

The Discussion on Artificial Intelligence (AI)/Machine Learning (ML) for 5GS Service to enable 5GC and Air interface Intelligence

China Mobile, Vivo

Motivation

- The convergence of communication network and AI technology already made some progress. Up to now, the 5GS including both RAN and SA2 has studied and/or specified the AI-enabled network architecture and leverage Artificial Intelligence (AI)/Machine Learning (ML) to enable 5GC and Air interface Intelligence in terms of data collection, ML model training, analytics inference, and closed-loop procedures by consuming data analytics, etc.
- Based on the above, the work of AI/ML for 5GS in Rel-19 is proposed to expand the scope of network AI services to leverage AI/ML technologies to enable 5GC and Air interface Intelligence by providing network automation and improving the efficiency of 5G network architecture.
- In order to leverage AIML technologies to enable 5GC and Air interface Intelligence, this study item is to focus on following two parts:
 - ❖ Part A: Architecture enhancement to support 5G Core intelligence.
 - ❖ Part B: AI/ML alignment and convergence for Air interface and 5G Core network.

The following slides focus on **Part A: Architecture enhancement to support 5G Core intelligence.** and see joint discussion S2-2306460 from vivo/China Mobile for Part B

AI enabled Use Cases example---

Detection/prevention/mitigation of signaling storm

□ Issues and requirement:

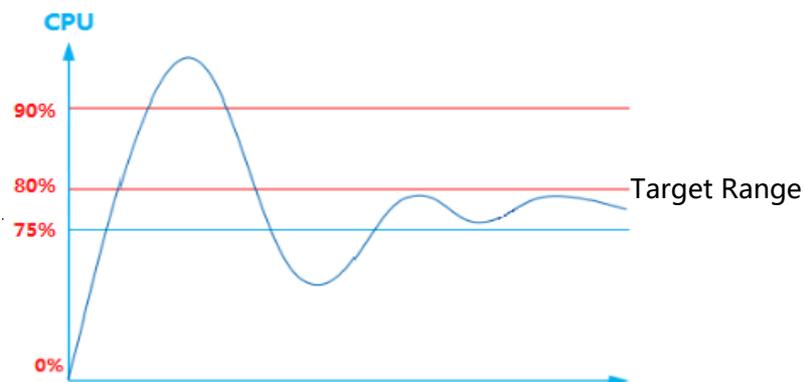
- The system needs to be more intelligent, proactively, dynamically and globally to prevent and mitigate from signalling storm or network abnormal behavior, such as adjust flow control parameters or back-off timer for NFs based on NF loads and failure rates of different interfaces.

□ Potential enhancement:

- Study whether and how to detect or measure signalling storm with the assistance of NWDAF.
- Study the mechanisms of prevention/mitigation for the signaling storm to guarantee the 5GS system stability with the assistance of NWDAF.
- Study whether and how NWDAF provides network level digital twin services to verify candidate actions provided by the 5GC NFs to avoid unexpected impacts on the network.

Signalling Storm Possible Reason

- **Terminals:** e.g., Large amount of UEs attach or connect at once or at a small area, when Holidays or Large-Scale Activities.
- **Public Network Attack or abnormal operation:** e.g., ToB application paging to all Business UEs.
- **CN failure:** e.g., NF restarts triggered UE reattach.



Signalling Storm Mitigation

AI enabled Use Cases example---

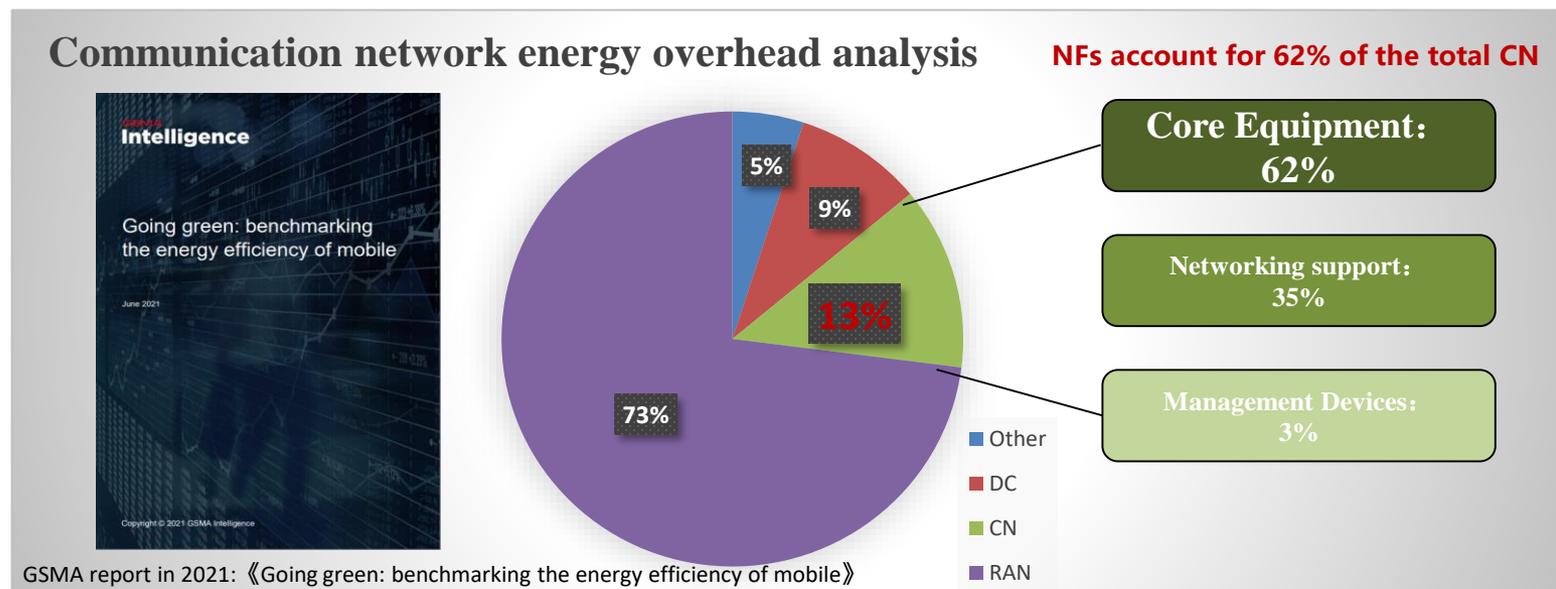
NWDAF assisted energy saving

□ Issues and requirement:

- Based on GSMA research and analysis on 31 operators, wireless network consumes the most energy (73%) followed by core network(13%).
- Energy saving solutions should be studied to reduce carbon emissions of core network, based on analytics data of user plane volume, PDU sessions(user) number, UE access control, etc.

□ Potential enhancement:

- Study whether and how to predict the capacity and load trend of NF(s) with the assistance of NWDAF.
- Study the NWDAF assisted solution for energy saving, e.g., load balancing or redistribution among multiple NF instances.



AI enabled Use Cases example---

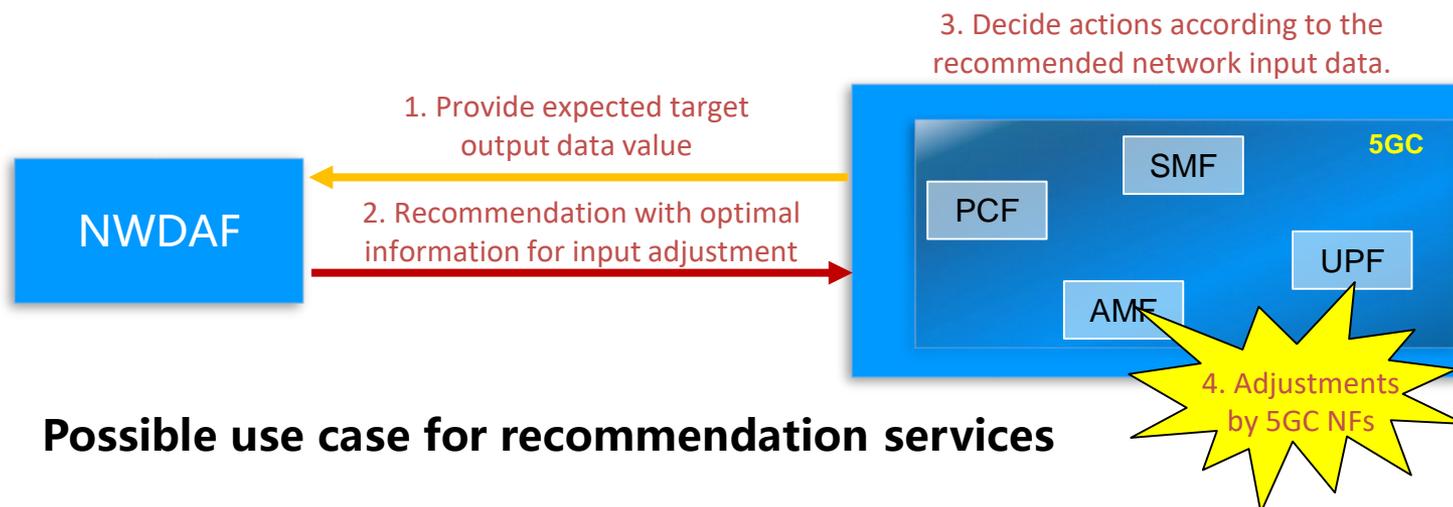
NWDAF assisted policy recommendation

□ Issues and requirement:

- PCF uses static configuration for QoS decisions, which cannot adapt to the diversity of multi-services and personalized policies.
- The network needs to be aware of resource status in time and adjust QoS policies dynamically.

□ Potential enhancement:

- Study whether and how to provide global optimal recommendation to 5GC NFs. For example, based on the analysis of network status, service experience requirements, etc, NWDAF could make policy decisions and adjusts user QoS parameters in time.



Leveraging AI Technologies example---

Online Learning

Issues and requirement:

- NWDAF based data collection and AI/ML training are offline. AI/ML models need to adapt to rapidly changing data in some use cases.
- E.g., NWDAF trains application detection ML model with UE/AF when the characteristics of the packet flows has changed frequently due to application update.

Potential enhancement:

- Network architecture enhancement to support online learning, able to quickly adjust the model in real-time based on online feedback data, enabling the model to reflect changes in a timely manner and improve the accuracy of prediction.

**Offline Learning
(Current)**

D features

	x_1	x_2	x_3	...	x_d	y
N samples	x_1	x_2	x_3	...	x_d	y
	x_1	x_2	x_3	...	x_d	y
	x_1	x_2	x_3	...	x_d	y
	x_1	x_2	x_3	...	x_d	y
	x_1	x_2	x_3	...	x_d	y

Batch training




Trained model

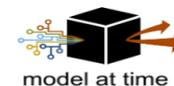
**Online Learning
(Future)**

Time increases

Input data at time t

x_1	x_2	x_3	...	x_d	y
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Online update

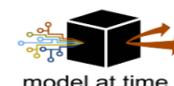



model at time t

Input data at time $t+1$

x_1	x_2	x_3	...	x_d	y
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Online update

model at time $t+1$

Input data at time $t+2$

x_1	x_2	x_3	...	x_d	y
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Online update




model at time $t+2$

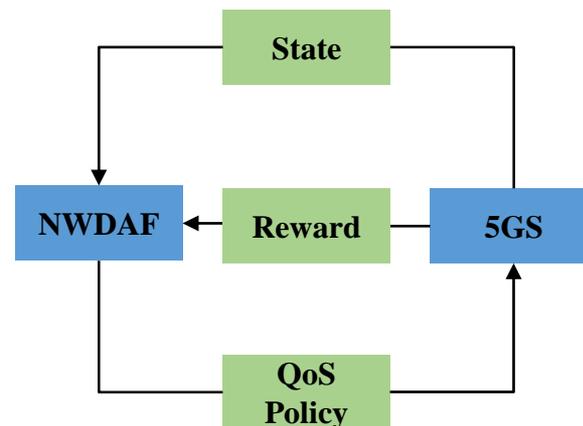
Leveraging AI Technologies example--- Reinforcement Learning

□ Issues and requirement:

- The network can not perceive whether NWDAF analytics data are gaining or losing to the network.
- Based on interactive environment, the optimal model could be generated.

□ Potential enhancement:

- Network architecture enhancement to support the mechanism of reinforcement learning.



Leveraging AI Technologies example---

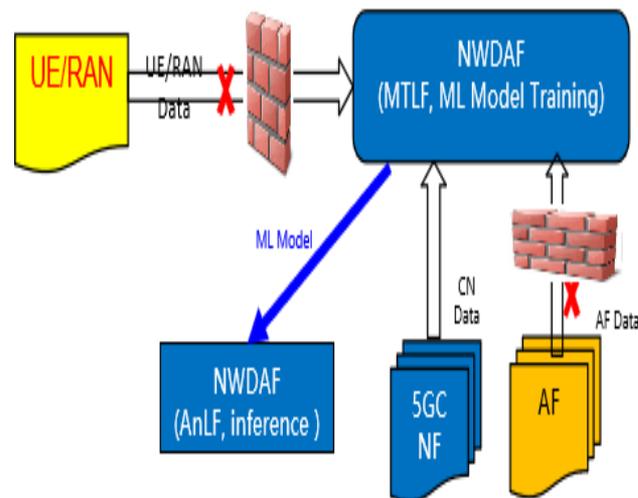
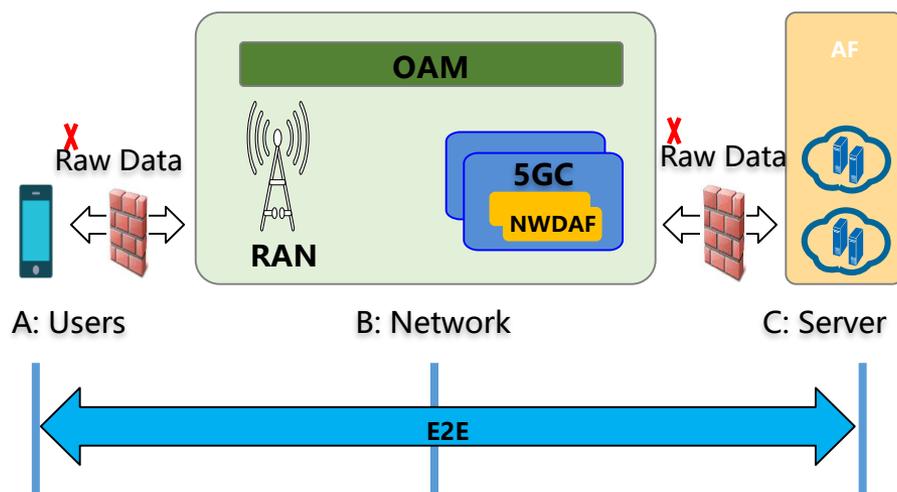
Vertical Federal Learning

Issues and requirement:

- Data analytics in 5G network usually needs data collection from different domains, but each domains (e.g. UE/RAN/CN/AF) may be isolated.
- Each domain have many private implementations and is not willing to report their data related to the private implementations.

Potential enhancement:

- Network architecture enhancement to support vertical federated learning, allowing different domains to exchange necessary intermediate information to assist E2E data analysis without exposing RAW data.



Support for AI/ML for air interface

□ Issues and requirement:

- In R18 RAN WG1/WG2 researched three AI scenarios: AI based CSI, beam management and positioning; RAN WG3 R18 has introduced three AI enabled use cases: network energy saving, load balancing and mobility optimization.
- In Rel-18, no impact between NG-RAN node and CN.
- In Rel-19, RAN and 5GC need to collaborate in functional deployment, data collection, model distribution, and other aspects.

□ Potential enhancement:

- Network architecture enhancement to support for AI/ML for air interface, the following may to be studied:
 - ✓ **Use case related:** 5GC assisted Positioning, CSI, Beam Management, gNB Energy Saving, Load Balancing and Mobility Optimization, etc.
 - ✓ **Architecture related:** Vertical Federated Learning, existing NFs/Nodes/Interface enhancement or increasing.
 - ✓ **Data related:** UE Data collection, RAN Data collection, AF Data collection etc.
 - ✓ **Model related:** Model delivery/transfer, Model Training, Model storage, Model inference, Model monitoring and Model Identification/registration, etc.
 - ✓ Other aspects.

Support for AI/ML for air interface example---

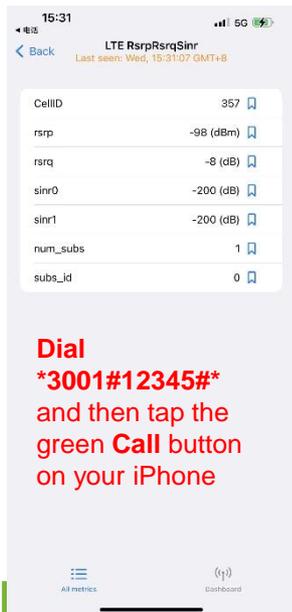
Data Collection of real-time data about UE radio link via User Plane to enable more accurate analytics

Issues and requirement:

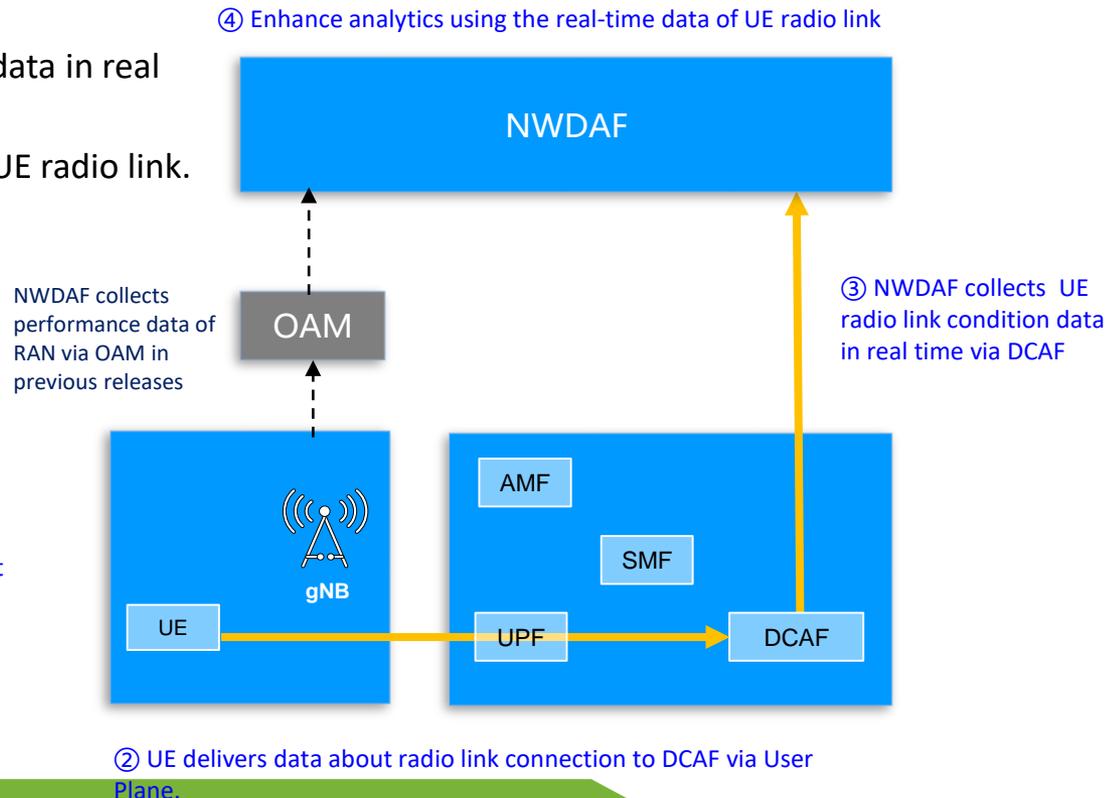
- In previous releases, NWDAF collects performance data of RAN via OAM. It is not real-time Data collection.
- When the target of data collection is a specific UE, OAM MDT service is used. But MDT is inconvenient in live network, especially for a large number of UEs.

Potential enhancement in R19:

- NWDAF collects UE radio link condition data in real time via DCAF.
- Enhance analytics with real-time data of UE radio link.



① UE has real-time data about radio link connection.



Proposed objectives for AIML for 5GS (draft in S2-2306462)

□ Part A: Architecture enhancement to support 5G Core Intelligence

• Objective#1: AI/ML enabled Use Case(s) of 5GS Service:

- WT#1.1: Detection/prevention/mitigation of signalling storm
 - Study whether and how to detect or measure signalling storm with the assistance of NWDAF.
 - Study the mechanisms of prevention/mitigation for the signaling storm to guarantee the 5GS system stability with the assistance of NWDAF.
 - Study whether and how NWDAF provides network level digital twin services to verify candidate actions provided by the 5GC NFs to avoid unexpected impacts on the network.
- WT#1.2: NWDAF assisted energy saving
 - Study whether and how to predict the capacity and load trend of NF(s) with the assistance of NWDAF.
 - Study the NWDAF assisted solution for energy saving, e.g., load balancing or redistribution among multiple NF instances.
- WT#1.3: NWDAF assisted policy recommendation
 - Study whether and how to provide global optimal recommendation to 5GC NFs. For example, based on the analysis of network status, service experience requirements, etc, NWDAF could make policy decisions and adjusts user QoS parameters in time.

• Objective#2: Leveraging AI/ML technologies of 5GS AIML Service

- WT#2.1: Study whether and how to enhance architecture to support vertical federal learning, including UE, RAN, 5GC and AF.
 - Allowing UE and/or AF to exchange necessary intermediate information to assist E2E data analysis without exposing RAW data.
- WT#2.2: Study whether and how to enhance architecture to support online learning in the 5GC.
- WT#2.3: Study whether and how to enhance architecture to support enforcement learning in the 5GC.

□ Part B: AI/ML alignment and convergence for Air interface and Core network (see joint paper S2-2306460 from vivo/China Mobile for details)

Thanks!