3GPP TSG RAN RP#102
Edinburgh, GB, December 11-15, 2023

RP-233427

Views on R19 AI/ML for Mobility

Agenda Item: 9.1.2.4

Source: CMCC

Document for: Discussion

Content

- Background
- Motivation
- Potential issues and considerations
- Potential Objectives

Background (1/3)

NR HO mechanisms

- **R15: Basic HO**
  - ✓ NW-controlled mobility, HO decision is made by NW
  - ✓ UE performs measurement and reports the measurement results (including beam-level results)
- **R16: CHO, DAPS**
  - ✓ **CHO (Robustness improvement):**
    - Handover is executed by the UE when execution condition (configured by NW) is met
    - The measurement results of candidate cells for CHO execution are not reported to NW
  - ✓ **DAPS (0ms interruption):**
    - UE receives DL user data from both source gNB and target gNB simultaneously during HO procedure
- **R18: L1/L2-triggered Mobility (LTM)**
  - ✓ Enable a serving cell change via L1/L2 signalling
  - ✓ Reduce the latency, overhead and interruption time

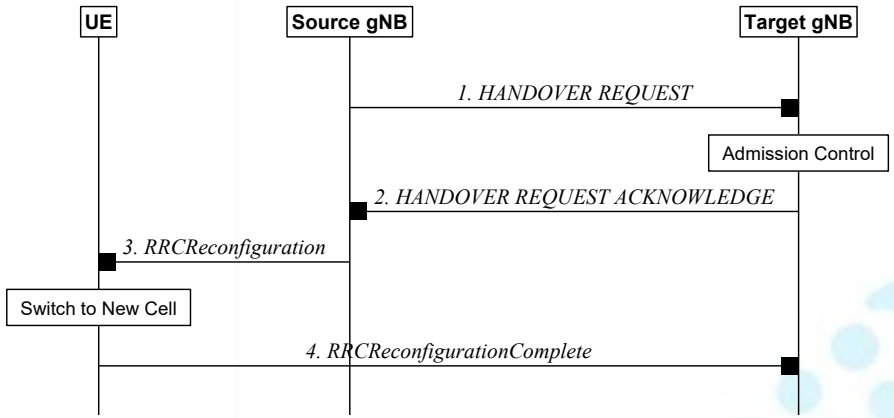

Fig. Basic inter-gNB handover procedure

Background (2/3)

R18 RAN3-led AI/ML for NG-RAN

- **AI/ML based mobility optimization has been specified as one of the use cases of AI/ML for NG-RAN in R18, in order to select the proper target cell to improve successful handover rates, efficiency and performance**

  - ✓ AI/ML model can be used to
    - Predict UE trajectory
    - Make HO decision
  - ✓ Only inter-node information exchange is introduced
    - A cell-based UE trajectory prediction is transferred to the target NG-RAN node, e.g. the predicted NG-RAN cells the UE will connect to; the trajectory prediction is limited to the first-hop target NG-RAN node
    - For feedback, the measured UE trajectory (one-time report) and UE performance are conveyed from target node to source node

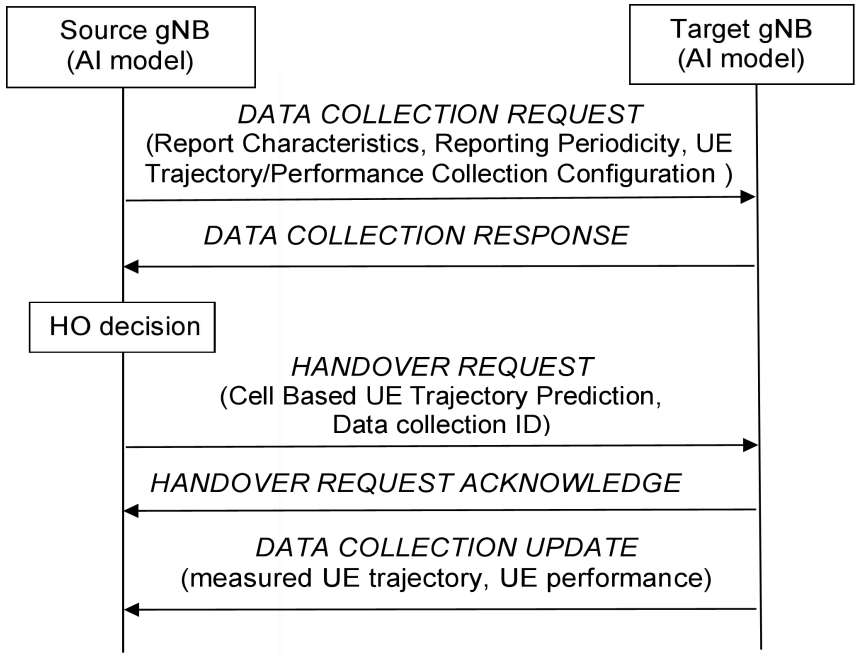

Fig. Signalling procedure for AI based Mobility Optimization

Background (3/3)

R18 RAN1-led AI/ML for Air interface SI

- **Three PHY use cases are studied:**
  - ✓ CSI enhancement
  - ✓ Beam management
  - ✓ Positioning accuracy enhancement
- **LCM procedures (Functionality/Model ID-based LCM)**
  - ✓ Data collection
  - ✓ Model training
  - ✓ Inference
  - ✓ Performance monitoring
  - ✓ Model/functionality identification
  - ✓ Model/functionality management (e.g. selection, activation, deactivation, switching, fallback)
  - ✓ Model transfer/delivery

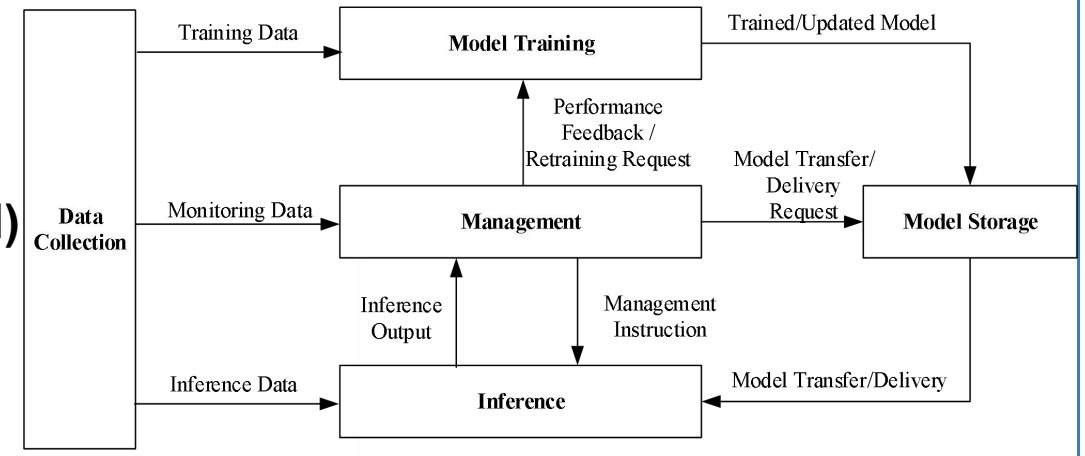

Fig. Functional framework for AI/ML for NR Air Interface

Motivation

Justifications

- **In RAN#101, the following potential justifications were proposed based on the moderator's summary [1]:**
  - ✓ The existing handover mechanisms are reactive by design
  - ✓ The existing decisions are made based on historical measurements and sometimes inaccurate RRM measurements and/or UE location that can impair good handover decisions
  - ✓ The complexity, measurement effort, and signalling overhead may be high
  - ✓ New services like XR may require a reliable mobility connection
  - ✓ For the failure in mobility, there may be RLF, beam failure and HOF happened, and current failure handling methods focus on fast recovery, and they are reactive and cannot eliminate the interruption or bad services caused by a failure event

- **Potential objectives according to RAN Chair's guidance [2]:**
  - Type of mobility
    - L3-based mobility and L1/L2-triggered mobility (LTM) are both considered
  - HO optimization in Network side ~~[/UE side]~~, including
    - Candidate/target cell prediction in L3-based mobility, or, candidate/target beam(s) and cell(s) prediction in LTM
  - RRM measurement and event prediction, including
    - Beam-level measurement prediction
    - Cell-level measurement prediction, e.g., using intra-frequency measurement results to forecast the RRM measurement of inter-frequency/inter-RAT cells
    - HO failure/RLF prediction
    - Measurement events prediction
  - LCM framework and others
    - The conclusions in Rel-18 AI/ML study should be used as baseline
    - Other impacts are further studied
  - ~~[UE RRM enhancement, RAN4]~~
  - Note 1: no intention to change the existing framework for the mobility under connected mode
  - Note 2: In the SID, target performance metrics and impacts should be clarified
  - Note 3: Avoid overlap work with RAN3

- **Potential issues and considerations:**
  - ✓ Type of mobility, sub-use cases
  - ✓ Type of model
  - ✓ HO optimization
  - ✓ LCM related

[1] RP-232622 Moderator's summary for REL-19 RAN2 topic AI/ML for Air Interface SI (Mobility)
[2] RP-232745 Summary for RAN Rel-19 Package RAN123-led

Potential issues and considerations (1/3)

Type of Mobility

- In RAN#101, companies showed interests on AI/ML-based mobility for both L3-based mobility and LTM
- In general, L3-based mobility (HO/CHO) is a kind of basic and essential mobility, while LTM is further enhancements to reduce latency/overhead which is more applicable for FR2
- From the perspective of operator, R15/R16 mobility has been deployed in current network, so we prefer to mainly focus on L3-based mobility in R19 study on AI/ML-based mobility enhancement considering the commercial deployment
- **Proposal 1: R19 study on AI/ML-based mobility mainly focus on L3-based mobility.**

Type of Model

- During R18 AI/ML for Air interface SI, one-sided model and two-sided model are both studied, wherein two-sided model is only applicable for CSI compression sub-use case. However, there are still some remaining issues on two-sided model which have not been concluded or studied well in RAN1
- For mobility use case, the motivation and scenario to introduce two-sided model is not clear, we think one-sided model (UE-side/NW-side model) is sufficient to predict such as HO decision, RRM measurement and unintended events
- **Proposal 2: Only one-sided model (UE-sided model and/or NW-sided model) is considered in R19 study on AI/ML-based mobility.**

Potential issues and considerations (2/3)

HO optimization

- To differenciate the work from RAN3 AI/ML for NG-RAN, the study of R19 AI-based mobility should focus more on the impacts on air interface. However, considering the interaction between gNBs in mobility may be not avoided especially for L3-based mobility, the impacts on Xn signalling should also be studied. We understand the progress in RAN3 AI-based mobility can be reused as much as possible with necessary enhancements.
- **Proposal 3: R19 study on AI/ML-based mobility should focus more on air interface, and the progress on R18 RAN3 AI-based mobility can be reused as much as possible with necessary enhancements.**

- In legacy, the HO decision is always made by NW, and the procedure is under NW control (via explicit HO command or configured execution condition). For AI/ML-based mobility, we prefer not to change the legacy logic and the same principle on HO decision should be followed.
- **Proposal 4: Follow the legacy principle on HO decision for AI/ML-based mobility, i.e. the HO decision is always under NW control.**

Potential issues and considerations (3/3)

LCM related

- The functional framework and LCM procedure for AI/ML for Air interface have been studied and captured in TR 38.843
- In our undersatnding, the general framework and LCM procedure are common for all AI/ML use cases, and can be applicable for mobility
- To avoid duplicated discussion, we think it is straighforward that the functional framework and LCM procedure can be reused for R19 study on AI/ML-based mobility with necessary enhancements
- **Proposal 5：The functional framework and LCM procedure introduced in R18 AI/ML for air interface SI can be reused for R19 study on AI/ML-based mobility with necessary enhancements.**

- During R18 AI/ML for air interface SI, the following sub-use cases of beam management have been studied:
  - ✓ BM-Case1: Spatial-domain Downlink beam prediction for Set A of beams based on measurement results of Set B of beams
  - ✓ BM-Case2: Temporal Downlink beam prediction for Set A of beams based on the historic measurement results of Set B of beams
- We see that there are some common issues between mobility and beam management, such as beam quality prediction, AI function-to-entity mapping, one-sided model (NW-sided/UE-sided) is used. Therefore, R18 study on Beam Management could be considered as reference for R19 study on AI/ML-based mobility.
- **Observation 1: R18 study on AI/ML-based Beam Management could be considered as reference for R19 study on AI/ML-based mobility.**

Potential Objectives

Proposed Objectives

- Study AI/ML-based Mobility enhancements, including [RAN2, RAN3, RAN4, RAN1]
  - ✓ Identify supported type of mobility
    - AI/ML for L3-based mobility is prioritized, AI/ML for LTM is second priority
  - ✓ Study on general framework and LCM, where UE-sided model and NW-sided model are both considered
    - Components identified by Rel-18 study item can be reused with necessary enhancements for mobility
  - ✓ Study potential procedure and signalling for the following aspects
    - RRM measurement
      - Cell-level measurement prediction, e.g., using intra-frequency measurement results to forecast the RRM measurement of inter-frequency/inter-RAT cells
      - Beam-level measurement prediction
    - HO optimization in network side
      - Candidate/target cell/beam prediction
      - UE assistance information may be needed, e.g. UE trajectory information
    - Failure handling
      - Unintended event prediction e.g., HO failure, RLF, Too early HO, Too late HO, Ping-Pong HO, Beam failure prediction, …

Thank you!