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Further enhancement on NR mobility for Rel-18

China Telecom

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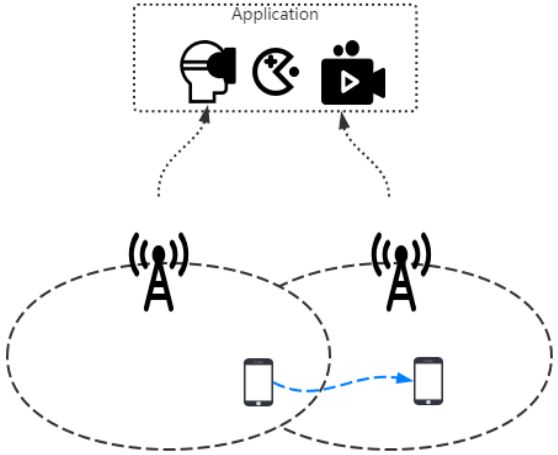
Background

Background

- With increased frequency carrier in 5G evolution, the deployment of base stations will be more intensive and the cell coverage radius will be smaller. UE will experience more frequent cell selection/re-selection, handover or PScell change, this will undoubtedly increase UE energy consumption, reduce mobility performance and cause high signaling overhead.
- The requirement of packet delay and data rate for new emerging applications (such as XR, 4K/8K video, cloud gaming, etc…) is much stringent, the network needs to provide high quality and consistent services for users especially when user is moving.
- In R16/17, 3GPP has introduced CHO/CPAC and DAPS to enhance mobility robustness and reduce data interruption, however the above technologies can only be used in limited use cases. Further enhancement on mobility enhancement should be studied in R18 to guarantee the consistency of user services.



Consistent service guarantee during mobility procedure

Summary of RAN Rel-18 Workshop

- About 26 companies (contributions and Q&As) provided views on mobility enhancement with wide interest to support, including operators, network vendors, UE vendors, etc.
- Mobility enhancement was included in the set of topics for further discussion in the workshop summary RWS-210659:
  - **3. Mobility enhancements**, with the following example areas:
    - Layer 1/layer 2 based inter cell mobility
    - DAPS (Dual Active Protocol Stack)/CHO (Conditional HandOver) related improvements
    - FR2 (frequency range 2)-specific enhancements
- Other areas related to mobility enhancement discussed in the R18 workshop email-discussions are as follow:
  - Data forwarding optimization (about 2 companies proposed)
  - Support inter-RAT PScell change (about 2 companies proposed)
  - Fast failure detection and recovery (about 6 companies proposed)
  - Network signaling reduction (about 3 companies proposed)
- In our view, it is crucial to enhance current mobility procedures to provide consistent high data rate with low latency performance, based on this, we propose:
  - The L1/L2 based inter cell mobility, DAPS/CHO related enhancement (e.g. DPAS+DC/CA, DAPS+CHO, CHO+MRDC, NG-based CHO, etc…), and data forwarding optimizations should be handled with high priority;
  - For FR2-specific enhancement, reduce data interruption for FR2 to FR2 case is necessary, support DAPS HO in FR2 scenario is worth to be considered;
  - Other areas can be treated with low priority and considered together with the TUs allocated in R18.

L1/L2 based inter cell mobility

L1/L2 based inter cell mobility

- L1/L2 based mobility can reduce the UP data interruption compared with legacy L3 controlled mobility solutions, and it would not increase much UE complexity compared with DAPS solution. However in R17, only L1/L2 centric intra-DU mobility is supported, expanding L1/L2 mobility to serving cell change for intra-DU and inter-DU(intra-CU) scenarios are desirable. For inter-CU scenario, as there may be much impact on the specification, it can be considered as low priority in R18.
- With L1/L2 based mobility solution, the candidate cells are pre-configured (e.g. in NR SA, CA and MR-DC scenarios), UE stores the configuration and performs measurement and beam management, and then UE can initiate fast cell switching based on L1/L2 signaling. For MRDC scenario, switching between PCell and PSCell can be considered at the early stage, other use cases can be further explored if time allowed.

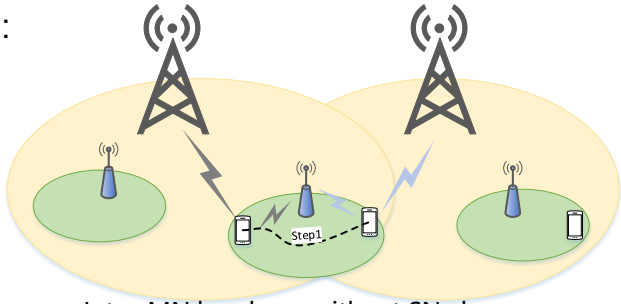
Potential scope:

- Specify L1/L2 based inter-cell mobility solutions which are not addressed in R17, to reduce the data interruption time in multiple scenarios (e.g. NR SA, CA and MR-DC): [RAN2, RAN1, RAN3, RAN4]
  - Support serving cell change for intra-DU and inter-DU(Intra-CU) L1/L2 mobility approaches;
  - Support switching of Pcell, switching of Scell, switching between Pcell and PSCell, etc…

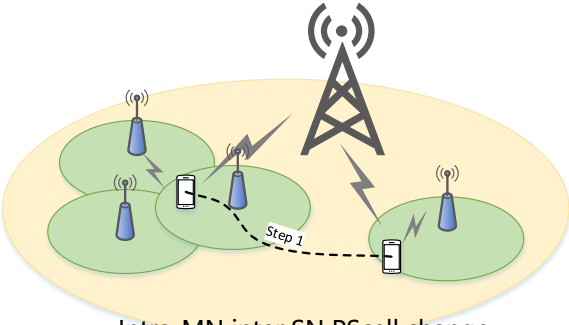
DAPS/CHO related improvements

DAPS/CHO related improvements

- Due to the limitation of UE capabilities or avoid causing overly network signaling, DAPS and CHO/CPAC can only be used in limited scenarios, further extensions should be supported to provide consistent high data rate and low latency mobility performance.
- Following aspects related to DAPS enhancement can be considered:
  - ✓ **DAPS+DC/CA**: DC/CA can be used to provide high data rate businesses, however in current specification, the UE needs to release Scell/SCG before perform DAPS HO, which limits the usage of the DAPS handover and may cause data interruption. Therefore, DAPS supporting DC/CA should be supported. Moreover, support DAPS approach in SCG change scenario is also beneficial to reduce data interruption.
  - ✓ **DAPS+CHO/CPAC**: In R16/17, CHO/CPAC cannot be configured simultaneously with DAPS HO, but in some mobility cases, the HO robustness and 0ms interruptions are both desirable for the UE, therefore, extend current handover procedure to fulfill the user requirement is worth to study.



Inter-MN handover without SN change



Intra-MN inter SN PScell change

DAPS/CHO related improvements

- Following aspects related to CHO enhancement can be considered in R18:
  - ✓ **CHO+MRDC:** CHO and MRDC cannot be supported simultaneously, which will reduce the usage of CHO and may cause RLF in some cases and due to the limited TUs left in R17, it is also hard to be supported in R17, then it should be studied in R18.
  - ✓ **CHO+CPAC:** CPAC and CHO cannot be configured for a UE at the same time in R16. Support coexistence of CHO and CPAC can improve the mobility robustness in MRDC scenarios.
  - ✓ **NG-based CHO:** Only CHO for Xn interface is supported in R16, however there is not necessarily an Xn interface between the base stations, support CHO over NG interface can improve the mobility robustness.
  - ✓ **Inter-RAT CHO**: Support inter-RAT CHO can enhance the robustness and speed up the execution time.

Potential scope:

- Enhance DAPS and CHO approaches to support consistent high data rate with low interruption during mobility procedures, such as: [RAN2, RAN3, RAN4]
  - DAPS related enhancement, such as DAPS + DC/CA, DAPS+CHO/CPAC…
  - CHO related enhancement, such as CHO+MRDC, CHO+CPAC, NG-based CHO, inter-RAT CHO…

FR2-specific enhancement

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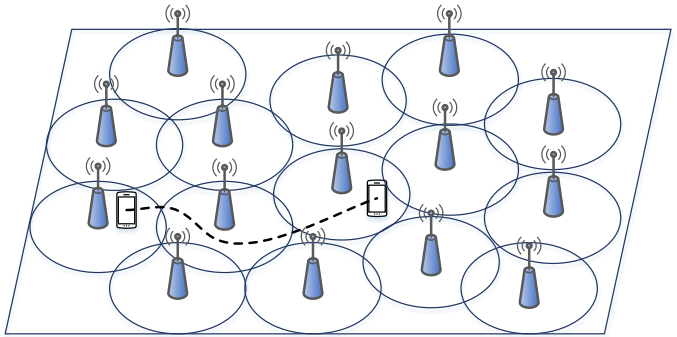
- In FR2, users will experience more frequent handovers, the data interruption during the handover procedure will seriously affect users‘ service experience. However, the DAPS handover for FR2 to FR2 case is not supported in current specification, this is mainly due to the limitations related to UE capabilities.
- Due to the services with high throughput and low latency are popular e.g. 4k/8k TV, online game, and XR/VR according to the market, we need to re-consider if the DAPS handover for FR2 to FR2 case should be supported in Rel-18 (e.g. enable RRC-based DAPS handover in FR2 for multiple-panel UE). Other enhancement such as MBB and RACH-less HO, which were specified in LTE but not supported in NR can also be considered.

Potential scope:

- Specify solutions for mobility enhancements on FR2, especially for reducing interruption, such as DAPS HO, MBB HO, RACH HO, etc... [RAN2, RAN3, RAN4]

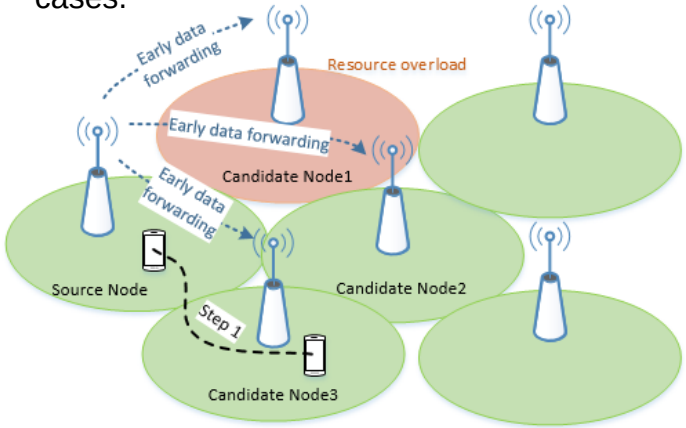
  Note: If DAPS HO can be extended to FR2 scenario, then MBB and RACH-less HO can be deprioritized.



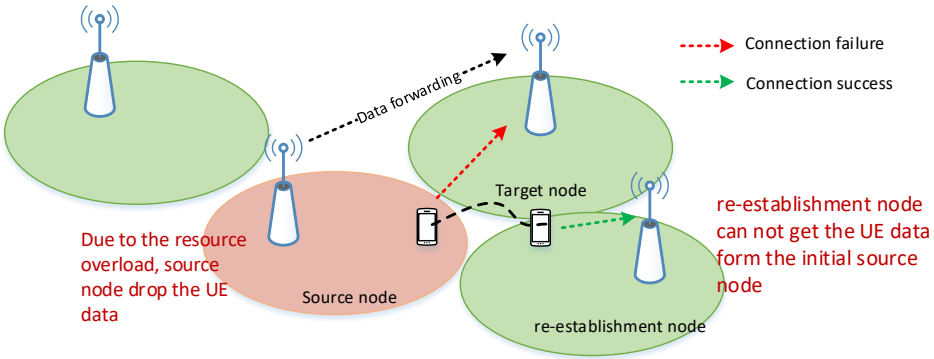
UE Handover more frequent duo to the high frequency deployment

Other aspects related to mobility enhancement (1)

- Data forwarding enhancement:
  - The current data forwarding procedure can be enhanced to ensure data continuity and reduce network latency, following enhancements can be considered in the next release:
    - ✓ **Early data forwarding enhancement:** Enhance current data forwarding procedure to release the data which has been successfully transmitted timely can help the BS reduce the cache pressure.
    - ✓ **Exception handling**: Design the data acquisition procedures to help the base station retrieve the UE context when necessary(i.e. In case of HO to wrong cell/too early HO, if HO failed before UE set up connection to the target cell, and the source node has dropped the UE context), which can reduce data interruption due to failure cases.



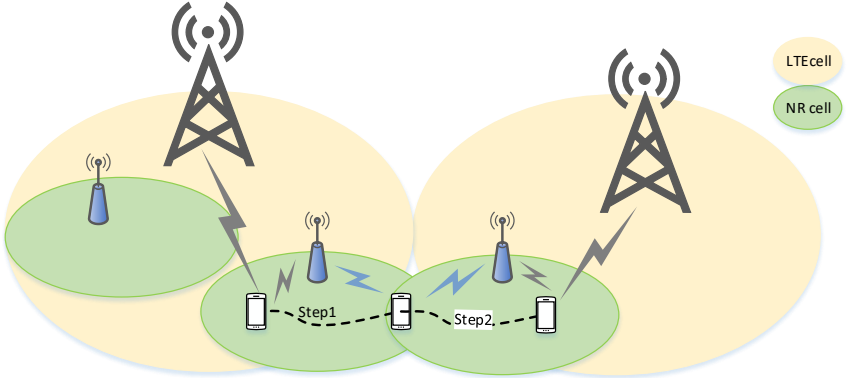
Early data forwarding may cause resource overload



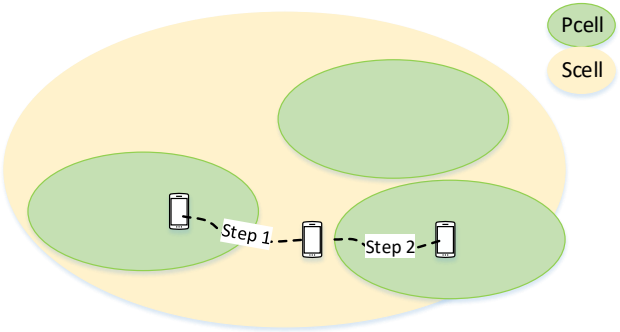
User data may loss duo to the high traffic load of source node

Other aspects related to mobility enhancement (2)

- Support of inter-RAT PScell change：
  - Inter-RAT SN change procedure with single RRC reconfiguration is not supported in current specification (i.e. no transition from EN-DC to NR-DC), support inter-RAT PScell change procedure can reduce data interruption and ensure service continuity for the users.
- Fast failure detection and recovery：
  - Given that fast failure recovery is an essential procedure which provides transmission reliability, enhancement on fast failure detection and recovery especially for FR2 would be an important part for mobility enhancement. For example, similar as fast MCG failure recovery in Rel-16, fast failure recovery for PCell through SCell in FR2 should be supported.



Inter-RAT PScell Change (ENDC to NRDC)



Pcell failure occurs in CA scenario with Pcell in FR2

Other aspects related to mobility enhancement (3)

- Network signaling reduction：
  - The signaling interaction between the network and users will become more frequent due to the FR2 deployment, which will undoubtedly cause high signaling overhead and may cause RLF in some cases.
  - Solutions to reduce network signaling are worth to study, for example, the UL signal based mobility procedure could potentially reduce measurement reporting overhead and power consumption. Other aspect such as optimize current handover configuration (such as CHO configuration) to reduce network signaling can also be considered.

Potential scope:

- Specify the solutions on the following aspects to enhance mobility performance: [RAN2, RAN3, RAN1]
  - Data forwarding enhancement
  - Support of inter-RAT PScell change
  - Fast failure detection and recovery
  - Network signaling reduction

Potential Scope

- The following objective can be considered in R18:
  - Specify L1/L2 based inter-cell mobility solutions which are not addressed in R17, to reduce the data interruption time in multiple scenarios (e.g. NR SA, CA and MR-DC): [RAN2, RAN1, RAN3, RAN4]
    - Support serving cell change for intra-DU and inter-DU(Intra-CU) L1/L2 mobility approaches;
    - Support switching of Pcell, switching of Scell, switching between Pcell and PSCell, etc…
  - Enhance DAPS and CHO approaches to support consistent high data rate with low interruption during mobility procedures, such as: [RAN2, RAN3, RAN4]
    - DAPS related enhancement, such as DAPS + DC/CA, DAPS+CHO/CPAC…
    - CHO related enhancement, such as CHO+MRDC, CHO+CPAC, NG-based CHO, inter-RAT CHO…
  - Specify solutions for mobility enhancements on FR2, especially for reducing interruption, such as DAPS HO, MBB HO, RACH HO, etc... [RAN2, RAN3, RAN4]

    Note: If DAPS HO can be extended to FR2 scenario, then MBB and RACH-less HO can be deprioritized.
  - Specify the solutions on the following aspects to enhance mobility performance: [RAN2, RAN3, RAN1]
    - Data forwarding enhancement
    - Support of inter-RAT PScell change
    - Fast failure detection and recovery
    - Network signaling reduction

Thanks！