3GPP TSG-SA WG1 eMeeting #97-e
E-meeting, 14th February– 24th February 2022

S1-220014

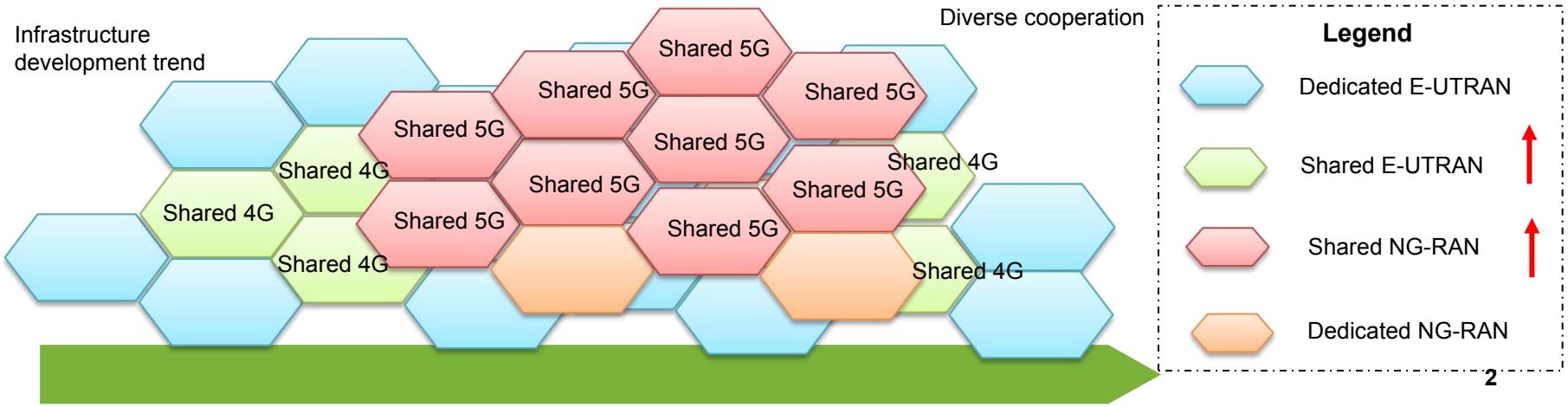
Discussion paper of network sharing in 5G

China Unicom

weiqun5@chinaunicom.cn

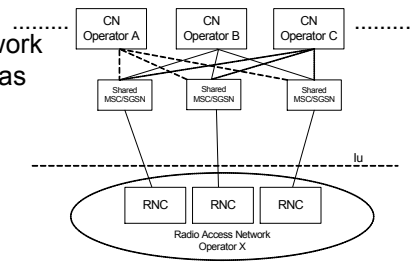
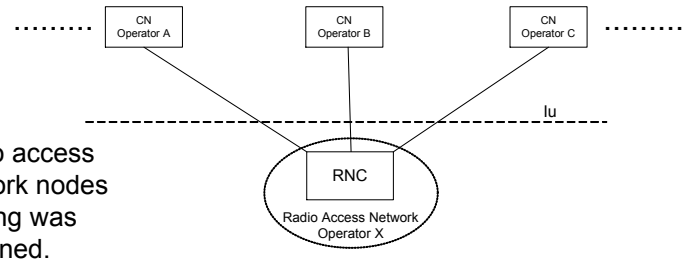
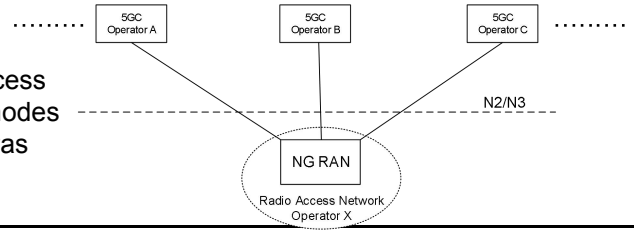
Trend and new cooperation

- Sharing networks and network infrastructure has become more important part of 3GPP systems.
  - **Infrastructure at long-term sharing**——In 5G, the network-sharing scenario not only allows operators without a 3GPP license to share the network and provide 4/5G services to their customers, but also provides solution alternatives targeting at dedicated networks, **such as infrastructure sharing aiming at long-term sharing**, which for example is the case when one or more operators lack frequency license or not.
  - **More shared NG-RAN** —— It is worth mentioning that 5G networks have been designed to share facilities at the beginning of the deployment. That means when 4G networks have independent E-UTRAN coverage and shared E-UTRAN coverage, users served by shared NG-RAN may have **more than independent dedicated NG-RAN**.
  - However, With the development of sharing technology, **new ways of cooperation and scenarios have emerged**, which may lead to the enhancement of technology.



Historical silhouettes and missing case

- There are many network-sharing scenarios possible depending on different operator strategies but also on rules and legislation in different countries.
  - **More kinds of possible cooperation need to be introduced**——When In TS 23.501 R17, only the 5G Multi-Operator Core Network (5G MOCN) network sharing architecture is supported, in which **only the RAN is shared in 5G System**, it is suggested to investigate what shortcomings currently in the specifications may prevent a standardized approach to the deployment of shared networks, e.g. **when the connection between shared RAN and core is not feasible(Lack case)**.

Previous system R16	Core network sharing was designed. 	Radio access network nodes sharing was designed. 
R17	Not defined	Radio access network nodes sharing was designed. 
Future functions	**lack of cases?**	Radio access network nodes sharing was designed

- And core network sharing has been discussed with historical reference and is understood to be valuable in 3G.
- We could find out Multi-Operator Core Network (MOCN) and Gateway Core Network (GWCN) in “Network Sharing; Architecture and functional description” both in R16, but only RAN is shared for 5G access for IP based network.
  - GWCN: Besides shared radio access network nodes, the core network operators also share core network nodes.
  - MOCN: refers to which multiple CN nodes are connected to the same RNC and the CN nodes are operated by different operators.

Differences between RAN sharing and missing scenario

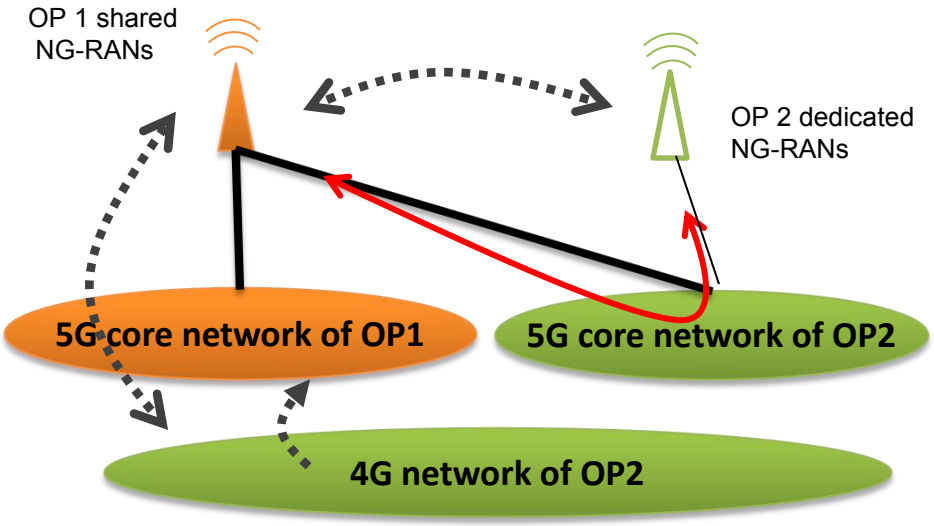


Figure1: RAN sharing(Existing case)

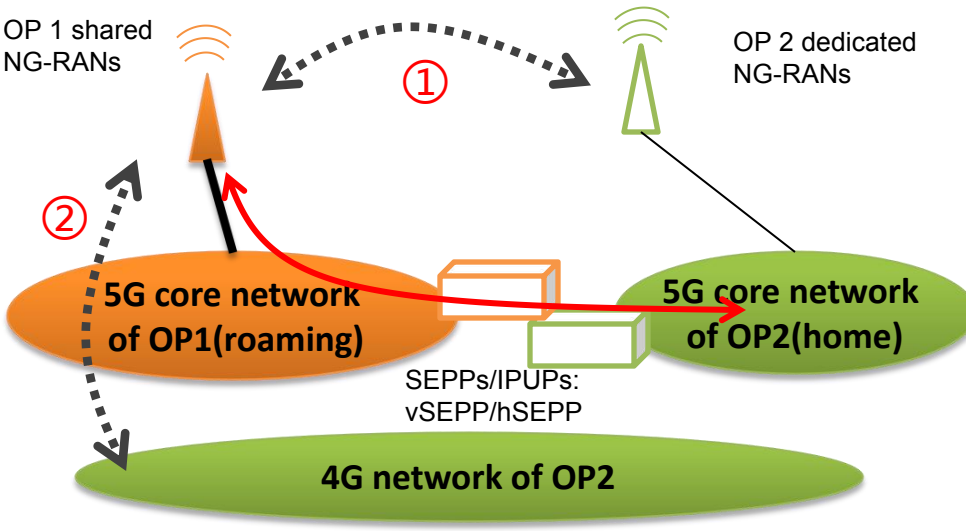


Figure2: RAN sharing with roaming(Lack case)

1, OP2's core network has a direct physical link with the shared RAN of OP1, and the mobility could be done by the home network of OP2.

1, Different from RAN sharing, OP 2's core network and shared RAN do not have a direct physical link, but transfer the route through the core network of OP1.

2, OP2's UE could move to OP 1's shared NG-RANs and obtain services from it.

2, same as left one.

3, OP2's UE could receive OP2's PLMN through SIB.

3, same as left one.

Note1: Reference from TS 23.501 R17.
Note2: Please notice the black and red lines.

Differences between inter-national roaming and missing scenario

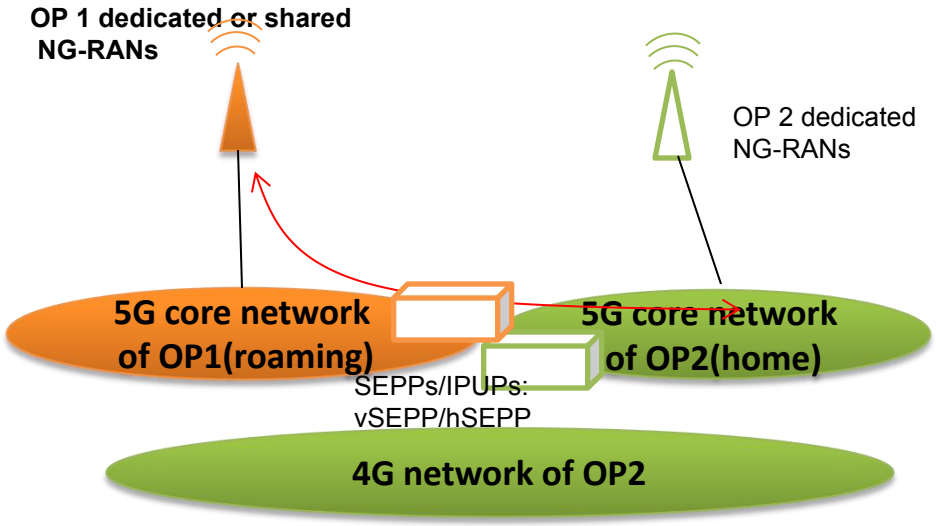


Figure1: Inter-national roaming(Existing case)

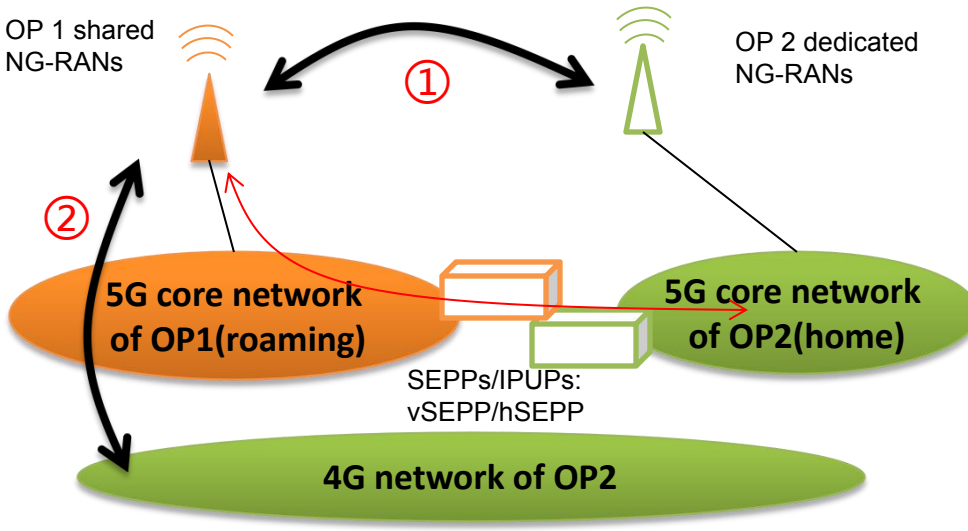


Figure2: RAN sharing with roaming(Lack case)

1, OP 2 core network and dedicated/shared RAN do not have a direct physical link, but transfer the route through the core network of OP1.	**1,** same as left one.
2, OP2's UE could move to OP 1's shared NG-RANs and obtain services from it.	**2,** same as left one.
3, OP2's UE could receive OP1's PLMN through SIB.	**3,** OP2's UE could only receive OP2's PLMN through SIB.
4, OP1's RAN could be dedicated or shared.	**4,** OP1's RAN need to support sharing.
5, There is no mobility between OP1's radio and OP2's.	**5,** There is mobility between OP1's radio and OP2's.

Note1: Also different from national roaming, which needs mobility of inter PLMN of different OPs,

Differences between NPN and missing scenario

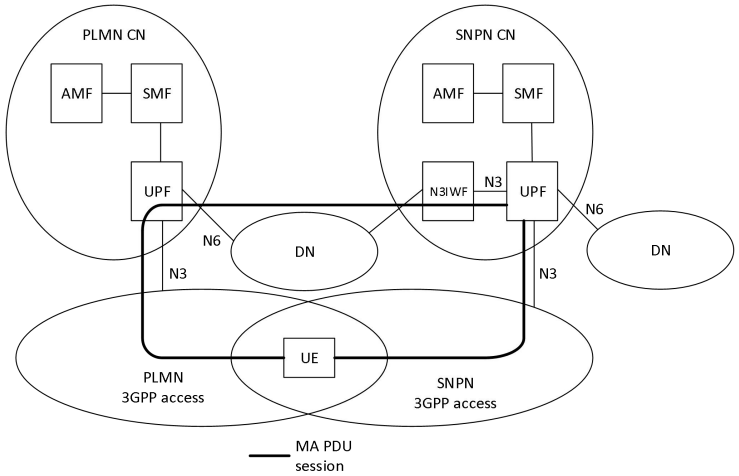


Figure D.6-1: MA PDU session with ATSSS support for dual radio UE accessing to Stand-alone Non-Public Network services via Uu and NWu interfaces(Existing case)

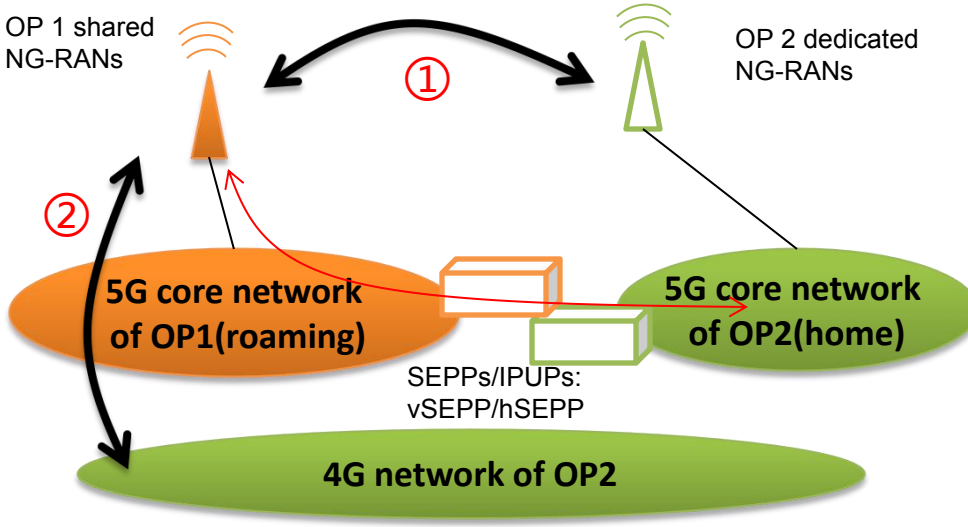


Figure2: RAN sharing with roaming(Lack case)

1, SNPN's core network and PLMN's RAN do not have a direct physical link, but transfer the route through the core network(by session).	**1,** same as left one,OP 2 core network and shared RAN do not have a direct physical link, but transfer the route through the core network of OP1.
2, SNPN's UE could move to PLMN's NG-RANs and obtain services from it.	**2,** same as left one.
3, SNPN's UE could receive PLMN's PLMN through SIB.	**3,** OP2's UE could only receive OP2's PLMN through SIB.
4, UE need to register PLMN and SNPN both.	**4,** UE could only have one register.
5, Interworking with EPS is not supported for SNPN。roaming is not supported for SNPN, e.g. roaming between SNPNs. Handover between SNPNs, between SNPN and PLMN or PNI NPN are not supported.	**5,** There is mobility between OP1's radio and OP2's 5G/4G.

Note1: Reference from TS 23.501 D.6 Support for session/service continuity between SNPN and PLMN when using N3IWF.

mobility scenario assumptions

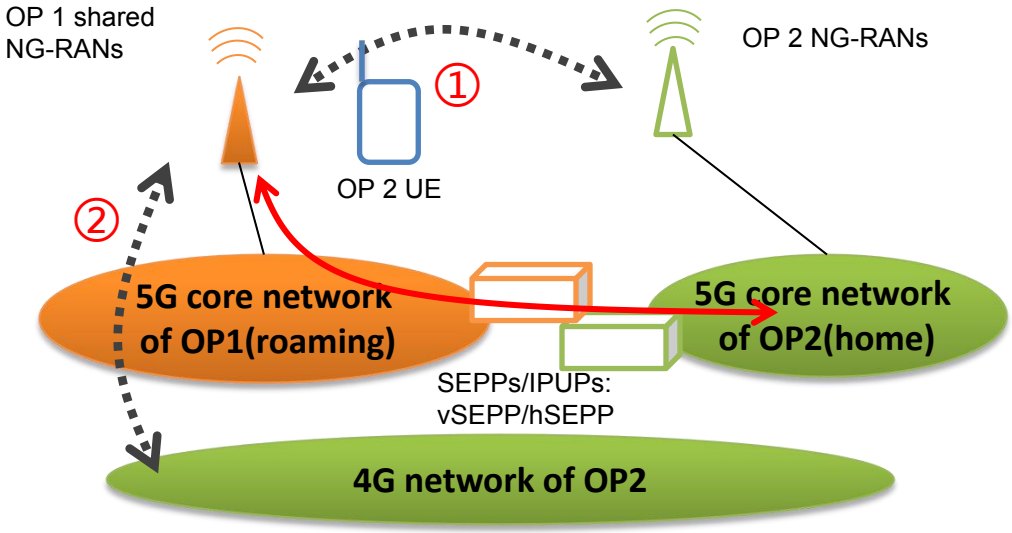


Figure: RAN sharing with roaming(Lack case)

In the condition:

1，UE belongs to OP2

2，UE register from OP2's PLMN in shared NG-RAN area

3，UE move between OP1's and OP2's area

4，The black arrow represents a direct link

5，The red arrow represents the logical direction of signaling or data.

Scene discovery and examples:

- **Scenario (1)** the 5G terminal initiates a voice call in the shared area and establishes a voice call with VONR. The terminal does not move. The standard roaming scheme is shown in the red line in the figure2;
- **Scenario (2) shared 5G->home 5G,** the 5G terminal initiates a voice call in the shared area, establishes a voice call with VONR, and moves to home 5G network. As shown as ① in figure , N14 interface needs to be established, otherwise the service will be interrupted for 2-3 seconds, affecting the user experience;
- **Scenario (3) shared 5G->home 4G,** 5G terminal initiates a voice call in the shared area, establishes a voice call with VONR, and moves to home 4G network. As shown as ② in Figure , N26 interface needs to be established, otherwise the service interruption will last for 2-3 seconds, affecting the user experience;
- **Scenario (4) home 4G->shared 5G,** the 5G terminal initiates a voice call at home 4G and establishes a voice call with EPS fallback. During the call, it moves to the shared area without handover. After the voice is finished, it quickly accesses to the shared 5G;
- **Scenario (5) home 5G->shared 5G,** the 5G terminal initiates a voice call at home 5G, establishes a voice call with VoNR, and moves to the shared area. As shown as ① in Figure , N14 interface need to be established, otherwise the service interruption will last for 2-3 seconds, affecting the user experience.

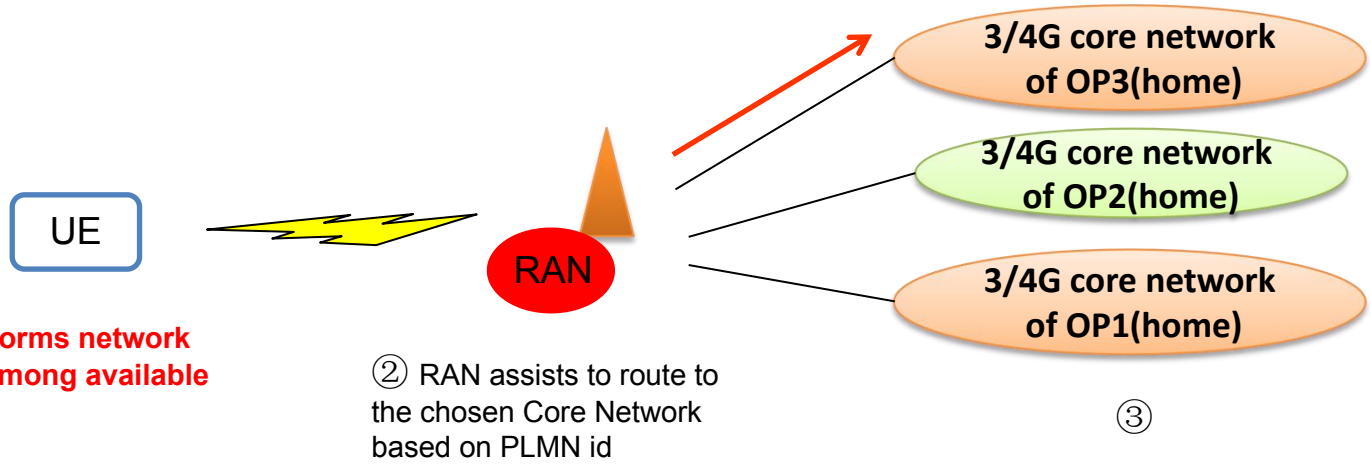
Note: the PLMN of shared NG-RAN may be the same or different from home PLMN

Gap analysis 1

- What we already support：
  - there has been functionality that supports a basic network sharing since the Release 5 versions of the 3GPP specifications, which experienced discussion of five scenarios related to GERAN and UTRAN described, on the basis of R99 version, and relevant normative work were incorporated into 3GPP TS 22.011, TS 22.101, TS 22.115, TS 22.129, TS 22.951.
  - 3GPP TS 23.251 allow different core network operators to connect to a shared radio access network, and the operators do not only share the radio network elements, but may also share the radio resources themselves, which introduced the stage 2 details and descriptions of how these requirements are supported in a 3GPP GERAN, and UTRAN based network. To scope with Release 8 in 3GPP E-UTRAN, RAN Sharing Enhancements are further updated in TS 22.101.
  - Only the evolution of access network sharing in 5G is completed in TS 23.501, considering the mechanisms we already have as equivalent PLMN, PLMN restrictions, network selection between different PLMNs, and mobility, without other scenarios, such as core network sharing in TS 23.251.
  - Various effort of other working groups, etc..

MOCN, supporting UE

Only access sharing



① Supporting UE only selects PLMNs in the Multiple PLMN ID List and sends the chosen core network operator PLMN-id;

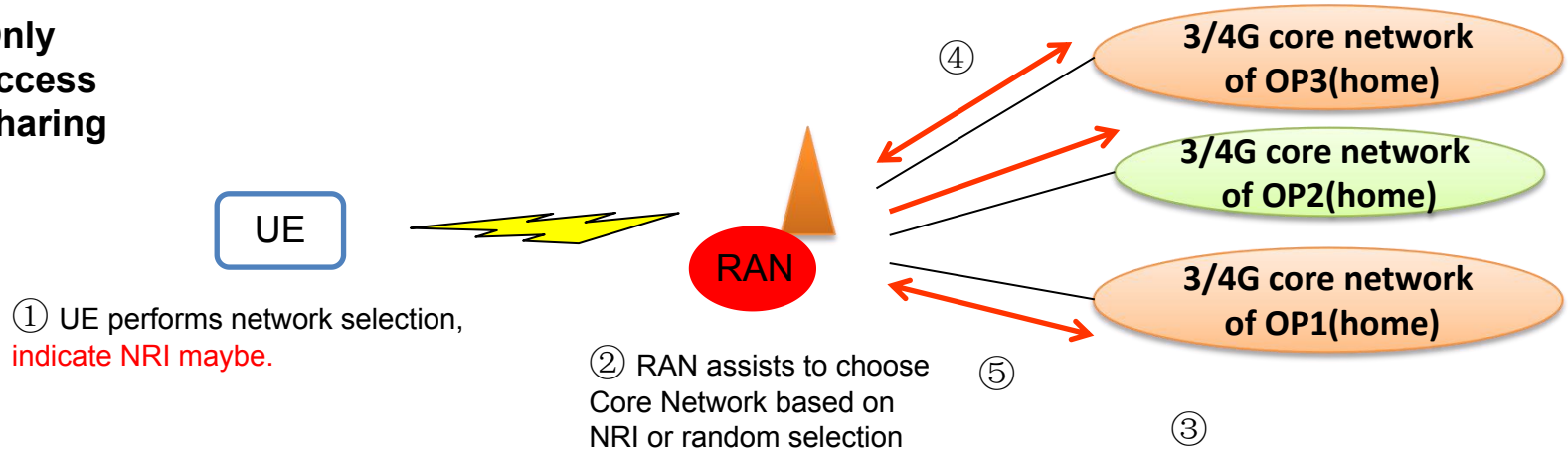
② RAN uses information in header to route the ATTACH REQUEST message to the chosen core network operator based on PLMN-id;

③ CN determines whether the UE is allowed to attach and sends the appropriate ACCEPT/REJECT message back to the UE.

The PLMN selection of UE is relatively reliable.

MOCN, non-supporting UE

Only access sharing



① Non-supporting UE directs or redirects to CN operators;

② RAN sends ATTACH REQUEST message to the core network based on NRI if present or by random selection;

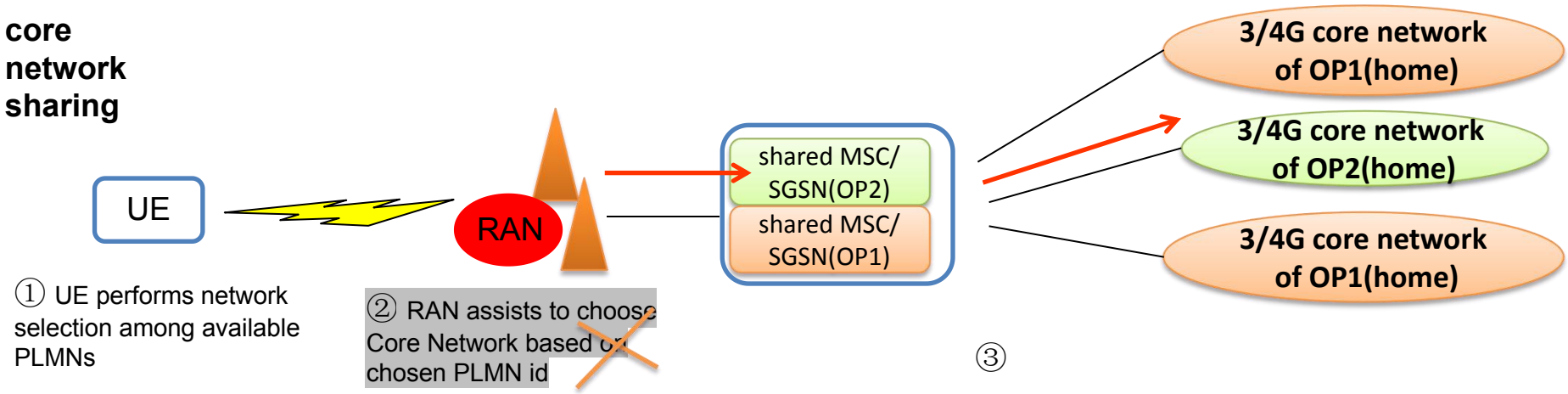
③ CN requires the IMSI of the UE and determines whether the UE is allowed to attach;

④ If CN rejects, a Reroute Command message is sent back to the RAN, then RAN selects a CN operator based on deterministic IMSI analysis in the next step;

⑤ If CN accepts, a Reroute Complete message is sent back to the RAN.

UE register with NRI or not. NRI is for the none-supporting UE. Whether to access the core network is determined according to IMSI by the core network.

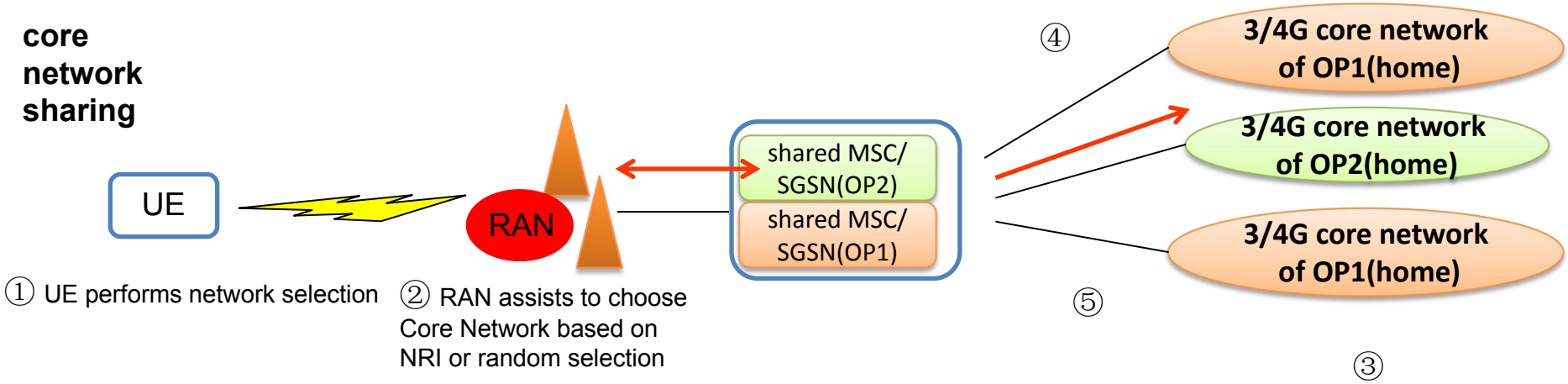
GWCN, supporting UE



① Supporting UE only selects PLMNs in the Multiple PLMN ID List and sends the chosen core network operator PLMN-id;
② RAN sends ATTACH REQUEST message to the selected core network based on PLMN-id;
③ CN determines whether the UE is allowed to attach and sends the appropriate ACCEPT/REJECT message back to the UE.

RAN may not need to assists to choose Core Network based on chosen PLMN id.-> MOCN , supporting UE.

GWCN, non-supporting UE



① For non-supporting UE, common PLMN is the only candidate to be considered;

② RAN sends ATTACH REQUEST message to the selected core network based on NRI if present or by random selection;

③ CN determines whether the UE is allowed to;

④ If CN rejects, a Reroute Command message is sent back to the RAN for coordination purposes, then RAN selects a CN operator based on IMSI analysis;

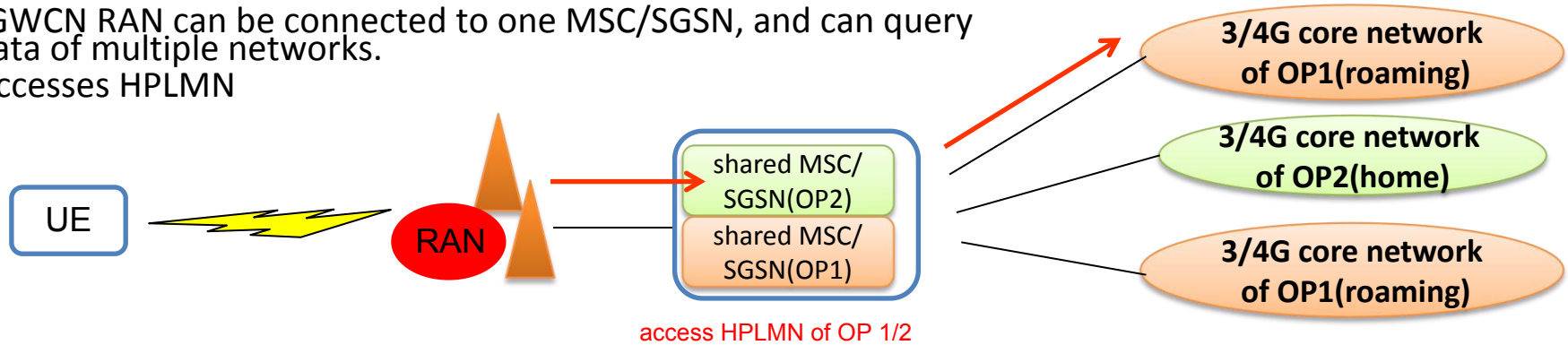
⑤ If CN accepts, an ATTACH ACCEPT message is sent back to the UE.

RAN may assists to choose Core Network based on UE IMSI。Maybe No redirection between CN。->MOCN non-supporting UE.

Gaps of GWCN

GWCN, supporting UE

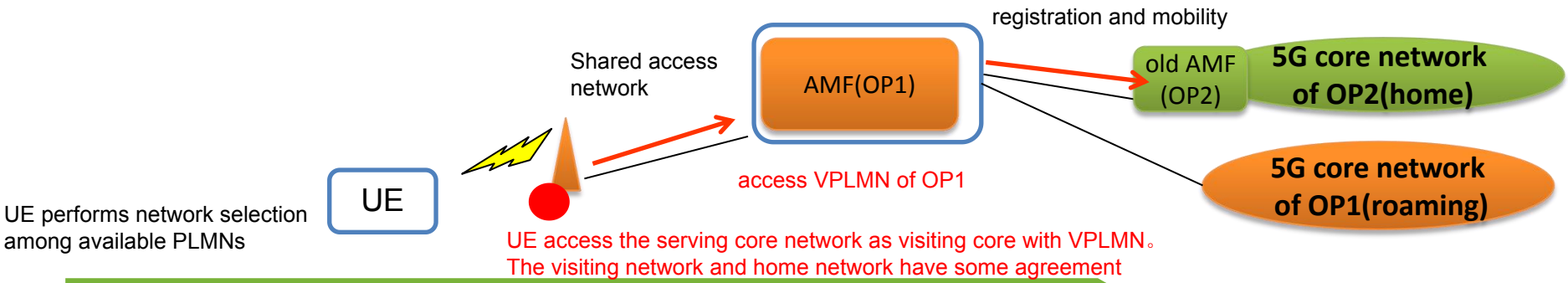
1,For each MOCN RAN connected to each HPLMN core network
2,For GWCN RAN can be connected to one MSC/SGSN, and can query user data of multiple networks.
3,UE accesses HPLMN



New scenario

1,networksharing scenarios
2,RAN is connected to OP1 in the visited network
3,There is a visited network between RAN and HPLMN
4,UE's user data is not in OP1
5,UE accesses the visited network

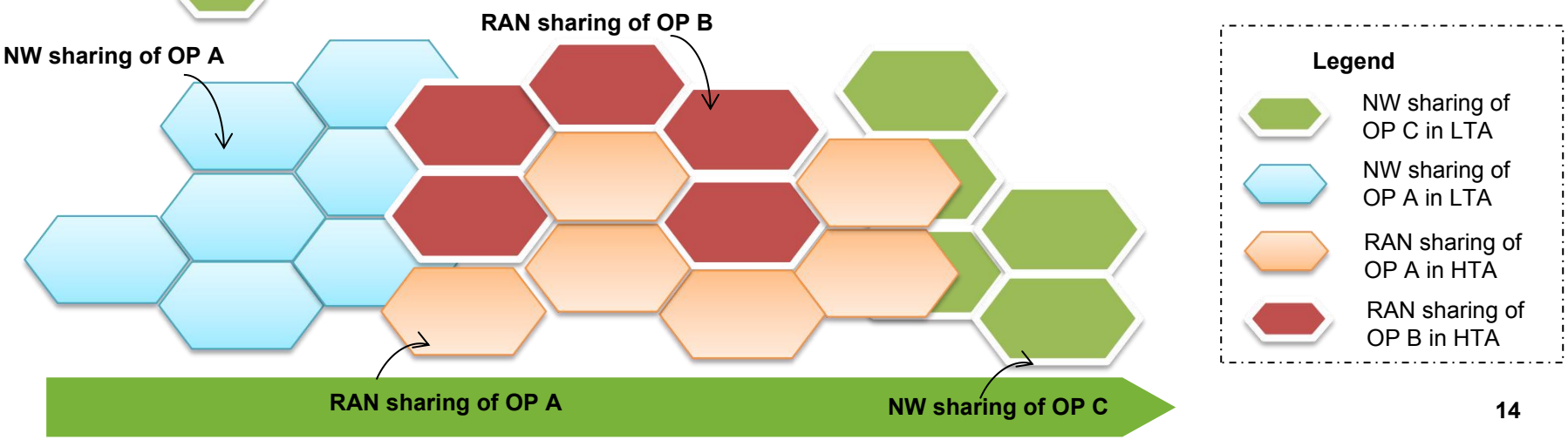
The registeration and mobility management is between PLMNs of OP1's and OP2's.
AMF of OP1 determines whether the UE is allowed to attach, which asking the old AMF OP2? or UDM?



For concepts and definitions: roaming based network sharing? or network sharing?

Cooperation bussiness mode

- Operators A and B, both licensed to operate a 4G network, and a 5G network have agreed to **share the core and the radio access networks** in some areas of the country where the traffic is expected to be low **(Low Traffic Areas, or LTA)** while building **share or dedicated 5G radio access networks** in the areas with higher traffic density (**High Traffic Areas or HTA**). The LTA/HTA is split in two parts, one built by Operator A, the other by Operator B or Operator C.
  - **RAN sharing_ Infrastructure at long-term sharing for HTA**: In areas with high user density and Traffic , the construction of shared ran infrastructure can better ensure the service experience. Two or more operators will maintain long-term cooperative relations to improve frequencies utilization.
  - **Core network sharing for LTA area**: In remote area, operator A and C shares NG-RAN. At present, users use services continuously when they move between and . We hope that users can also use services in in the future, and use services continuously when moving between and .



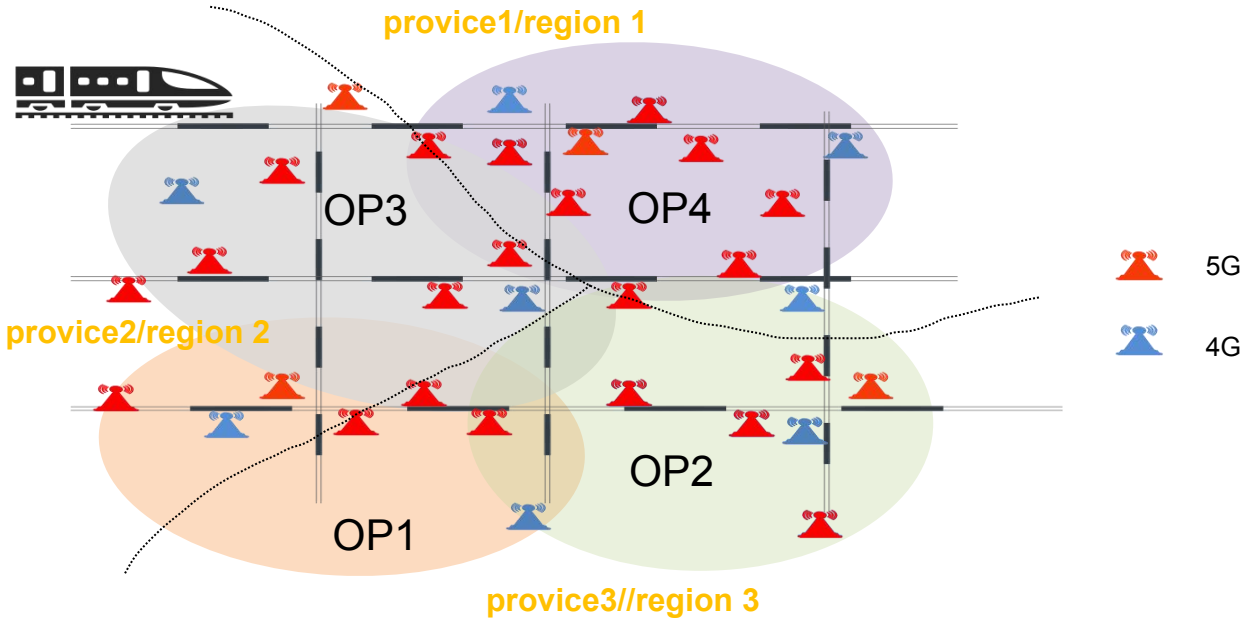
Potential Scenario: 5G Railway shared Network

1,5G has a range of 500 meters, and 4G has a [50%] increase in density.

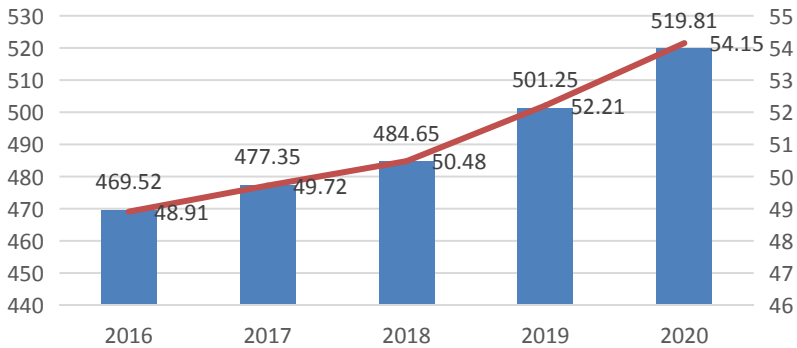
2,Railway construction costs increased significantly.

3,Sub-regional cooperation in infrastructure may be one of the effective ways.

4,A unified PLMN on the phone screen needs to be displayed along the railway line in the country, while supporting the service continuity along the railway line.



other use cases



-Left axle, 10000 km, total mileage
-Right axis, kilometers, hundred square kilometers, density

Figure 1. Partial transportation trend chart from 2016 to 2020

1,long distance transportation

2,The total length of long-distance transportation will increase about 500,000 kilometers in five years, and the average annual increase of first-class highways will be 2,300 kilometers.

3,Need to reduce the difficulty of covering long-distance lines such as "transfusion vessels" and "lifelines".

1,Private Network Dedicated Scenario

2,UAM air traffic communication,airport line, commuter line

3,Reduce coverage costs and meet demand for dedicated markets.

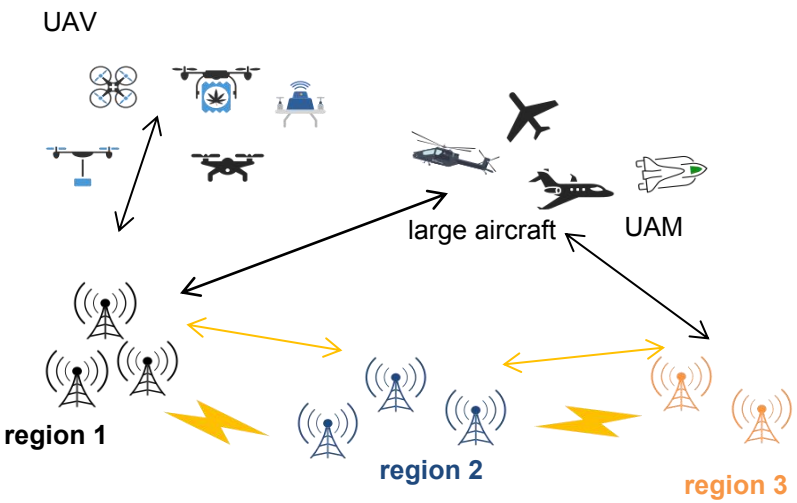


Figure 2. Schematic diagram of aircrafts scenario

Detail analysis 1

assumption:

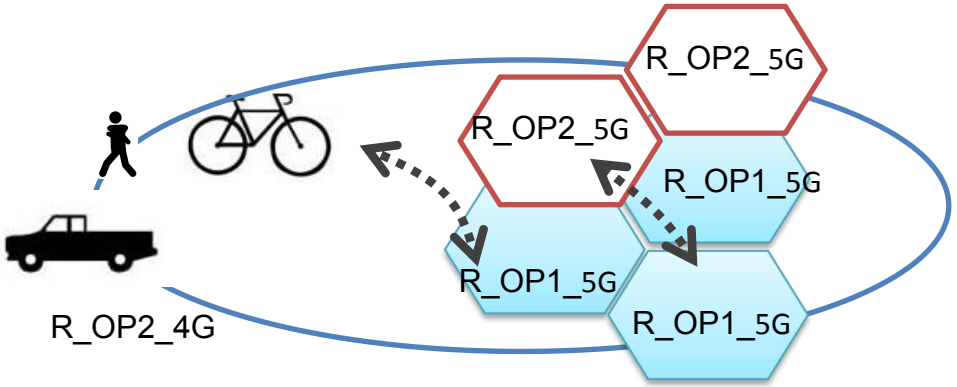
1,OP1 and OP2 use same PLMN-ID for 4G and 5G; only OP1 5G is “shared”

2,OP1 5G shared RAN broadcast 2 (sharing) PLMN-IDs: OP1-closed and OP1-Open (call it OP1)

3,OP1 shared 5G can overlap with OP2 4G; may ALSO overlap with OP2 5G (e.g. at OP1 border)

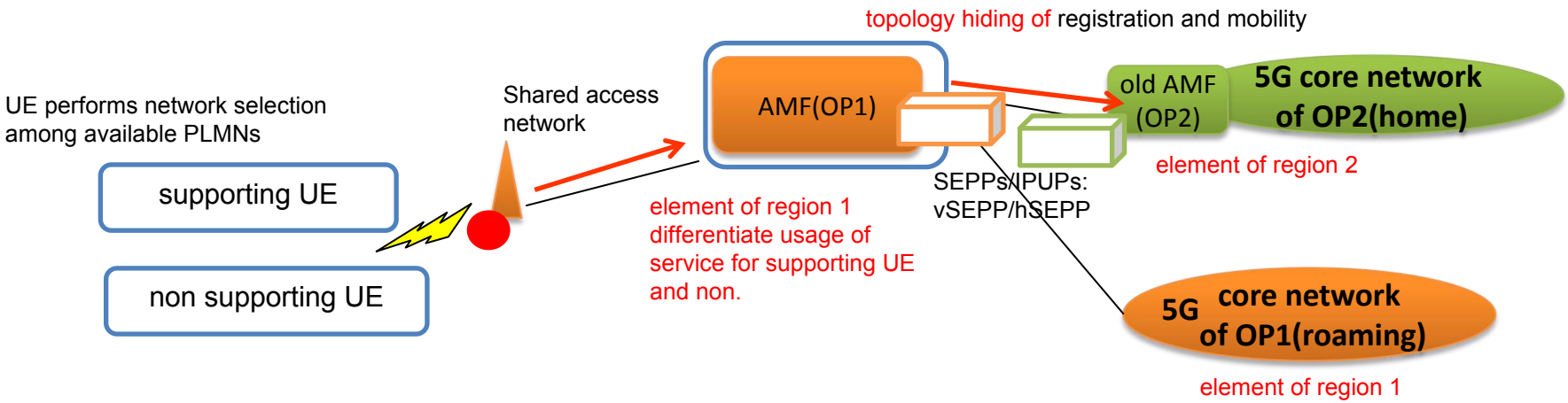
-i.e. following coverage scenarios are possible: OP1 only, OP1 + OP2-4G (OP1 preferred), OP1 + OP2 4G&5G (OP2-5G preferred), OP2 only

-OP2 UE should stay on OP1, if under OP1 coverage, unless OP2-5G is available



Scenario	1 (OP1)	2 (OP1->OP2-5G)	3 (OP1->OP2-4G)[no OP2-5G]	4 (OP2-4G->OP1)[no OP2-5G]	5 (OP2-5G->OP1)
a) I-PLMN sel	No	Yes	No	No	No
b) I-PLMN cell resel	No	Yes (via ePLMN, + I-freq priority)	Yes (via ePLMN), only at OP1 border	Yes (via ePLMN, + IRAT priority)	Yes (via ePLMN), only at OP2 border
c) I-PLMN HO	No	Yes (via ePLMN)	Yes (via ePLMN), only at OP1 border	Yes (via ePLMN)	Yes (via ePLMN), only at OP2 border

Detail analysis 2



1, Decoding information of element or UE in topology hiding between OP1 and OP2.

2, Charging requirements or principles if needed.

3, Analyze how to ensure the usage of service , compared with the existing network sharing, or network, of supporting UE and non supporting UE.

4, home network anchoring and visiting network anchoring

Objective

- What we need to analyze:
  - The purpose of this technical report is to collate in a single document the requirements, considerations, deployment scenarios that operators as well as users need to see fulfilled for a successful use of a shared network and highlight the expected user experience for them. It mainly focuses on the following:

    -Extended 5G network sharing deployment scenario, e.g. an supplement scenario to geographical areas or use cases where only access sharing are not enough.

    -whether there is any impact on UE, for example, it is necessary to point out any visible risks in this scenario when network sharing supporting UE and network sharing non-supporting UE access the network.

    -The possible mobility and service continuity requirements, any differences from existing technology between 4G/5G and 5G/5G, for example, handover or reselection.

    -If the communication between two PLMN's network through the interface generates potential security requirements, for example, the necessary decoding information of element or UE in topology hiding.

    -Charging requirements or principles if needed.

    -Analyze how to ensure the usage of service , compared with the existing network sharing, or network, of supporting UE and non supporting UE.

    -Investigate the impact of RAN sharing on PWS maybe included.

    And serves for the existing 4G operators who intend to deploy a NG Radio Access Network to complement the existing E-UTRAN coverage.

Thank you