3GPP TR 22.852 V2.0.0 (2013-06)

Technical Report

3rd Generation Partnership Project; Technical Specification Group SA; Study on RAN Sharing Enhancements (Release 12)

Keywords
User Plane, Congestion

3GPP

Postal address

3GPP support office address
650 Route des Lucioles - Sophia Antipolis
Valbonne - FRANCE
Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Internet
http://www.3gpp.org

Contents

Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

- x the first digit:
  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document provides a study on scenarios of multiple operators sharing radio network resources and creates potential requirements that complement existing system capabilities for sharing common E-UTRAN resources.

The scenarios illustrate e.g.:

- Means for efficiently sharing common E-UTRAN resources according to identified RAN sharing scenarios (e.g. pooling of unallocated radio resources).
- Means to verify that the shared network elements provide allocated E-UTRAN resources according to sharing agreements/policies.
- Indication of and potential actions upon overload situation in consideration of sharing agreements/policies.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TR 22.951: “Service aspects and requirements for network sharing”

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1], TR 22.951 [2] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1] and TR 22.951 [2].

Hosting RAN: E-UTRAN resources provided by a Hosting RAN Provider for use by a Participating Operator.

Hosting RAN Provider: A Provider of a Hosting RAN.

Participating Operator: Operator that uses allocated shared RAN resources provided by a Hosting RAN Provider under agreement.

Wholesale charging: This is the charging by the Hosting RAN Provider of any usage of a Shared RAN by subscribers of a Participating Operator.

Wholesale charging event: An event occurring in the Shared RAN which provides to the Hosting RAN Provider the ability to determine usage of the Shared RAN and identify a specific Participating Operator to be charged.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

4 Scenarios and Use Cases

4.1 General

4.1.1 Network sharing use-case actor roles

4.1.1.1 General on roles in RAN Sharing

The arrangements for network sharing between the involved entities can vary widely, being influenced by a number of factors including business, technical, network deployment and regulatory conditions. Within all of this variation, there is a set of common roles centered around connecting network facilities between the parties participating in a network sharing agreement. This section presents these common roles to aid in understanding the entities described in the use cases.

4.1.1.2 Hosting RAN Provider

The Hosting RAN Provider is identified as sharing a hosting RAN with one or more Participating Operators. The characteristics of the Hosting RAN Provider include:

- Has primary operational access to particular licensed spectrum which is part of the network sharing arrangement.

Note: The Hosting RAN Provider does not necessarily own licensed spectrum but has agreement to operate in that spectrum.

- Has deployed a RAN in a specific geographic region covered under the network sharing arrangement
- Operates the RAN identified in the previous two items.
- Provides facilities allowing Participating Operators to share the RAN covered under the network sharing arrangement

Within the concept of a Hosting RAN Provider, other entities can be involved such as outsourcing, joint ventures, or leasing agreements such as for operating, owning the RAN infrastructure or managing the sharing agreements.

4.1.1.3 Participating Operator

The Participating Operator is identified as using shared RAN facilities provided by a Hosting RAN Provider, possibly alongside other Participating Operators. The characteristics of the Participating Operator include:

- Uses a portion of the particular shared licensed spectrum to provide communication services under its own control to its own subscribers.
- Uses a portion of the shared RAN in the specific geographic region covered under the network sharing arrangement.

Within the concept of a Participating Operator, other entities can be involved such as outsourcing, joint ventures, or leasing agreements such as for operating or owning the service infrastructure.

4.1.1.4 Roaming operators (HPLMN and VPLMN)

Roaming and roaming agreements between operators provides a similar capability to RAN sharing where a subscriber of the HPLMN can obtain services while roaming into a VPLMN. This can be viewed as a form of sharing where the VPLMN shares the use of its RAN with the HPLMN for each HPLMN subscriber roaming into the VPLMN.

The distinction between roaming and RAN sharing is:

- when roaming, the subscriber uses the VPLMN when outside of the HPLMN geographic coverage and within the VPLMN geographic coverage
- in a RAN sharing arrangement, all of the participants (Hosting RAN Provider and one or more Participating Operators) provide the same geographic coverage through the Hosting RAN.

4.1.1.5 Operators with multiple roles

Operators can take on multiple roles at the same time depending on business needs. For the purposes of this TR, each specific network set (spectrum-region-RAN) can be considered independently and combined with other network sets in various combinations.
Examples include:

- An operator has its own spectrum which he does not share and additionally uses the shared RAN in the same region (Participating Operator) provided by Hosting RAN Provider.
- Two operators set up a joint venture to build and operate a shared network. The two operators are both Participating Operators and the joint venture is a Hosting RAN Provider.
- Two operators A & B, divide a region covered by a joint spectrum license and each build and operate the RAN in their portion of the region. In the region covered by operator A's RAN, operator A is the Hosting RAN Provider and at the same time Participating operator while operator B is only Participating Operator. In the region covered by operator B's RAN, operators A and B are the Participating Operators and operator B is the Hosting RAN Provider.

Note: Roaming could be considered a form of network sharing where the Visited Operator allows an individual UE to use the visited RAN (VPLMN) in coordination with the Home Operator. However for the purpose of this specification, RAN sharing only applies to deployments where a shared RAN operates as a home network (HPLMN) for each of the Participating Operators.

4.1.2 What constitutes a shared RAN

A Hosting RAN Provider may share E-UTRAN resources with Participating Operators in various ways.

In the context of the current study it is assumed that at least

- a set of Radio Base Stations (RBS)

are shared for use by Participating Operators.

The sharing agreement between Hosting RAN Provider and Participating Operators may or may not include

- Sharing of a part of the radio spectrum of the Hosting RAN Provider

For example, a MVNO as a Participating Operator would use the spectrum provided by the Hosting RAN Provider.

In the context of the current study the sharing of Core network nodes, while not excluded, is not considered.

Typically RAN sharing arises out of the following situations:

- A Greenfield deployment – two operators jointly agree to build out a new technology (typically 4G). At the outset, the new shared network infrastructure and operations can be based on capacity and coverage requirements of both operators. The operator can e.g. fund built-on 50:50 or according to their expected needs.

- Buy-in – when one of the sharing operator has already built (4G for example) and looking for another operator to share this network. In this case, the second operator would typically either pay a capacity usage fee or up-front fee to acquire in the network.

4.2 Scenario and Use Case 1 (RAN Sharing Monitoring)

4.2.1 Description

This use case demonstrates that a Participating Operator will want to obtain the same OAM status information from a Hosting RAN as from an unshared E-UTRAN. It also shows that a hosting operator will want to restrict the Participating Operator from accessing certain OAM status information from a Hosting RAN for business, operational or technical reasons.

4.2.2 Pre-conditions

Operator A is sharing E-UTRAN X.

Operator B has an unshared E-UTRAN R but is in need of additional capacity.

Operator B negotiated an agreement with Operator A to use the E-UTRAN X.

Operator B obtains RAN OAM status information from E-UTRAN R in the normal course of operating and engineering its network.

4.2.3 Service Flows

Operator B wants to receive the same level of RAN OAM status information from the shared E-UTRAN X as it receives from LTE R in order to use LTE X as a seamless offload from LTE R.

Operator A sets up Operator B's access to E-UTRAN X OAM status information only regarding the information about the E-UTRAN X resources allocated or used by Operator B.

4.2.4 Post-conditions

Operator B is able to obtain the needed E-UTRAN X OAM status information to perform the planned seamless offload and integrate it into internal processes.

Operator A is able to set the limits of what OAM status information that Operator B is allowed to access in E-UTRAN X.

4.2.5 Alternate Flows

Operator A decides that some OAM status information provided by the E-UTRAN X could provide details of other Participating Operator's service usage of the E-UTRAN X and for business reasons blocks Operator B from accessing this information but allowing access to other non-sensitive information.

4.2.6 Requirements

The requirements derived from this use case are:

- The Hosting RAN shall be able to provide to the Participating Operators access to the Hosting RAN OAM status information to the same level of detail as would be available from a non-shared E-UTRAN.

- The Hosting RAN shall be able to provide for setting limits on what OAM status information each Participating Operator can access from the Hosting RAN including (but not limited to):

  - Only the resources allocated to or used by the Participating Operator.

  - Individual or classes of information elements for business, technical or operational reasons.

4.3 Scenario and Use Case 2 (MDT Support for RAN operator)

4.3.1 Description

Minimization of Drive Testing (MDT) is a feature introduced in Release 10 to allow the harvesting of network coverage & quality information from customer UEs as they move within the coverage of the RAN. This provides better quality data, at a lower cost, than that produced by the RAN operator performing drive testing of the RAN using test UEs.

This use case describes the generation & retrieval of MDT data by a Hosting RAN Provider that does not have an adjunct core network & which therefore does not provide service, other than RAN connectivity, to the UEs connected via its network.

4.3.2 Pre-conditions

The Hosting Provider agrees to share RAN resources with one or more Participating Operators.

The Hosting Provider does not have a core network adjunct to the RAN.

All UEs connected through the RAN are associated with one or more of the Participating Operators.

The Participating Operators have network sharing agreement with the Hosting RAN Provider that UEs owned by Participating Operators are allowed to be selected for MDT data collection purpose triggered by the Hosting RAN Provider.

The Hosting RAN Provider requires to initiate collection of MDT data.

4.3.3 Service Flows

1) The Hosting Provider requests retrieval of MDT data by UEs which is allowed to do this task by participating operators connected to the RAN.

2) The Hosting provider collects the retrieved data.

4.3.4 Post-conditions

The Hosting Provider is in possession of the coverage & network quality data for the shared RAN provided by MDT.

4.3.5 Requirements

The requirements derived from this use case are:

- Subject to agreement between The Hosting RAN Provider and Participating Operators the Hosting RAN Provider shall be able to control collection of MDT data by UEs connected through its RAN.

Subject to agreement between The Hosting RAN Provider and Participating Operators the Hosting RAN Provider shall be able to retrieve MDT data collected by UEs connected through its RAN.

4.4 Scenario and Use Case 3 (Use case regarding RAN sharing granularity)

4.4.1 Description

This use case describes the description where a shared network allocation granularity needs to be at the radio sector level. It can be found where there are political border situations where some sectors crossing the border need to be shared and those providing coverage in the local territory must not be shared.

4.4.2 Pre-conditions

- Operator A operates in country X and has cell sites operating near the border with country Y. Some of the sectors of the cell sites cover areas across the border in country Y.
- Operator B operates in country Y using adjacent spectrum to Operator A.
- Both operators agree to operate a shared network using Operator A's RAN covering both operator's bands. This shared network is limited to the sectors which provide coverage across the border into country Y.

The following diagram illustrates the network sharing arrangement:

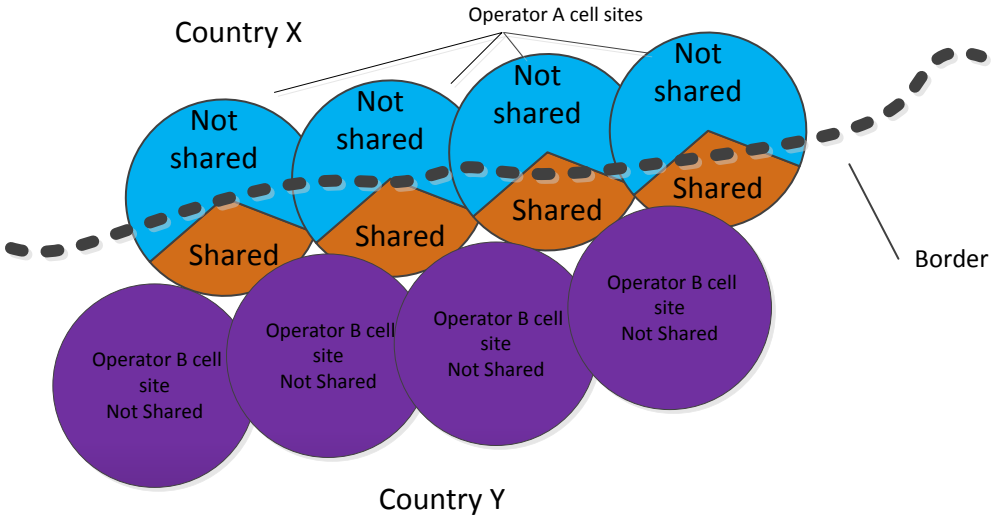

Figure 1: Shared network allocation granularity at the radio sector level

4.4.3 Service Flows

- A UE subscribed to Operator B starts in Country Y in an area well away from the border and starts obtaining wireless services in one of Operator B's non-shared cell/sectors.
- The UE moves to the shared RAN cell/sector in Operator A's RAN, still in Country Y. The UE continues to use wireless services from operator B.
- The UE moves across the border into Country X and into the coverage of Operator A's RAN, but in a non-shared cell/sector. The UE continues to use wireless services as a roamer.

4.4.4 Post-conditions

- The UE operates in the Home PLMN while being served by both Operator B's cell/sectors and in Operator A's shared cell/sectors and is charged non-roaming rates.
- The UE operates in the Visited PLMN while being served in Operator A's non-shared cell/sectors and is charged roaming rates.

4.4.5 Requirements

- A shared RAN shall allow setting a different portion of resource allocation per each Participating Operator down to the cell/sector level.

4.5 Scenario and Use Case 4 (maximizing RAN sharing revenue)

4.5.1 Description

Maximizing revenues and efficient use of a RAN are often two goals for any wireless operator. However in the case of shared networks, depending on the wholesale business model, a Hosting RAN Provider may find it necessary to trade one off for the other. This use case presents a scenario where Participating Operators have variable RAN resource usage; this enable Hosting RAN Provider to apply different charge based on the resource usage.

4.5.2 Pre-conditions

1) Operator A is a Hosting RAN Provider only providing network wholesale services to Participating Operators.

2) Operators B and C are Participating Operators using the shared RAN only to offload its own non-shared RAN.

3) Operator A, in order to maximize predictable revenue flow establishes the following rates:

   - A base rate for a committed percentage dedicated shared RAN capacity
   - 2x base rate for a percentage of dedicated shared RAN capacity for a month
   - 3x base rate for a percentage of dedicated shared RAN capacity for a week
   - 5x base rate for first come first served access to any remaining RAN capacity

4.5.3 Service Flows

1) Operator B expects that its offload use of the shared RAN will be minimal and does not want to commit in advance for any shared RAN usage. Operator B is willing to pay the highest rate for this on demand usage of the shared RAN.

2) Operator C expects a significant amount of its traffic will be offloaded to the shared RAN and will commit to 25% of the shared RAN capacity and will commit to an additional 10% shared RAN capacity during the summer months to handle vacation traffic.

4.5.4 Post-conditions

1) Operator B and C are able to use the shared RAN in a cost efficient manner.

2) Operator A is able to gain a predictable revenue stream at least from operator C. Operator B provides an additional revenue based on demand RAN resource usage.

4.5.5 Requirements

1) The shared RAN shall have the flexibility to allocate RAN resource capacity by the following but not limited to:

   a. Fixed allocation

   b. Fixed allocation for a specified period of time

   c. First come-first served allocation to all the Participating Operators collectively (i.e. on demand).

4.6 Scenario and Use Case 5.a (Asymmetric RAN Resource Allocation)

4.6.1 Description

At full or nearly-full capacity, RAN resources are shared among two Participating Operators proportional to their financial interest in the Hosting RAN.

4.6.2 Pre conditions

Two Participating Operators have an unequal controlling interest in a Joint Venture (JV), which builds, operates and maintains the Hosting RAN. The JV investment level is as follows: Participating Operator Partner "Primary" (P) has 60% interest; Participating Operator Partner "Secondary" (S) has the remaining 40% interest. Each of these partners owns and manages its own EPC infrastructure independently from each other.

Note that this use case is also applicable when one entity is the Hosting RAN Provider and the others are Participating Operators

The agreement between Primary and Secondary for the JV is that each Partner will be guaranteed shared network resource allocation proportional with its controlling interest level in the JV.

4.6.3 Service flows

As a one-time (or infrequent) operation, the Hosting RAN is given information about the 60/40 resource allocation proportion among the two partners, so that it can conduct or assist in resource management operations accordingly.

Resource management operations include:

- Bearer admission (allocation of a new bearer) decisions for either of the two partners;
- Uplink/downlink radio transmission (e.g., packet transmission scheduling).

The shared RAN routinely charges for resource management operations for Partners P and S separately, i.e., when admitting a bearer for P, it records it as such, and likewise for S. Similar applies for scheduler and other operations.

Case L: Low traffic load

At times of low traffic load (below full capacity of the eNB), new bearers are admitted on the basis of overall resource availability, i.e. the pre-agreed resource allocation proportion interest is not taken into consideration.

Since traffic load is low, such scheduler decisions result in comfortably meeting QoS objectives for all bearers belonging to either of the two partners.

Case H: High traffic load

At times of high traffic load (approaching the full capacity of the eNB), a new bearer is admitted by taking into consideration the agreed resource allocation proportion interest of each of the partners. If admission of a new bearer belonging to Partner S would result in projected imbalance of RAN resource consumption in excess of the proportional interest (allowing for by a margin of tolerance), the new bearer is not admitted. Otherwise, the new bearer is admitted. Similar Hosting RAN behavior applies for Partner P bearer admission. Additionally, any admission decisions are governed by overall capacity constraints of the eNB.

Radio resource scheduling takes into consideration the resource allocation proportion breakdown of partners P and S. In principle, the scheduling is such that the average amount of resources committed to each of the partners P and S is proportional to their interest in the JV.

A possible algorithm for resource distribution could be that each partner's pre-agreed usage portion of the Hosting RAN becomes a Participating Operator weighting factor. This weighting factor is added to all other existing factors. Radio resource scheduling considers when deciding to grant a request for a radio resource. When traffic load is high, due to ebbs and flows of traffic, mobility effects, etc., scheduler decisions may result in occasionally not meeting QoS objectives for one of more bearers. The Participating Operator weighting factor determines the proportion among the Partners P and S in which such failure to meet QoS objectives can occur.

4.6.4 Post conditions

Usage of radio resources is tracked for each partner. Radio resource usage during the time RAN is at or near full capacity is proportional for each of the partners based on their Participating Operator pre-agreed usage portion of the Hosting RAN. Partners P and S can negotiate details of the implementation of the RAN sharing partnership with some degree of flexibility, and can convey them to the RAN elements to carry out.

4.6.5 Requirements for this use case

1) It shall be possible to establish each Participating Operator's pre-agreed usage portion of the Hosting RAN.

2) A shared RAN element shall measure network resource usage at all times separately for each Participating Operator and identify whether the Participating Operator's pre-agreed usage portion of the Hosting RAN is being used.

3) A shared RAN element involved in user plane packet transmission scheduling shall be capable of differentiation among traffic associated with the Participating Operators, based on the Participating Operator pre-agreed usage portion of the Hosting RAN.

4) A shared RAN element at or near capacity shall conduct bearer admission by taking into consideration the assigned Participating Operator's pre-agreed usage portion of the Hosting RAN, such that the balance of RAN resources upon admission decision does not violate the Participating Operator pre agreed usage portion of the Hosting RAN, within a margin of tolerance.

5) When a Hosting RAN element is at or near capacity, user plane packet transmission shall be such that the average amount of resources allocated to each Participating Operator is based on their Participating Operator pre-agreed usage portion of the Hosting RAN, within a margin of tolerance.

6) The Hosting RAN shall be capable to apportion among the Participating Operators reduced resource allocations when QoS objectives cannot be met, due to excessive traffic load, distributed according to Participating Operators pre-agreed usage portion of the Hosting RAN.

4.7 Scenario and Use Case 5.b (Asymmetric RAN Resource Allocation in a static way)

4.7.1 Description

RAN resources owned and operated in a joint venture are shared among two RAN Sharing Partners proportional to their interest in the joint venture statically.

4.7.2 Pre conditions

Two Participating Operators have an asymmetric unequal controlling in a Joint Venture (JV), which builds, operates and maintains the Hosting RAN. The JV investment level is as follows: Participating Operator Partner "Primary" (P) has 60% interest; Participating Operator Partner "Secondary" (S) has the remaining 40% interest.

Note that thus use case is also applicable when one entity is the Hosting RAN Provider and the others are Participating Operators

The agreement between Primary and Secondary for the JV is that each Partner will be guaranteed shared network resource allocation proportional to its controlling interest level in the JV.

4.7.3 Service flows

As a one-time (or infrequent) operation, the Hosting RAN is given information about the 60/40 resource allocation proportion among the two partners, so that it can conduct or assist in resource management operations accordingly.

Resource management operations include:

- Bearer admission (allocation of a new bearer) decisions for either of the two partners;
- Uplink/downlink radio transmission (e.g., packet transmission scheduling).

The shared RAN routinely charges for resource management operations for Partners P and S separately, i.e., when admitting a bearer for P, it records it as such, and likewise for S. Similar applies for scheduler and other operations.

- For Partner P and S:

A new bearer is admitted by taking into consideration Participating Operator pre-agreed resource allocation proportion. If admission of a new bearer belonging to Partner S would result in exceeding this proportion, the new bearer is not admitted. Otherwise, the new bearer is admitted. Similar Hosting RAN behavior applies for Partner P bearer admission.

Radio resource scheduling takes into consideration the Participating Operator pre-agreed resource allocation proportion of partners P and S. In principle, the scheduling is such that the average amount of resources committed to each of the partners P and S is based on their Participating Operator pre-agreed resource allocation proportion.

Scheduler decisions due to hard limit per participating operator may result in occasionally not being able to meet QoS objectives for one or more bearers. The Participating Operator pre-agreed resource allocation proportion determines the distribution among the Partners P and S that such failure to meet QoS objectives can occur.

4.7.4 Post conditions

Usage of radio resources is tracked for each partner. Radio resource usage is proportional for each of the partners based on their Participating Operator pre-agreed usage portion of the Hosting RAN. .

4.7.5 Requirements for this use case

1) It shall be possible to establish each Participating Operator's pre-agreed usage portion of the Hosting RAN.
2) A Hosting RAN element shall measure network resource usage at all times separately for each Participating Operator and identify whether the Participating Operator's pre-agreed usage portion of the Hosting RAN is being used.
3) A Hosting RAN element involved in user plane packet transmission scheduling shall be capable of differentiated control among traffic associated with the Participating Operators, based on the Participating Operator pre-agreed usage portion of the hosting RAN.
4) A Hosting RAN element shall conduct bearer admission by taking into consideration the Participating Operator's pre-agreed usage portion of the Hosting RAN, such that the balance of Hosting RAN resource remains in accordance with the pre-agreed usage portion of the Hosting RAN.
5) User plane packet transmission shall be such that the average amount of resources given to each Participating Operator remains in accordance with the Participating Operator's pre-agreed usage portion of the Hosting RAN.
6) The Hosting RAN shall be capable to apportion among the Participating Operators reduced resource allocations when QoS objectives are not met, distributed according to the Participating Operator pre-agreed usage portion of the Hosting RAN.

4.8 Use Case 6 (Dynamic RAN Sharing Enhancements)

4.8.1 Description

This use case presents a scenario where the Participating Operator may require varying network capacities during different time periods of the day or the week. The Participating Operator requests various allocations of a portion of the shared RAN to meet projected variation in network usage.

4.8.2 Pre-conditions

Operator A is Hosting RAN provider sharing RAN X.

Operator B is a Participating Operator owning an unshared RAN Y, but is in need of additional capacity during specific times during week days.

Upon careful analysis, Operator B requests the following portion of shared RAN (RAN X) resources from Operator A:

- Monday – Friday (4:00 pm – 7:00 pm) 30%
- Monday – Friday (Rest of the time not covered above) 0%
- Saturday – Sunday 0%

Operator A determined that it can accommodate Operator B's request and still utilize RAN X in an optimal manner to meet projected usage.

Operator A and B negotiated an agreement to share the RAN X

Tom, a subscriber of Operator B is using his UE at 3:59 pm on Monday. Tom's communication is established via RAN Y.

Jerry, a subscriber of Operator B is using his UE at 6:59 pm on Friday. Jerry's communication is established via the shared RAN X.

4.8.3 Service Flows

Based on the dynamic RAN sharing agreement, Operator A will provide Operator B with RAN sharing capacities to RAN X based on the mutually agreed-upon RAN Sharing schedules.

Tom's case:

As the 4:00pm RAN Sharing Period starts, Operator B notifies Tom's UE to the availability of additional RAN resources in the shared RAN (RAN X)

Mobility management of Tom's UE may utilize the availability of RAN X.

Jerry's case:

As the RAN Sharing Period is due to expire at 7:00pm, the shared RAN steers Jerry's UE away from RAN X and towards RAN Y based on Operator B's policies.

4.8.4 Post-conditions

Operator A optimizes its shared RAN both from an operating and financial standpoint.

Operator B is able to optimize its need for additional RAN capacity efficiently according to the traffic patterns of its customer base.

4.8.5 Requirements

1) The system shall provide flexibility in handling dynamic changes in the cell's RAN Sharing allocation to Participating Operators.

2) Participating Operators shall be able to drive both connected and idle UEs towards the Hosting RAN at the beginning of the RAN sharing period and the Hosting RAN Provider shall be able to drive both connected and idle UEs away from the shared RAN resources at the end of the RAN Sharing Period.

3) Subject to the Hosting RAN Provider settings, the RAN shall be able to involve Participating Operators in the decision of where to drive both connected and idle UEs to when multiple options are available at the end of the RAN Sharing Period.'

4.9 Scenario and Use Case 7 (On-demand Automated Capacity Brokering)

4.9.1 Description

This use case describes the situation of a Hosting RAN Provider that might share by automatic means some designated portion of its RAN capacity with other Participating Operators (e.g., MVNOs). Such designated portion of the shareable RAN resources shall support On-demand Capacity requests for additional capacity by Participating Operators.

A typical situation for this use case would be a Hosting RAN Provider with designated sharable excess capacity during the night that Participating Operators request to use, e.g., M2M services as security video surveillance, meter measurements, etc.).

Another example could be a major event (e.g., sports, concerts, fairs …) requiring short term additional capacity from a Participating Operator for that event.

A third example could be a monthly special bargain of reduced usage charges by the Hosting RAN Provider for a limited time available to the Participating Operators.

4.9.2 Pre-conditions

The Hosting RAN provider provides shareable resources designated as On-demand Capacity that are available for Participating Operators to request.

The Participating Operator has identified the need for additional resources dedicated temporarily in the shared network through automatic network engineering mechanisms and has identified:

- The time period the additional shared resources are needed,
- the quantity of shared resources needed, and
- any service specific attributes of the shared resources needed.

The need for additional resources may arise in addition to the resources already allocated to the Participating Operator either statically or on-demand.

4.9.3 Service Flows

The Requesting Participating Operator sends a request to the Hosting RAN Provider, indicating the needed amount of capacity for a predefined period of time, whether exclusive or non-exclusive access to granted capacity is requested and any service specific attributes required (e.g., based on standardized QCIs).

The Hosting RAN Provider then verifies automatically whether the RAN sharing request can be fulfilled.

- If the request can be fulfilled the allocation is signalled to the Participating Operator and the shared RAN is re-configured as requested.
- If the request cannot be fulfilled, the Hosting RAN will signal to the Participating Operator that the resources requested are not available.
- If the request cannot be fulfilled, the Hosting RAN may signal to the Participating Operator how much of the request can be fulfilled or

- If the request cannot be fulfilled, the Hosting RAN may allocate the portion of the request that can be fulfilled and signal to the Participating Operator the actual resource allocation.

4.9.4 Post-conditions

On demand requests which are granted are allocated from the pool of Operator On-demand Capacity resources in the shared RAN for the duration of the grant.

The Participating Operator receiving the grant will have exclusive or non-exclusive access to the allocated granted resources according to the grant request specification for the specified duration of the grant.

4.9.5 Requirements

The requirements derived from this use case are:

- The Hosting RAN shall be able to offer by automatic means sharable eUTRAN resources as on-demand capacity to Participating Operator's networks.
  The offer may indicate the period of time for the offer, any applicable shared network resource identification, whether exclusive or non-exclusive access can be granted and any service specific attributes e.g., based on standardized QoS Class Identifiers (QCIs).

- The Participating Operator's networks shall be able to request offered on-demand resources.

- The Hosting RAN Provider shall be able to allow a Participating Operator to request the cancellation of granted on-demand requests.

- The Hosting RAN Provider shall be able to withdraw a granted request (within SLA/business agreement)

4.10 Scenario and Use Case 8 (Participating Operator managing allocated resources)

4.10.1 Description

This use case describes a shared RAN providing selective O&M access to a Participating Operator to perform O&M tasks (troubleshooting) supporting the Participating Operator's use of the shared RAN. The shared RAN O&M elements allow access by the Participating Operator based on the Hosting RAN Provider O&M access policies.

4.10.2 Pre-conditions

1) Operator A is a Hosting RAN Provider sharing a RAN.

2) Operator B is a Participating Operator using a portion of capacity of Operator A's shared RAN.

3) Operator B's O&M systems have access the O&M elements of the shared RAN is under control of Operator's A's policy.

4.10.3 Service Flows

1) A fault occurs in a cell site of the shared RAN and is reported to the shared RAN O&M elements

2) The fault is reported to Operator A's operation staff to fix.

3) The fault is reported to Operator B's O&M systems by the shared RAN O&M elements to inform Operator B of a cell outage.

4) Operator B's operation staff contact Operator A's operation staff to obtain an update of the situation.

5) Operator B's operation staff reset fault reporting from the shared RAN O&M elements so as to not receive any further related faults.

6) Operator A's operation staff continue to receive fault reports.

7) An intermittent failure condition is detected on the link between one of the shared RAN base stations and Operator B's core network.

8) Operator B's operation staff decides that a link test from the shared network base station is required to help troubleshoot the problem.

9) Operator B's O&M system is able to initiate the required link test in the base station through the shared RAN O&M elements.

4.10.4 Post-conditions

1) Operator B is able to perform O&M tasks on the shared RAN related to Operator B's usage of the shared RAN

2) Operator A is able to control what O&M tasks Operator B is able to perform on the shared RAN.

4.10.5 Requirements

- The shared RAN shall be able to provide selective O&M access to the Participating Operator to perform O&M tasks supporting the Participating Operator's use of the shared RAN.

- The shared RAN O&M elements shall be able to use the Hosting RAN Provider O&M access policy to control access by each Participating Operator.

4.11 Scenario and Use Case 9 (Load balancing in shared RAN)

4.11.1 Description

This use case describes the situation of a certain shared coverage area consisting of several cells, which are shared by multiple operators. The agreed shares are predefined among these operators. In this case Load balancing between these cells needs to take the network sharing ratio per operator into account.

4.11.2 Pre-conditions

Two neighbouring cells (A and B) are shared by Operator 1 and 2.

Two neighbouring cells (C and D) are shared by Operator 1 and 2.

Cell A and B does not overlap with Cell C and D.

Agreed usage of RAN resources:

- Operator 1 is allowed to use 30% of cell capacity of A and B, and Operator 2 is allowed to use 70 % of cell capacity of A and B.

- Operator 1 is allowed to use 30% of cell capacity of C and D, and Operator 2 is allowed to use 70 % of cell capacity of C and D.

Load status of cells and usage per PLMN prior to load balancing:

- Cell A is 40 % loaded (60% spare)

  - 31 % used by Operator 1

  - 9 % used by Operator 2

- Cell B is 50 % loaded (50% spare)
  - 20 % used by Operator 1
  - 30 % used by Operator 2
- Cell C is 90% loaded (10% spare)
  - 31% used by Operator 1
  - 59% used by Operator 2
- Cell D is 30% loaded (70% spare)
  - 10% used by Operator 1
  - 20% used by Operator 2

4.11.3 Service Flows

1) Although the ratio of Operator 1 exceeds 30% in cell A, the whole load of Cell A is very light. In addition the total percentage used by Operator 1 in Cell A and B does not exceed 30%. The 1% additional radio resource usage of operator 1 exceeding his guaranteed use of 30% cell capacity in Cell A is allowed and will not trigger Operator 1's load balancing towards Cell B. In other words, when Cell A is lightly loaded, even though Operator 1's usage exceeds his guaranteed cell capacity, load balancing towards Cell B is not necessary. This is mainly to avoid unnecessary load balancing behaviour, e.g. handover Operator 1's subscribers from Cell A to Cell B would result in more risks on network performance, e.g. increasing call drop rate or handover failures.

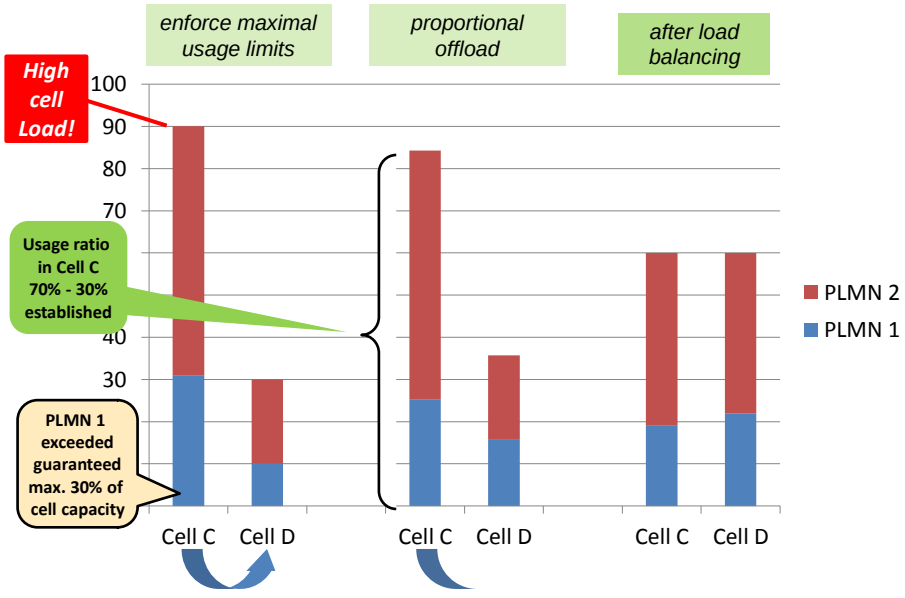

Figure 2: Service Flows for Use Case 9: Load balancing in shared RAN

2) In case of Cell C and D, not only does the ratio of Operator 1 exceed 30% but also the overall Cell C load is very high (figure 2). Load balancing has to be triggered to offload Cell C's traffic to Cell D by exchanging cell load information between these affected cells:
Since Operator 1 exceeds the ratio of predefined usage ratio, traffic from Operator 1 would be handed over to Cell D, until the maximal usage limit of operator 1 has been reached. After that, traffic from Operator 1 and Operator 2 will be offloaded to Cell D to achieve further load balancing between the cells while trying to keep usage ratio of both operators proportional to their relative shares.

4.11.4 Post-conditions

Load status of cells and usage per PLMN after load balancing (under optimal conditions):

- Cell A is 40 % loaded
  - 31 % used by Operator 1
  - 9 % used by Operator 2
- Cell B is 50 % loaded
  - 20 % used by Operator 1
  - 30 % used by Operator 2
- Cell C is 60% loaded
  - 19% used by Operator 1
  - 41% used by Operator 2
- Cell D is 60% loaded
  - 22% used by Operator 1
  - 38% used by Operator 2

4.11.5 Requirements

- The System shall be able to support load balancing within a shared RAN while respecting the agreed shares of RAN resources based on the whole cell load level and the load level for each operator.
- When load levels, defined by the Hosting RAN Provider, of individual cells are exceeded the 3GPP System shall be able to enforce agreed maximal usage limits of each Sharing Operator and to reduce the total load of the cell by e.g. preferably handing over UEs to neighbouring cells if possible.

4.12 Scenario and Use Case 10 (RAN Sharing Charging Event Triggering)

4.12.1 Description

This use case describes the situation of two or more RAN operators with wholly or partially overlapping coverage; for example one RAN provides contiguous coverage, the other covers areas including those where additional capacity is required. A Hosting RAN Provider (hereafter known as HP) shares its RAN capacity (in the areas where the additional capacity is required) with Participating Operators, including that associated with the overlaid RAN (hereafter known as PO1).

In order to generate wholesale start/stop charging records for proper accounting of usage of the shared RAN, it is necessary to generate a wholesale charging event record for an event when the UE enters or exits HP's shared RAN.

4.12.2 Pre-conditions

The Hosting Provider (HP) agrees to share RAN resources with one or more Participating Operators including PO1.

Each Participating Operator has additionally operates its own non-shared RAN that geographically overlaps (wholly or partially) the shared RAN.

Each Participating Operator supports service continuity when subscriber's UE handover between HP's shared RAN and their own non-shared RAN, including that associated with PO1.

Participating Operators and the Hosting Provider have established mutual commercial wholesale charging arrangements.

A subscriber of one of the Participating Operators (PO1) is currently in an area of overlap of the HP's shared RAN and PO1's non-shared RAN.

4.12.3 Service Flows

When the UE is in connected state and mobile, it may experience several kinds of handovers: From HO cell to another HO cell, from PO1 cell to HO cell, and vice versa.

The shared RAN generates wholesale charging events when a UE connects to and disconnects from the shared RAN, but does not generate wholesale charging events when a UE moves within the shared RAN.

4.12.4 Post-conditions

The Hosting Provider is able to efficiently process wholesale charging event records detailing usage of the shared RAN. Each wholesale charging event record can be identified as being chargeable to one of the Participating Operators.

4.12.5 Requirements

The requirement derived from this use case is:

- The shared RAN shall be able to generate accounting events that support the accounting of Participating Operators by the Hosting Provider. This includes:
  - Start of service in the shared RAN for a UE of the Participating Operator
  - End of service in the shared RAN for a UE of the Participating Operator
- The network shall be able to distinguish events caused by movement of the UE to & from the shared RAN, which require wholesale charging event messages to be generated, from those mobility events which do not require to be reported for accounting purposes.

Note: For example, if this function were to be provided using TA updates as currently described in 3GPP, then there would be a large number of non-charging related messages generated which would not have any useful function.

4.13 Scenario and Use Case 11 (RAN Sharing Charging Reconciliation)

4.13.1 Description

This use case describes the situation of a Hosting RAN provider sharing its RAN capacity with one or more Participating Operators. The Hosting RAN provider needs to be able to independently verify usage of the RAN, and to generate wholesale charges for each of the Participating Operators proportionately for their subscribers' usage of the shared RAN.

The Hosting RAN provider uses detailed wholesale charging event records, classified by Participating Operator, to charge each PO for the amount of data transported per QoS levels to & from its subscribers. Each Participating Operator may also wish to receive wholesale charging event records generated by the shared RAN for its own subscribers; the Participating Operator may need these wholesale charging event records for wholesale charging verification, for onward Third Party (MVNO) charging, etc.

4.13.2 Pre-conditions

The Hosting RAN Provider agrees to share RAN resources with one or more Participating Operators.

Wholesale charging and usage information exchange to support wholesale charging of shared network usage is established between the Participating Operators and the Hosting Provider.

4.13.3 Service Flows

- The service activities of subscribers operating on the shared RAN trigger the need for wholesale charging event records to be generated within the RAN. The wholesale charging event records provide details of each wholesale chargeable event including the Participating Operator with which the subscriber's usage is associated.
- The wholesale charging event records are available to the Hosting Provider who is able to separate the wholesale charging event records into groupings associated with each Participating Operator.
- After processing by the Hosting Provider, the wholesale charging event records associated with a particular Participating Operator are delivered to that Participating Operator.

4.13.4 Post-conditions

The Hosting Provider is able to perform both overall shared RAN wholesale charging tasks as well as Participating Operator specific tasks such as periodic wholesale charging.

The Participating Operator is able to perform shared RAN wholesale charging verification tasks as well as integrated the share wholesale charging event records with other charging event records it generates internally such as Hosting Provider wholesale charging verification and 3rd party usage charging.

4.13.5 Requirements

The requirements derived from this use case are:

- The shared RAN shall be able to generate wholesale usage information identifiable per each Participating Operator; e.g. characterized by such parameters as data volume, QoS level supported, location, time.
- The wholesale usage information of any specific Participating Operator's subscribers may be independently available (i.e. directly from the RAN elements) to that Participating Operator, to allow verification of wholesale charges & onward charging.
- The Hosting RAN Provider shall be able to check and filter any wholesale usage information sent from the RAN

4.14 Scenario and Use Case 12 (PLMN selection enhancements towards a shared RAN)

4.14.1 Description

This use case describes the situation that when a UE is moving towards a shared RAN, which is shared by its Home operator as well as other operators, the UE shall be able to select to its HPLMN based on the operator guidance to get better user experience.

4.14.2 Pre-conditions

UE is originally camped on Cell A and PLMN A (non-HPLMN for the UE) is its registered PLMN;

UE is now moving from Cell A to Cell B which is shared by PLMN A and PLMN B (UE's HPLMN);

Cell B broadcasts the PLMN identifiers of the participating operators.

4.14.3 Service Flows

When trying to camp on Cell B, the UE would read the system information and realize its Home operator is one participating operator. Based on the operator's policy, UE can choose to start PLMN registration procedure by selecting its Home PLMN, i.e. PLMN B, instead of keeping the original registered PLMN A.

4.14.4 Post-conditions

After updating PLMN registration the UE is now successfully registered to its HPLMN and can enjoy local services with lower charging.

4.14.5 Requirements

Upon the operator's policy, the UE shall be able to reselect to its HPLMN when moving towards a shared RAN where at least one participating operator is UE's Home operator, even though the old registered PLMN is still available.

Note 1: This is applied if and only if the UE is in automatic network selection mode.

Note 2: This use case exceeds the current scope of RSE since PLMN selection would involve GERAN and UTRAN too.

4.15 Scenario and Use Case 13 (PWS in shared RAN)

4.15.1 Description

Public Warning System is a broadcast capability where all UEs in a RAN coverage area designated by the warning message will receive the warning message to alert a user of an urgent condition concerning public safety.

4.15.2 Pre-conditions

1) Operator A is the Hosting Provider and has RAN X which is not shared and RAN Y which is shared.
2) Operators B is a Participating Operator who is using RAN Y and has its own RAN Z which is not shared.
3) Operator A has a regulatory obligation to broadcast PWS message to all UEs operating on RAN X and RAN Y.
4) Operator B has a regulatory obligation to broadcast PWS messages to all UEs operating on RAN Y and RAN Z.

4.15.3 Service Flows

1) A Public Safety agency creates a PWS message for a specific region which is covered by RAN X, RAN Y and RAN Z.
2) The Public Safety agency sends the PWS message to both Operator A and Operator B.
3) Operator A and Operator B both broadcast the PWS message in the area designated over all the RAN they have regulatory obligations for (RAN X, RAN Y and RAN Z).
4) UEs which are operating in RAN X or RAN Z may handover to RAN Y during the period the PWS message is periodically rebroadcasting.
5) UEs subscribed to Operator A operating in RAN Y may handover to RAN X during the period the PWS message is periodically rebroadcasting.
6) UEs subscribed to Operator B operating in RAN Y may handover to RAN Z during the period the PWS message is periodically rebroadcasting.

The following table illustrates which RAN a UE could receive a particular PWS while located in an area covered by RAN X, Y and Z.

UE is subscribed to:	PWS can be received from		
	RAN X (unshared)	RAN Y (shared)	RAN Z (unshared)
Operator A	From Operator A only	From both Operator A & B	No
Operator B	No	From both Operator A & B	From Operator B only

4.15.4 Post-conditions

1The UE only displays one copy of the PWS message and rejects the remainder received as rebroadcasts regardless of the RAN it is operating in or may handover to.

4.15.5 Requirements

- The Hosting RAN shall be able to broadcast PWS messages originated from the core networks of all Participating Operators

5 Considerations

5.1 General

Although it might be possible for the Hosting Providers to request the Participating Operators to collect MDT data in a shared RAN environment, issues such as the area of service provided to each Participating Operator, which may or may not be contiguous and/or overlapping, & data confidentiality, require that the RAN operator should have the ability to request & collect MDT data independently.

The prime issue consideration is that the mechanism chosen to generate these charging messages shall not cause a large number of spurious messages to be generated; i.e. spurious messages that would be triggered by non-chargeable events

It is realized that collection of usage data in the RAN will place an additional burden upon the eNB, but this is probably unavoidable. It can be compared to collection of other data by eNB, such as Minimization of Drive Testing, which is already accepted as a function that can only be provided by the eNB in this network environment.

Relative to Use Case 14, current 3GPP specifications limit PWS to only a single core network (CBC) provide the PWS to the RAN. The result of this is to force a shared network to designate a single Participating Operator to provide the PWS for all the Participating Operators. However the effect of this is to require either the Hosting RAN Provider to deploy enough core network elements to support PWS or require all the Participating Operators establish a business agreement with the Participating Operator providing PWS for the shared network in addition to the business agreement established with the Hosting RAN Provider.

These limitations must be lifted to support increased flexibility in RAN sharing arrangements.

5.2 Considerations on network evolution/rollout

It should be possible for these functions to be provided by a shared RAN even where the Participating Operator network supports with an earlier Release of 3GPP standards.

It should be possible for these functions to be provided by a shared RAN even where the Participating Operator network supports an earlier Release of the 3GPP standards (i.e. the PO network is pre Release 12).

It should be possible for these functions to be provided by a shared RAN even where the Participating Operator network supports with an earlier Release of 3GPP standards.

5.3 Considerations on security

Any automated mechanism for the Participating Operator to request any amount of any allocation type needs to have the Hosting RAN Provider approval.

Any shared RAN O&M function invoked by the Participating Operator needs to be under the control of the Hosting RAN Provider O&M access policy.

Privacy of subscriber information in MDT data shall be provided in the shared RAN environment to the same level as in the non-shared RAN environment.

Privacy of subscriber information in operational data shall be provided in the shared RAN environment to the same level as in the non-shared RAN environment.

The ability to create usage triggers without overloading uninvolved network elements is itself a security consideration, in reducing the possibility of a DoS attack on the network.

Privacy of subscriber information in charging records shall be provided in the shared RAN environment to the same level as in the non-shared RAN environment.

5.4 Difference with pre-Release 12 RAN sharing specification

RAN Sharing Monitoring is not possible in pre-Release 12 networks.

Standardized Hosting RAN OAM status reporting is not possible in pre-Release 12 networks.

Different types of capacity allocation were not considered in previous specifications. Shared RAN support of multiple types of capacity allocation concurrently were also not considered.

Specific access to shared RAN O&M functions by Participating Operators was not considered in previous specifications.

Support for MDT in a RAN sharing environment was not specifically considered in pre-Release 12 specifications. The consideration of alternative business arrangements between Hosting Providers and Participating Operators was not explored.

Support for collection of operational data by the Hosting RAN Provider in a RAN sharing environment was not specifically considered in pre-Release 12 specifications. The consideration of alternative operational arrangements between Hosting Providers and Participating Operators was not explored.

In pre-Rel-12 load balancing between cells does not take into account the percentage of shared RAN resources for each operator and the whole cell load together. Thus it remains unclear when to trigger load balancing and how to balance traffic between cells for each operator.

Support for charging events to be generated by a shared RAN was not specifically considered in pre-Release 12 specifications. The consideration of alternative business arrangements between Hosting Providers and Participating Operators was not explored.

Support for billing and charging reconciliation in a RAN sharing environment was not specifically considered in pre-Release 12 specifications. The consideration of alternative business arrangements between Hosting Providers and Participating Operators was not explored.

On-demand Capacity Brokering: On-demand Capacity Brokering is not possible in pre-Release 12 networks.

Consideration of PWS broadcast in shared RAN and mixed shared/non-shared RAN were not considered in previous specifications.

6 Potential Requirements

6.1 General

The following potential requirements on E-UTRAN sharing have been consolidated from the use cases in section 4 of this document. These requirements have been created to support enhanced E-UTRAN sharing and go beyond existing RAN sharing requirements in Rel.-12.

6.2 Consolidated requirements

Allocation of Shared RAN resources

From Use Case maximizing RAN sharing revenue And Use Case RAN Sharing Granularity	• The Hosting RAN shall be able to allocate RAN resource capacity to each of the Participating Operators by the following: a. Fixed allocation, i.e. guaranteeing a minimum allocation and limiting to a maximum allocation. b. Fixed allocation for a specified period of time and/or specific cells/sectors c. First come-first served allocation (i.e. on demand).
From Use Case Asymmetric RAN Resource Allocation	• A Hosting RAN Provider shall be able to define in the Hosting RAN the allocated share of RAN capacity for each Participating Operator. • A shared RAN shall be capable of differentiating traffic associated with individual Participating Operators. • A shared RAN shall conduct admission control based on the proportion of assigned RAN usage for each Participating Operator, within a margin of tolerance. • A shared RAN shall control transmission resource usage based on the proportion of assigned RAN usage for each Participating Operator, within a margin of tolerance. • The 3GPP System shall be capable of applying differentiated QoS attributes per Participating Operator for traffic in the Shared RAN.
OAM Access to the Hosting RAN	
From Use Case Participating Operator managing allocated resources	• The Hosting RAN shall be able to provide and control selective OAM access (e.g. to allow link test in the base station, provide fault reports…) to each Participating Operator to perform OAM tasks supporting the Participating Operator's use of the Hosting RAN.
From Use Case RAN Sharing Monitoring	• The Hosting RAN shall be able to allow Participating Operators to retrieve selective OAM status information to the same level of detail as would be available from a non-shared E-UTRAN.
Support for load balancing	
From Use Case Load balancing in shared RAN	• The Hosting RAN shall be able to support load balancing within a shared RAN while respecting the agreed shares of RAN resources based on the whole cell load level and the load level for each Participating Operator. • The Hosting RAN shall be able to perform load balancing per Participating Operator
Generation and retrieval of usage and accounting information	
From Use Case RAN Sharing Charging Event Triggering	• A Hosting RAN shall report events supporting the accounting of network resource usage separately for each Participating Operator. This includes: o Start of service in the Hosting RAN for a UE of the Participating Operator o End of service in the Hosting RAN for a UE of the Participating Operator
From Use Case RAN Sharing Charging	• The usage information generated by the Hosting RAN shall be on a per Participating Operator basis. • In addition to delivery to the Hosting RAN Provider a subscriber's usage information may be directly delivered to the subscriber's Participating Operator.

Reconciliation	
From Use Case MDT Support for RAN operator	• Subject to agreement between the Hosting RAN Provider and Participating Operators the Hosting RAN Provider shall be able to control collection of MDT data by UEs connected through its RAN. • Subject to agreement between the Hosting RAN Provider and Participating Operators the Hosting RAN Provider shall be able to retrieve MDT data collected by UEs connected through its RAN.
On-demand capacity negotiation	
From use case On-demand Automated Capacity Brokering	• The Hosting RAN shall be able to offer by automatic means sharable eUTRAN resources as on-demand capacity to Participating Operator's networks. • The Participating Operator's networks shall be able to request offered on-demand resources. • The Hosting RAN Provider shall be able to allow a Participating Operator to request the cancellation of granted on-demand requests. • The Hosting RAN Provider shall be able to withdraw a granted request (within SLA/business agreement)
Handover functionality due to RAN Sharing Agreements	
From Use case Dynamic RAN Sharing Enhancements	• At the beginning of RAN sharing Participating Operators shall be able to direct both connected and idle UEs towards the Hosting RAN and the Hosting RAN Provider shall be able to direct both connected and idle UEs away from the Hosting RAN at the end of the RAN Sharing Period. • If required by the on-demand granted RAN Sharing agreements, Participating Operators shall be involved in the decision of where to drive connected and idle UEs to when multiple options are available at the end of the RAN Sharing Period.
From Use case PLMN selection enhancements towards a shared RAN	• Upon the operator's policy, a UE in automatic network selection mode shall reselect to its HPLMN when moving towards a shared RAN where at least one participating operator is UE's Home operator, even though the old registered PLMN is still available
PWS support of shared RAN	
From Use Case on PWS	The Hosting RAN shall be able to broadcast PWS messages originated from the core networks of all Participating Operators

7 Conclusion and recommendations

The present document describes 14 scenarios and use cases in which specific enhancements to existing RAN sharing in E-UTRAN were analysed.

These enhancements have been found beneficial in offering savings as well as providing other benefits such as improving coverage of Participating Operators' networks. The analysed solutions expand the flexibility for RAN sharing arrangements for Participating Operators.

It is proposed to create normative requirements based on the potential requirements documented in section 6 of the present document.

Annex A:
Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2012-02	SA1 #57	S1-120018			Initial skeleton presented to SA1#57	n/a	0.0.1
2012-02	SA1 #57	S1-120272			Inclusion of S1-120019 RSE Scope	0.0.1	0.1.0
2012-05	SA1 #58	S1-121292			Inclusion of S1-121293, S1-121295, S1-121367, S1-121443	0.1.0	0.2.0
2012-08	SA1 #59	S1-122231			Inclusion of S1-122237, S1-122238, S1-122239, S1-122482, S1-122504, S1-122505, S1-122506, S1-122507	0.2.0	0.3.0 = 1.0.0
2012-11	SA1 #60	S1-124482			Inclusion of S1-124187, S1-124186, S1-124183, S1-124483, S1-124184, S1-124188, S1-124189,	0.3.0 = 1.0.0	0.4.0 = 1.1.0
2013-01	SA1 #61	S1-131132			Inclusion of: S1-131057, S1-131058, S1-131062, S1-131133, S1-131136, S1-131137	1.1.0	1.2.0
2013-05	SA1 #62	S1-133166			Inclusion of: S1-133162, S1-133025, S1-123163,	1.2.0	1.3.0
2013-05	SA1 #62	S1-133286			Editorial corrections	1.3.0	1.4.0
2013-06	SA#60	SP-130203			Updated by MCC to v.2.0.0 for SA approval	1.4.0	2.0.0