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1 Introduction

In RAN 2 NR Ad-hoc#1 meeting, there is highlighted FFS on whether there is a need for an additional indication that an on-demand SI is being broadcast or not.

Agreements related to SI provided by broadcast

3: The scheduling information for other SI includes SIB type, validity information, periodicity, and SI-window information in minimum SI irrespective of whether other SI is periodically broadcasted or provided on demand.

FFS Whether there is an additional indication that an on demand SI is actually being broadcast at this instant in time.

The last RAN2 Ad hoc meeting, the following agreements are achieved for MSG1 and MSG3 based on-demand SI request:

Agreements for Msg1 based SI request method:

- 1: RAPID is included in Msg2.
- 2: Fields Timing Alignment Information, UL grant and Temporary C-RNTI are not included in Msg2.
- 3: RACH procedure for SI requests is considered successful when Msg2 containing a RAPID corresponding to the transmitted preamble is received.
- 4: Msg2 reception uses RA-RNTI that corresponds to the Msg1 transmitted by the UE (details of RA-RNTI selection left to UP discussion)
- 5: UE retransmits RACH preamble according to NR RACH power ramping
- 6: Msg1 for SI request re-transmission is continued until reaching max preamble transmissions. Thereafter, a Random Access problem to upper layers is indicated. (depending on the NR RACH procedure design)

FFS: Upper layer actions when MAC reports Random Access problem. To be discussed in CP session.

- 7: Back off is applicable for Msg1 based SI requests but no special Back off subheader/procedure is required.

Agreements for Msg3 based SI request method:

- 1: UE determines successful Msg3 based on reception of Msg4

FFS Details of the Msg4 content used to confirm successful Msg3. To be discussed initially CP.

- 2: Preamble(s) for SI request using Msg3 based Method are not reserved.

- 3: RRC signalling is used for SI request in Msg3.

FFS: RRC signalling how to indicate the requested SI/SIB details left to ASN.1 work.

- 5: Temporary C-RNTI received in Msg2 is used for Msg4 reception

However, some issues still need to be addressed for MSG1 and MSG3 based SI request. This paper further discusses issues related to other SI request.

2 Indication for other SI

Before UE sends SI request, the UE needs to check the indication in minimum SI. This section further discusses the solutions of indication of other SI in minimum SI.

Two design options for the indication were discussed in previous papers [1] [2]:

Option a): a single bit that is dynamically changed to indicate a SIB is periodically broadcasted or provided on demand;

Option b): two bits are configured per other SI in scheduling information: the first indicator indicates whether the other SI is periodically broadcasted or provided on demand while the second one indicates whether the on-demand other SI is actually being temporarily broadcasted.

According to [3], the scheduling information in minimum SI includes an indicator whether the concerned SI-block is periodically broadcasted or provided on demand. If minimum SI indicates that a SIB is not broadcasted, then UE does not assume that this SIB is a periodically broadcasted in its SI-window at every SI periodicity. For the UE needs to acquire the SIB, it can send an SI request to receive this SIB if it is not acquired.

For option a, when the network broadcasts the requested other SI, it can change the related indicator to indicate that the SIB is broadcasted. For a later UE (e.g. entering the cell after the SI has started to be broadcast), if it wants the SIB and checks the indicator, it finds that the wanted SIB is being broadcasted. As a result, unnecessary SI requests will be avoided.

For option b, the network will keep the first indicator and change the second one if the requested on demand other SI is being broadcasted. For a later UE, it checks the second indicator and will not trigger SI request.

Based on the above discussion, it is worth noting that a single indicator can prevent the unnecessary SI requests from other UEs for a SIB while the SIB is being broadcasted due to one UE's request. There is no need for an additional indication for this purpose. In addition, option b) introduces extra overhead.

There are two solutions to signal the explicit indicator for option a):

Solution 1): the indicator is included in each scheduling information IE of corresponding SIB as one bit indication;

Solution 2): the indicator is formed as a bitmap, in a separate IE to the scheduling information sub-item of the other SIB.

For solution 2), the UE doesn't need to check each of the specific contents of scheduling information of the other SIB for detecting whether it is broadcast or not. It can determine the information just by checking the bitmap IE. And as it is a relatively independent IE, the change operation can be decoupled with the specific content of scheduling information of the other SIB rather than waiting for a modification period boundary it can be updated immediately. Furthermore, if the bitmap is signaled in a fixed SIB sequence (i.e. each bit in the bitmap always refers to the same SIB), regardless of whether the gNB broadcasts that SIB or not, the UE may directly be aware of whether to send a SI request or not without further having to refer e.g. to the order of SIBs in the scheduling information. Therefore, it is proposed:

Proposal 1: Signal a single bit per SIB that is dynamically changed for indication of whether one on-demand SI is broadcast or not, and the indication is broadcast in the form of bitmap in a separate IE.

Additionally, the change frequency of the indication depends on that of the UE's SI request. And the requested UE needs not to know the indication change triggered by itself. Therefore, the UE is not required to update the bitmap all the time. Conversely, it is beneficial for the UE only to update the bitmap before initiating the related Other SI request.

Proposal 2: The UE is only required to check the latest bitmap before initiating the Other SI request.

For the UE, after sending the OSI request, it will not wait to check whether the bitmap changes. To help the UE acquire the requested OSI as soon as possible, it is desirable that the network can deliver the requested OSI in the nearest SI window no matter whether the bitmap changes. From a network perspective, the SI can be delivered as soon as possible without waiting for some specific transmission window, e.g. modification period.

Proposal 3: If SI is requested, it can be delivered at any time, i.e. SI delivery is not restricted to some modification period.

Proposal 4: After sending SI request, the UE can check immediately whether the requested SI is broadcast or not, even if the bitmap is not changed in minimum SI.

Fig 1 below shows general illustration of the above solutions.

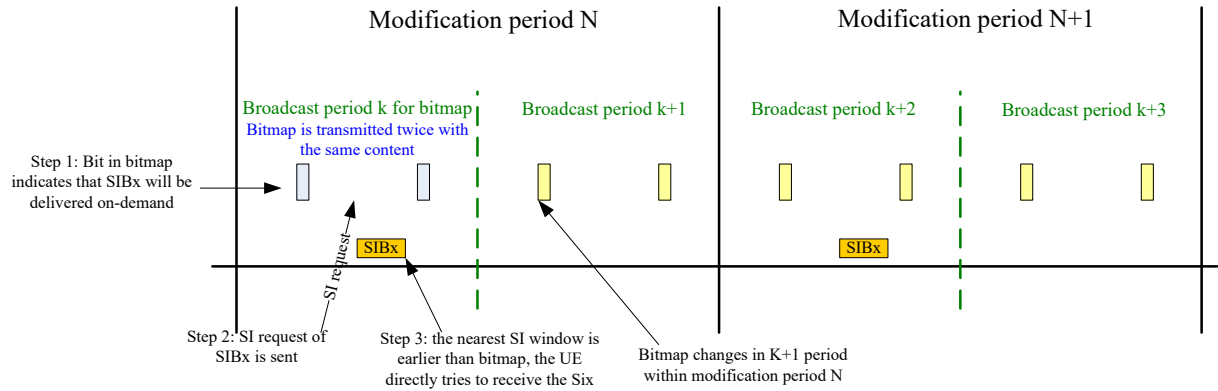


Fig 1: the procedure of bitmap changes and SI acquisition for UE

3 SI request

According to the agreements in the last meeting, after successfully sending the SI request via MSG1 or MSG3, for receiving the requested SIB, the UE monitors the SI window of the requested SIB in one or more periods according to the SI scheduling information indicated in MSI (Minimum SI). In the following sections, we will give detailed considerations on how to design MSG1 and MSG3 based request, acknowledgement transmission after SI request and the error handling mechanism.

3.1 MSG1 based other SI request

MSG1 based SI request will transmit a preconfigured preamble corresponding to the requested SIB(s) on the preconfigured PRACH resource. The number of preambles is limited. If too many preambles are allocated for SI request, it will reduce the available preambles for normal RACH and consequently lead to a higher collision probability of RACH.

In order to avoid the impacts on the normal RACH, we think preambles for SI request should not be reserved on all of PRACH resources, i.e. only part of PRACH resources can be used to reserve preambles for on demand SI request. The possible solutions can be:

- Solution1: To reserve preambles for SI request on the same PRACH resource. The remaining of preambles can be used for normal RACH on this resource.
- Solution 2: To reserve preambles for SI request on different PRACH resources. For example, if 4 preambles are reserved for SI request, these 4 preambles can be reserved on different PRACH resources. The preambles reserved on different PRACH resource can be the same but for different SI request.

The mapping of reserved preambles, PRACH resources and corresponding SI should be indicated to UE in Remaining Minimum SI.

These solutions can be shown in Fig.2 as below.

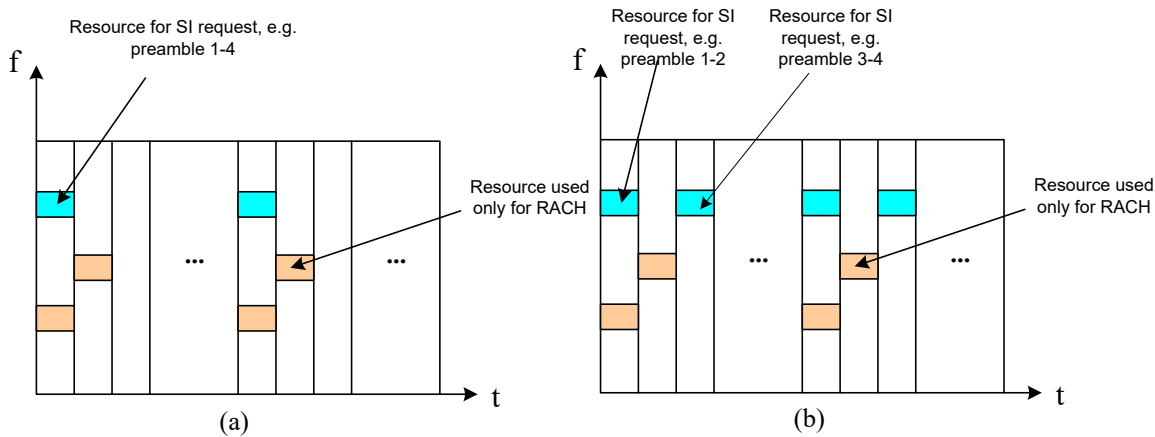


Fig 2: PRACH resource and preamble allocation for MSG1 based other SI request

For solution 1 as shown in Fig 2(a), all SI requests are initiated on the same resource and it could lead to the simultaneously SI transmission. However from configuration point of view, this solution could be simpler than the second one.

For solution 2 as shown in Fig 2 (b), the SI requests are distributed on multiple slots and the simultaneous SI request can be reduced. Although this solution may need more signalling, it is more flexible than solution 1.

We should avoid reservation on all PRACH resources for all SIs request considering normal RACH should not be impacted because of SI request.

Proposal 5: For MSG1 based method, SI can be requested on different PRACH Time/Frequency resource and the same preamble on different T/F resource can be used to request different SI.

3.2 MSG3 based other SI request

For MSG3 based SI request, there are still some issues which need to be addressed, and we will discussed one by one in the following section.

1. What's the granularity of requested SI for MSG3 SI request?

In RAN2#98 meeting, it was agreed that for MSG1 based SI request, the minimum granularity of requested SI is one SI message. However there is no confirmation on the minimum granularity of MSG3 based SI request. In our understanding, the minimum granularity of SI request in MSG3 is also one SI message.

Proposal 6: For MSG3 based method, the minimum granularity of requested SI is one SI message.

2. What RRC message should be used to request SI for MSG3 based solution?

It is agreed in the last meeting that RRC signalling is used for SI request in Msg3. But which RRC message is used for such request is not clear.

In LTE, only *RRCCConnectionRequest* and *RRCCConnectionReestablishmentRequest* can initiate service in RRC layer. In our understanding, both of them are not suitable for SI request. So, a new type of service request *RRCSysInfoRequest* can be defined in order to support SI request.

Proposal 7: A new type of RRC message *RRCSysInfoRequest* should be defined to support SI request.

For the UE in RRC_IDLE, there is no dedicated resource or security activation. The message can only be transmitted via CCCH with the signalling radio bearer of SRB0. For inactive state UE, it depends on the detailed design.

Accordingly, for the UE in RRC_IDLE, the message can only be transmitted via CCCH. The RLC Mode can only be TM mode. For inactive state UE, it depends on the detailed design.

Proposal 8: For the UE in RRC_IDLE state, the SI request is sent via CCCH with the signalling radio bearer of SRB0, and the RLC Mode for SI request can only be TM mode. Inactive state UE needs further discussion.

In the last meeting, bitmap based RRC message was discussed, but how to indicate the requested SI/SIB details of the RRC was left to ASN.1 work. Our understanding is that the basic principle shall be defined and we propose the following table of RRC content for MSG3 based SI request message for the two states:

Table 1 a profile of the SI request message for the two states

		RRC_Idle	RRC_Inactive
Content	requested information SI	mandatory	mandatory
	requested information UE	mandatory	mandatory
The Signalling radio bearer		CCCH	FFS
The RLC Mode		TM mode	FFS

Based on the above table, we provide ASN.1 of the SI request message:

– **SIRequest**

The *SIRequest* message is used to request the other SI.

Signalling radio bearer: SRB0

RLC-SAP: TM

Logical channel: CCCH

Direction: UE to NR

RRCSystemInfoRequest message

```
-- ASN1START
RRCSystemInfoRequest-r15 ::= SEQUENCE {
    criticalExtensions          CHOICE {
        RRCSystemInfoRequest-r15
        RRCSystemInfoRequest-r15-IEs,
        criticalExtensionsFuture
        SEQUENCE {}
    }
}
RRCSystemInfoRequest-r15-IEs ::= SEQUENCE {
    request-SIType-List        BIT STRING (SIZE (40)),
    spare                       BIT STRING (SIZE (8))
}
-- ASN1STOP
```

Proposal 9: Use the ASN.1 above as baseline for MSG3 based RRC message. Each bit of the bitmap corresponds to one SI in the same order as appeared in the scheduling information.

3. What's the content of MSG4?

In the last meeting, it was agreed that UE determines successful MSG3 based on reception of MSG4. But as for the content of MSG4 used to confirm successful MSG3, it was left for FFS.

As discussed above, it's possible that multiple UEs may use the same preamble to initiate RACH at the same time. In this case, contention will happen and there are at least two cases should be considered:

Case 1: the contention is between a normal RACH UE and the UE for SI request or two UEs request different SIs.

Case 2: the contention is between UEs request for the same SIs;

For the first case, network can only send one acknowledgement with contention resolution ID to one of them if legacy RACH procedure is followed. The legacy contention resolution method makes sure the following allocated radio resources can be used for one certain UE. But from the UE(s) sending SI request perspective, it has no data which needs to be transmitted and it only cares whether SI request for specific SI is received by the network. In this case, one possible solution is that network indicates SI requests received for SI based request. This indication can be one bit, a bitmap corresponding to SIs, or something else. This indication is not used for contention resolution, and it is just regarded as the acknowledgement of MSG3 SI request. If UE receives this indication, it ignores the contention resolution ID and to receive SI for some duration, if the SI is not what it requested, it will request again.

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