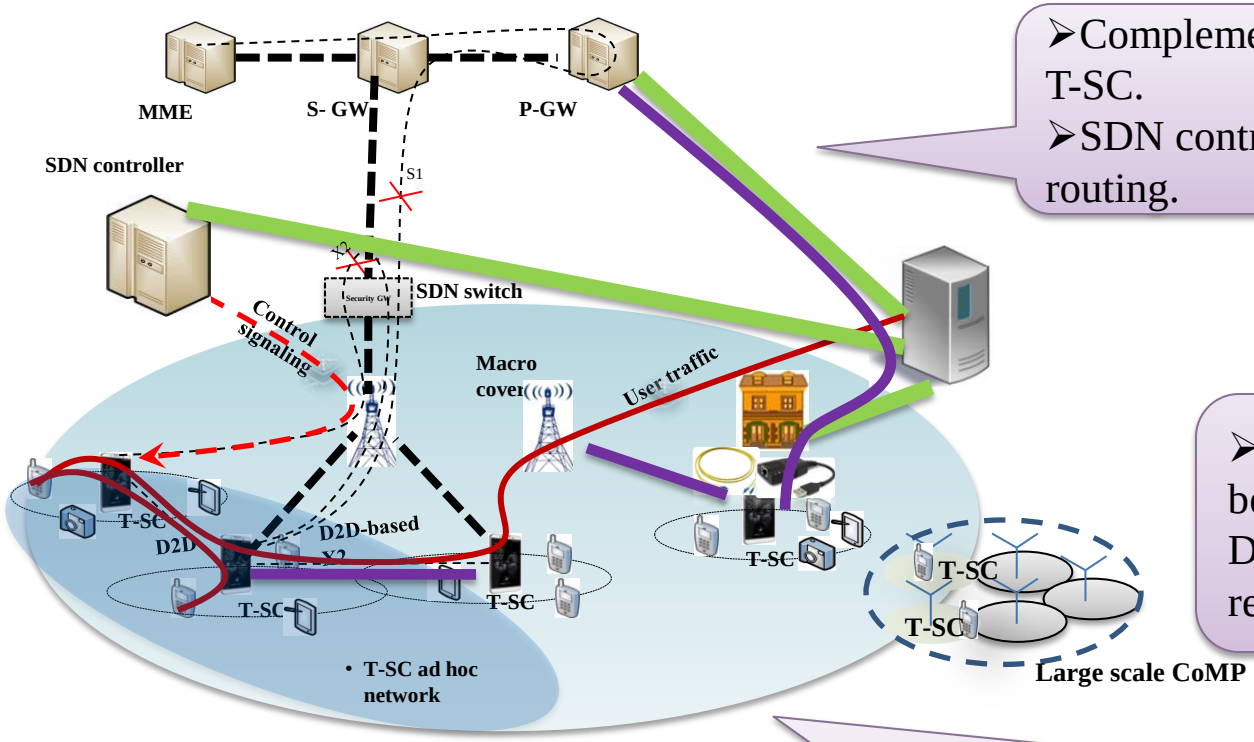
Opportunity: Mobile Terminal is more and more powerful!

- In Aug. 2010, MIT developed a super computing capability into android smart terminal.
- TACC(Texus Advanced Computing Center) developed an android app which can turn android smart terminal into mini super computer.
- …

Opportunity of using T-SC based **crowdsourcing** to construct 5G new access network.

- Mobile Terminal with part of small cell function (Terminal-Small Cell, T-SC).
- Apply crowdsourcing approach to share the construction cost and solve deployment difficulties via mobile users, e.g., contribution-based billing or sharing economy.

T-SC's role in 5G Radio Access Network



➢Complementary network infrastructure with T-SC.
➢SDN controlled terminal to realize smarter routing.

T-SC's backhaul

➢T-SC's backhaul can be 5G radio bearers, wired/wireless backhaul or D2D relayed backhaul, which can realize flexible deployment.

As new type of Small Cell, T-SC will integrate with other small cells to construct the 5G radio access network.

Potential Issues to Solve

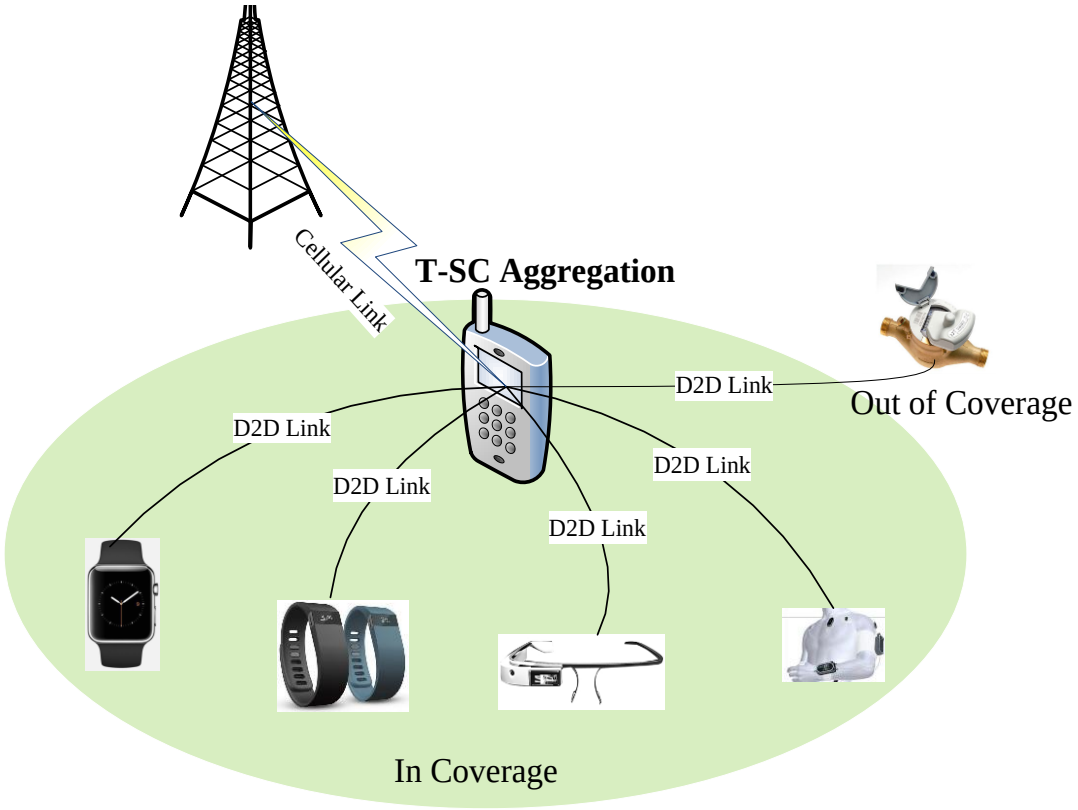
- ☐T-SC coverage provisioning and networking, to act as part of network infrastructure.
- ☐D2D-based backhaul between T-SCs, i.e., replace X2 interface.
- ☐T-SC support of UDN including large scale CoMP and virtualization.
- ☐SDN-enabled T-SC management and control.

IoT aggregation
- enabled by T-SC & D2D

To solve 10~100 × connections problem in large scale IoT

- Terminal Small Cell (T-SC) acting as the aggregation point for signaling and data traffic for IoT devices.

- T-SC provides cell access and shared access for other IoT devices on D2D links.
- T-SC forwards local traffic among IoT devices without traversing the network side.
- T-SC can control aggregated devices e.g. in authentication and authorization.



IoT aggregation
- Potential Issues

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- **Visibility to CN**

  ☐For in-coverage case, T-SC can hide the aggregated IOT devices to CN or expose them to CN.

  ☐For out-of-coverage case, there may be no NAS connection between IOT devices and MME meaning that the IOT device is invisible to CN.

- **Protocol layer aspects**

  ☐Protocol stacks may need modification/simplification to realize efficient IOT devices aggregation.

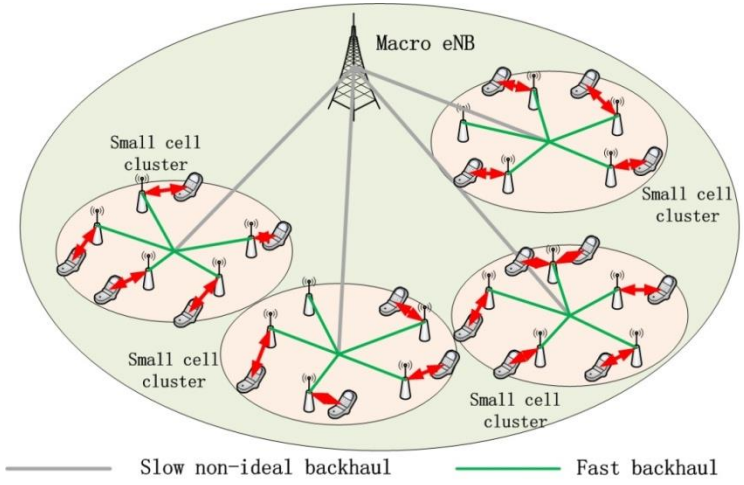
  - Reduce signaling overhead e.g., by context-based IOT devices grouping and signaling.
  - Bearer mapping or QoS of IOT data between T-SC PC5 and Uu should be considered.
  - T-SC based D2D link should take limited D2D link connections and mobility management into consideration.

- **Security aspects**

  ☐The trust relationship between T-SC and the aggregated IOT devices and the way to utilize this for security control of T-SC with light weight.

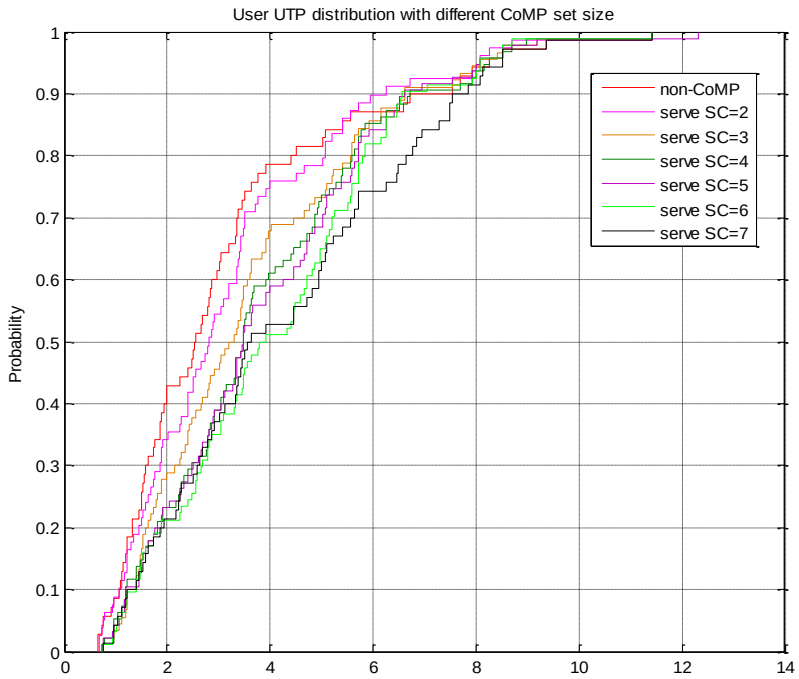
UDN (Ultra Dense Network)

- **Target**
  - The most important way to meet 1000 × traffic growth.
  - To increase the spectral reuse factor infinitely via deploying denser base stations.
  - To achieve hundreds of times capability improvement in hot-spot areas.
- **Challenges and problems**
  - Serious interference, frequent handovers and impacts for user experience, backhaul among cells.
- **Main technologies**
  - Interference management and suppression
  - Cell virtualization
  - Joint design of access and backhaul resource

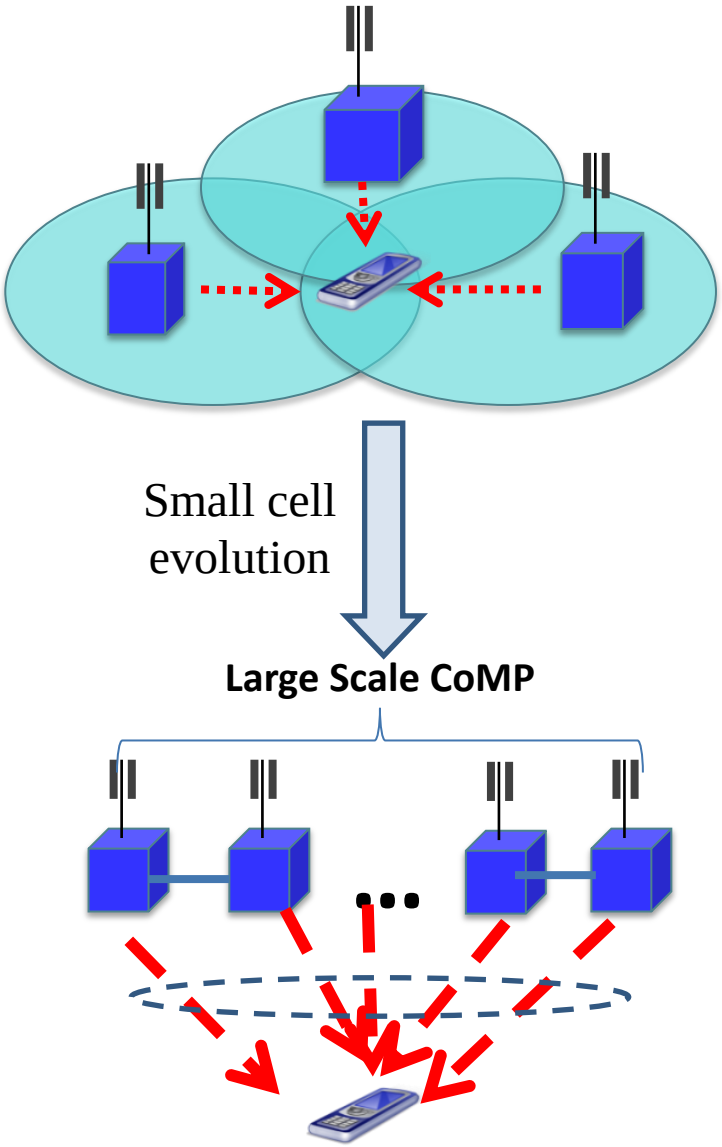


Large Scale CoMP in UDN

- **Challenges**: Severe interference problem among the small cells.
- **Proposals**: Increasing the cooperation size
  - ✓ Clustered small cells
  - ✓ Cooperation strategies
  - • Overhead reduction



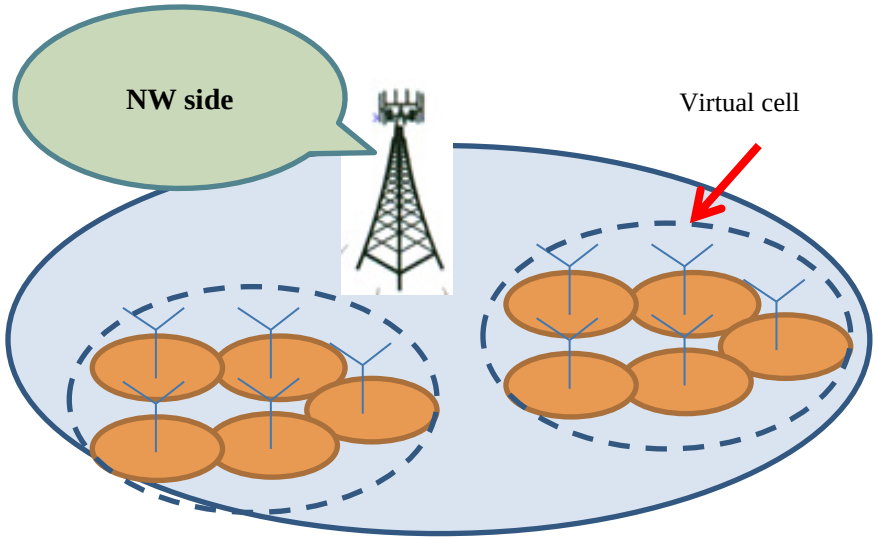
Large Scale CoMP vs. Terminal Throughput

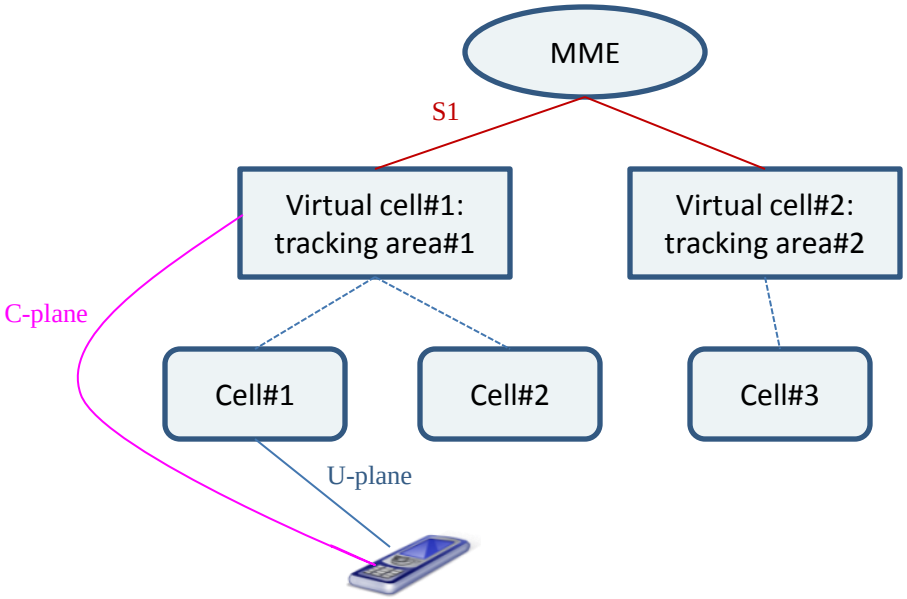


Cell virtualization in UDN

- NW side

- **Challenges**: Frequent handovers and impacts for user experience.
- **Proposals**: NW side virtualization
  - ✓ Provide user centric service by a virtual cell.
  - ✓ The virtual cell includes a group of coordinated cells which can be selected semi-statically.
  - ✓ Signaling exchange with CN is only needed when virtual cell is changed.
  - ✓ E.g., a virtual cell is comprised of all cells in a tracking area. Thus, both idle UE and connected UE need to indicate to CN only when changing tracking area.

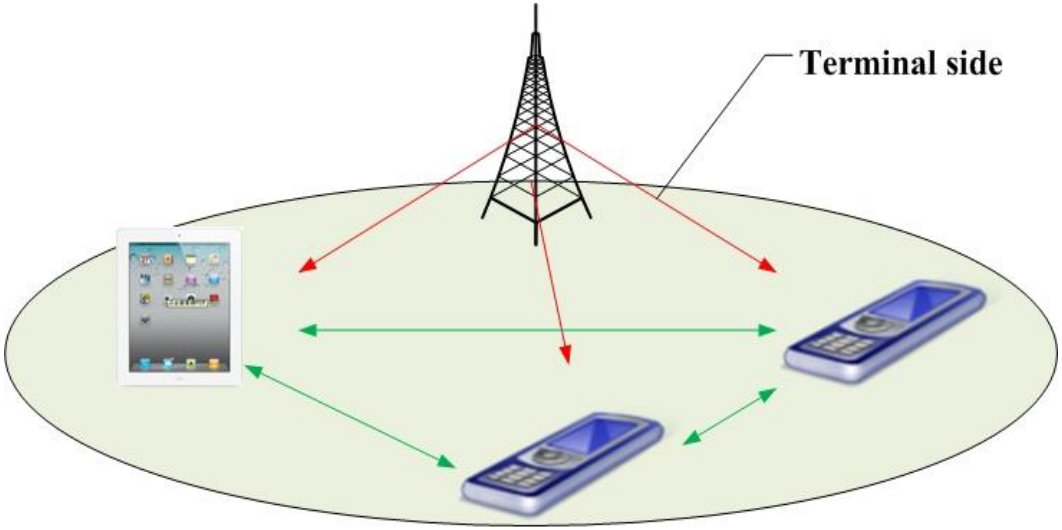


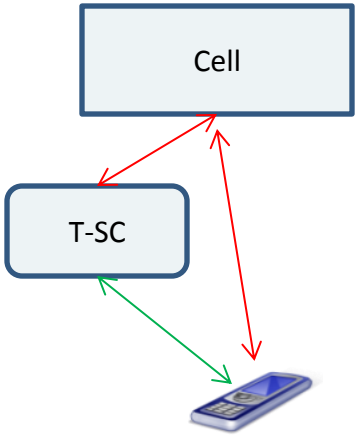


Cell virtualization in UDN

- Terminal side

- **Challenges**: Frequent handovers and impacts for user experience.
- **Proposals**: Terminal side virtualization
  - ✓ Select terminals with high capability to aggregate and forward the data between eNB and other terminals.
  - ✓ Terminal with high capability can be used as a Terminal small cell.
    - T-SC can be used to help data transmission between eNB and terminals with bad channel quality.
    - In addition, the channel quality between eNB and T-SC should be sufficient to support virtualization.





D2D evolution in 5G

- Motivations

- In 4G stage, i.e., R12 and R13, D2D has been an essential technical feature for LTE system from both EPC and E-UTRAN with the major targeted scenario as Public Safety for D2D communications. Only D2D discovery can be applied to non-PS area, i.e., commercial scenario.
- In 5G stage, i.e. from Rel-14 to Rel-16, Coolpad thinks that both D2D discovery and D2D communication may be extended, i.e., D2D evolution should be supported for commercial case, especially for some use cases including local data exchange and V2X service continuity.

UE collaboration for local data exchange enabled by D2D evolution

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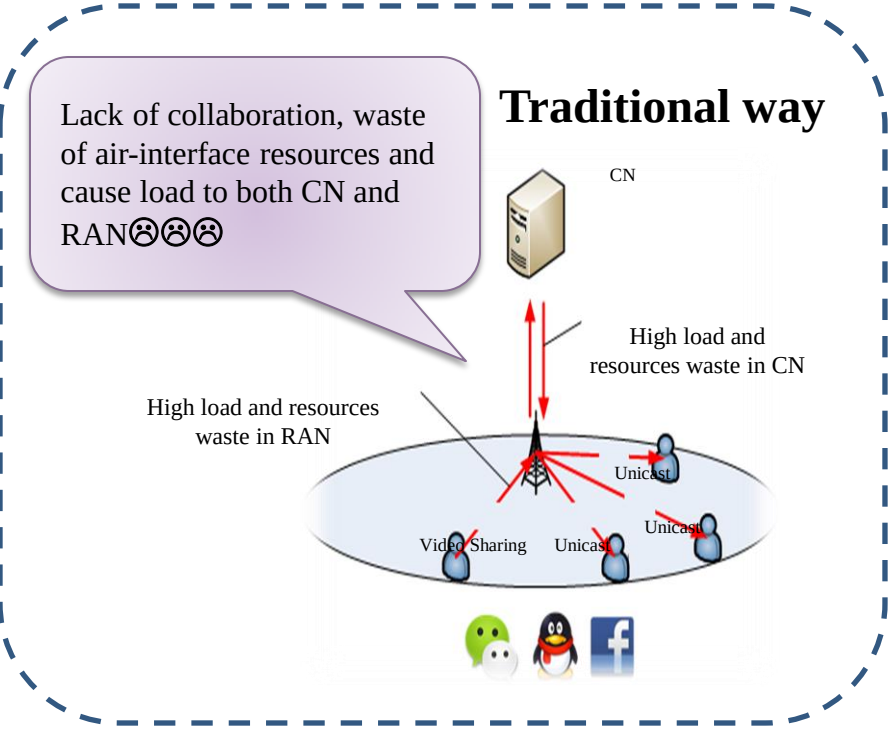
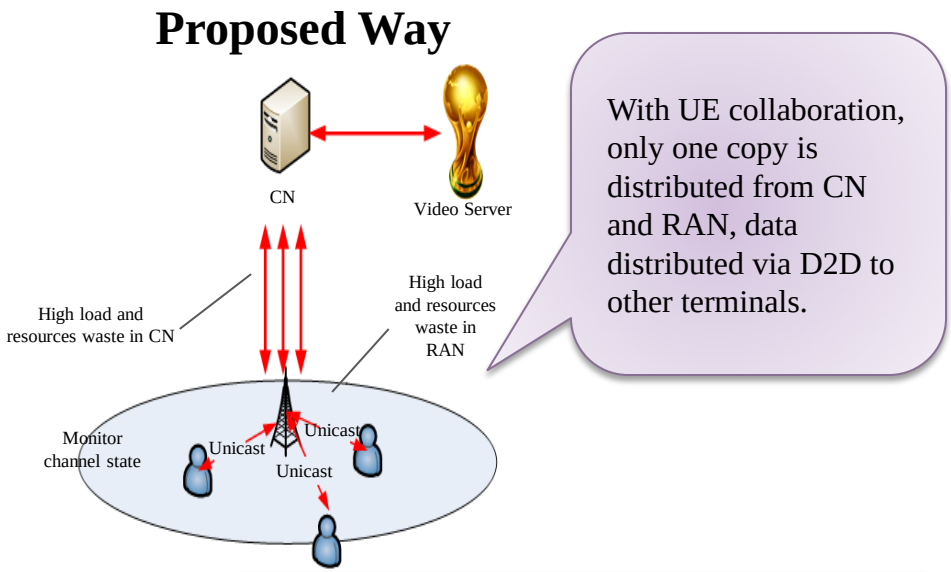
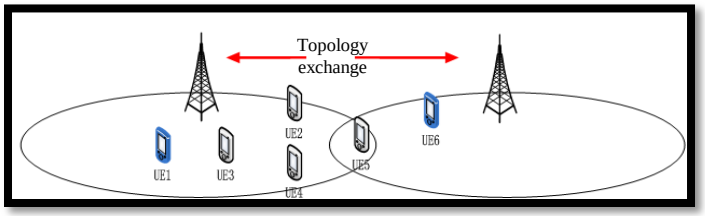
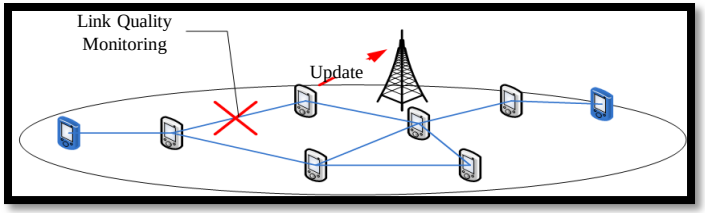






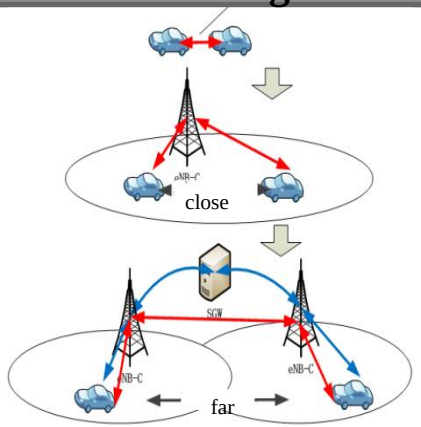
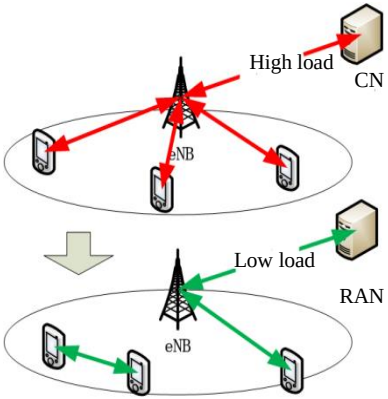


Observations :

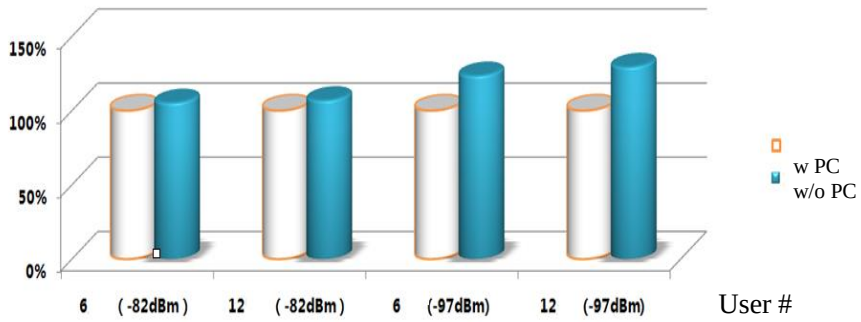
➢*With collaboration, efficiency for data distribution can be improved significantly and both CN and RAN can be offloaded.*

➢*UE-to-UE relaying as an enabling technique which has not been standardized in Rel-13.*

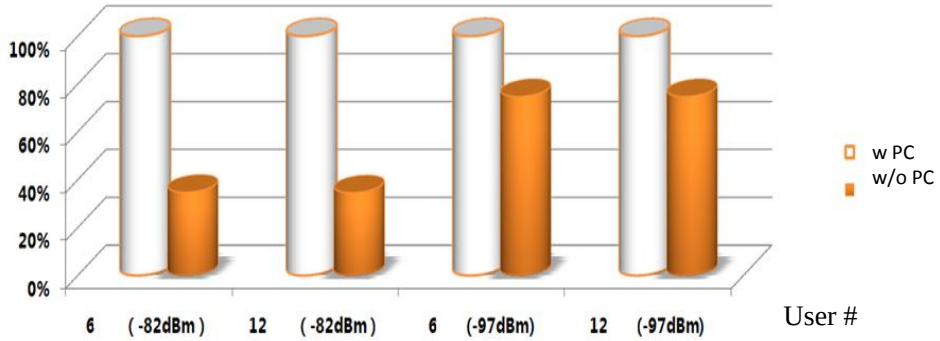
V2X service continuity enabled by D2D evolution

Mobility-triggered mode switching	Power and load-based mode switching
	
• Objective: Improve user experience and service continuity for D2D-based V2X with cellular system.	• Objective: Decrease terminal power consumption and reduce load of core and access network.

- V2X (i.e. car-to-car) as a major scenario in both 4G and 5G.
- Power control and load based service continuity solution and data forwarding during mode switching.
- Service continuity between D2D service and legacy/cellular service should be supported for V2X service via 5G.



Throughput gain



Power saving gain

5G could be Tactful and Successful Communications (T-SC).

Thanks a lot!