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Agenda Item: **10.4.1.6.5**

Source: **Ericsson**

Title: **Open issues on On-demand SI**

Document for: **Discussion, Decision**

1 Introduction

RAN2-97bis agreed that on-demand system information may be requested either using random access preambles (Msg1) or using a multi-step RA procedure (Msg1, Msg2, Msg3). RAN2 also agreed that the network indicates in the minimum SI, which of the two mechanisms the UE shall apply.

RAN2-98 agreed that for Msg1 based SI request the minimum granularity of requested SI is one SI-Message (a set of SIBs as in LTE) and one RACH preamble can be used to request multiple SI-Messages. It was further agreed that the on-demand SI request procedure should maximise commonality with the RACH procedure and that the network, in the case of Msg1 based SI request, sends an acknowledgement in Msg2 to confirm the SI request.

At the RAN2 Adhoc meeting in Qingdao, the following agreements were reached for on-demand SI:

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.

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

In this contribution we elaborate on:

- conditions for sending SI requests, including discussion on the need for an additional indication that an on-demand SI is actually being broadcast at this instant in time;

- handling of SI acquisition errors;
- contents of Msg3 and Msg4;
- link adaptations of transmissions of requested SI;
- transmission mechanism for Msg2 at Msg1 based SI request; and

the scheduling information for on-demand SI, including a proposed basis for the ASN.1 encoding of the SchedulingInfo IE.

2 Discussion

2.1 When may the UE send SI requests?

When a gNB updates SIBs in an SI-Message that is marked as "on-demand", many UEs in the cell may request that SI. A similar but less pronounced effect may occur when a large group of UEs enter a new cell where they may all transmit an SI request.

RAN2 discussed "*whether there is an additional indication that an on-demand SI is actually being broadcast at this instant in time*".

With the Msg1-based request the network is able to detect multiple preambles received in the same SI request resources. Multiple different preambles are mutually orthogonal and can be distinguished by the network. If multiple UEs transmit the same preamble, the network may not be able to distinguish each different transmission. This is however not a problem, since the received preamble transmissions will anyway trigger the same action from the network, i.e. broadcasting of the requested on-demand SI in the next therefore scheduled SI-Window. Secondly, a network may intend to apply beamforming to the delivery of the requested SI (note that this is still a broadcast transmission in the sense that it uses the SI-Message and the scheduling allocation is scrambled by SI-RNTI). Based on the received preamble the network could determine the beamforming characteristics and attempt to send the SI accordingly (still on the broadcast channel). If, however, many UEs across the cell area need the SI-Message, the network should be aware of that it should not beamform the transmission only into the direction of the first UE having sent the request. If some of the UEs interested in the same on-demand SI withhold their request transmissions, the network has no way of knowing whether there are more UEs listening for the broadcast than the one(s) transmitting the request.

The Msg3-based SI-request suffers more from many concurrent requests than the Msg1-based request since the network may have to distinguish and respond to the UEs' preamble transmissions and distinguish and decode their subsequent Msg3s. Hence, in particular a network using that mechanism might want to prevent too many UE from requesting SI concurrently e.g. upon SI modification.

However, we do not see a need for any new mechanism since the *SchedulingInfo* in the Minimum SI can serve this purpose. When the network updates the SIB(s) of an on-demand SI-Message, the network may choose to temporarily omit the "*si-RequestInfo*" in the *SchedulingInfo*, in which it anyway indicates that the SI-Message is updated (changed value tag), and temporarily broadcast the updated SI to prevent the otherwise expected multiple requests for the updated SI-Message. Another case when the network may temporarily omit the "*si-RequestInfo*" in the *SchedulingInfo* is when it has received a request to broadcast the concerned on-demand SI. When the broadcasting of the concerned SI-Message is finalized, the network may again include the "*si-RequestInfo*" in the SchedulingInfo.

Observation 1 **The network may use the already agreed indication in SIB1 (whether a SI-Message is subject to regular broadcast or only available upon request), to temporarily disable requests e.g. when updating SI and hence expecting many subsequent accesses or when it has received a request for a certain SI-Message and intend to broadcast it.**

Proposal 1 **A UE sends the SI-request solely based on the information in SIB1 that an SI-Message is only provided upon request. After sending the request, the UE attempts to acquire the requested SI-Message(s) in the SI-Window configured in SIB1.**

Proposal 2 **RAN2 does not introduce additional means for prohibiting UEs from sending SI requests for SI-Messages that are scheduled as "on-demand".**

2.2 Handling SI acquisition errors

Like in regular SI-broadcast, it may happen that a UE is unable to acquire the SI-Message in the SI-Window in which it was announced according to the SchedulingInfo in SIB1. In case of on-demand SI, this may also be due to that the request procedure fails, i.e. a Random Access problem. For the Msg1 based method it may be due to that the UE's Msg1 transmission is not received by the gNB or that the UE does not receive the Msg2 acknowledgement. Both these error cases look the same to the UE, i.e. it does not receive any Msg2 acknowledgement. This is similar to a regular random access failure and it is reasonable that the UE behaves similarly, i.e. repeat the Msg1 transmission with increased power.

Observation 2 **If a UE requesting on-demand SI does not receive Msg2, the UE may behave similarly as during a regular random access procedure and apply power ramping to Msg1 retransmissions.**

Another potential cause of failure to acquire the SI-Message is that the UE receives the acknowledging Msg2, but does not receive the SI-RNTI of the scheduling allocation of the requested SI-Message in the specified SI-Window. And further, yet another potential cause of failure is that the UE receives the scheduling allocation addressed to the SI-RNTI, but does not successfully receive the actual SI-Message. In these two latter error cases, the UE should retransmit the Msg1 (up to a maximum number of times), but without increasing the transmit power, since the acknowledging Msg2 has confirmed that the error is not caused by failure of the network to receive the preamble of Msg1. In case the requested SI-Message is broadcast multiple times in multiple subsequent occurrences of the SI-Window, and the UE manages to receive the associated scheduling allocations on the PDCCH, it is possible (subject to RAN1 decision) that the UE may accumulate energy from multiple receptions (or reception attempts) of the SI-Message (like for LTE coverage extension).

Observation 3 **If a UE requesting on-demand SI receives Msg2, there is no need for the UE to apply power ramping if the Msg1 is retransmitted due to later failures.**

Observation 4 **If the network broadcasts a requested SI-Message multiple times and the UE successfully receives the associated scheduling allocations on the PDCCH, the UE may accumulate energy from multiple receptions (or reception attempts) of the SI-Message. This is RAN1's responsibility to consider.**

With the Msg3 based method, the failure to acquire the SI-Message may have the same causes as in the case of the Msg1 based method, and the UE's behavior should be the same, i.e. retransmission of Msg1 with power ramping in case of absence of acknowledging Msg2 and retransmission of Msg1 without power ramping in case of failure to receive the scheduling allocation for the SI-Message or the SI-Message itself. In addition to these failure causes, with the Msg3 based method the failure may be caused by the failure of the network to receive Msg3. If the UE has transmitted Msg3 but does not receive the Msg4 acknowledgement, it should retransmit Msg1 (with a new random selection of the preamble) without power ramping (up to a maximum number of retransmissions). Similar to the Msg1 based method, the UE may successfully send a Msg3 SI request but not successfully receive the requested SI message, i.e. it receives a Msg4 ack but it does not receive the requested SI message in the SI window, or even the SI-RNTI of the corresponding scheduling allocation. The UE behavior should then be the same as for the Msg1 based method.

Proposal 3 **RAN2 should assume that if a UE requesting on-demand SI does not receive Msg2, the UE retransmits the Msg1 with increased transmit power.**

Proposal 4 **If a UE requesting on-demand SI receives Msg2, but still fails to acquire the requested SI-Message, the UE should re-initiate the request procedure (up to a maximum number of times) without applying power ramping to the Msg1 transmission.**

Proposal 5 **Discuss with RAN1 whether a UE may accumulate the SI-Message transmissions across several SI-Windows within the Modification Period (as for coverage extension in LTE) or whether it shall acquire SI-Messages only from individual SI-Windows.**

2.3 Consequences of final failure to acquire an on-demand SI-Message

The content of the SIBs that may be acquired through on-demand requests vary and hence also their importance to a UE's operation. Hence, if a UE fails to acquire a certain on-demand SI-Message (after a

maximum number of attempts or because the desired SIB(s) is(are) not available in the cell), the appropriate behavior of the UE depends on the content and criticality of the concerned SIB(s). Legacy behavior can be reused and there is no reason to specify different UE behaviors depending on whether a certain SIB is periodically broadcast or acquired through on-demand request.

Proposal 6 **The behaviour of the UE upon final failure to acquire a SIB should be independent on whether the SIB is periodically broadcast or acquired through on-demand request and may be specified per SIB.**

2.4 Msg3 and Msg4 content and link adaptation of transmissions of requested SI

For Msg1 based SI request, it was agreed at RAN2#98 that the minimum granularity of requested SI is one SI-Message (a set of SIBs as in LTE). There are no agreements on the content of Msg3 when the Msg3 based method for SI request is used, but it is reasonable to assume that the same minimum granularity of the requested SI as for Msg1 based request is used, i.e. one SI-Message, since a SI-Message is the smallest transmission entity in the SI distribution framework.

However, the Msg3 provides opportunities to provide other useful information. One such useful information would be the channel status information, so that the network can adapt its SI transmission accordingly, when it transmits the SI-Message(s) that the UE requests. The network can thus adapt the transmission property to achieve a suitable link budget.

For instance, the network may apply robust modulation and coding to increase the chances of successful reception for a UE with poor DL channel conditions or the network may transmit the requested SI-Message(s) with reduced power and/or less redundancy, thus reducing the resource consumption and the interference, when the requesting UE has good DL channel conditions. It is thus proposed that the UE includes information about its perceived DL channel status in the Msg3.

Regarding UE identity in the Msg3 (and Msg4), no need has been identified. Since the Msg3 SI request method triggers broadcast of System Information messages, which are addressed to many UEs using the SI-RNTI, and the request does not lead to any state change for the UE, there is no UE specific signalling after the Msg4 ack message. No contention resolution will thus take place during the procedure and there is no need for any UE identity within the Msg3 or Msg4 messages.

Proposal 7 **The minimum granularity of the requested SI should be the same for the Msg3 based SI request method as for the Msg1 based method, i.e. the smallest entity that can be requested should be one SI-Message.**

Proposal 8 **A UE may include DL channel status information in Msg3, during Msg3 based SI request, to enable the network to adapt the transmission of the requested SI accordingly.**

Proposal 9 **No contention resolution takes place at the Msg3 based SI request method. The Msg3 and Msg4 messages used for the Msg3 based SI request method do not contain any UE identity.**

When a gNB receives the SI request in Msg3, it will acknowledge the reception with Msg4 and start broadcasting the requested SI message(s). When the UE receives the Msg4 message it can determine that it does not need to resend the SI request. Since the Msg4 itself acknowledges the reception of the SI request the UE can then assume that the requested SI message(s) will be broadcasted, and thus start monitoring the corresponding SI window(s). There is therefore no need to include (within the Msg4 message) any information regarding what SI messages that will be broadcasted.

Proposal 10 **Msg4 does not contain any information about what SI messages that will be broadcasted.**

2.5 Transmission mechanism for Msg2 acknowledgement message at Msg1 based SI request

Msg1 based SI request method, one or many UEs may transmit the same PRACH preamble in the same PRACH resource. The gNB will be able to determine the SI request even if there are several UEs transmitting the same PRACH preamble and will then transmit the Msg2 acknowledgment message to confirm the reception. Depending on the gNB ability to detect the direction of the UE(s) sending the Msg1 request, which e.g. may be cumbersome in urban areas with reflection, it might be difficult to determine the DL beam(s) to use for successful Msg2 transmission. If the gNB cannot determine the direction of the UE(s) sending the SI request, it may need to transmit the Msg2 in a large area, perhaps even using beam sweeping.

To avoid that beam sweeping thus is needed for transmission of the Msg2 acknowledge message, the gNB should be able to determine what beams to use based on the PRACH preamble reception. The needed information could be achieved either from the timing of the PRACH preamble, which can be different between the beam (SS Block occasion) in the cell, or based on that different PRACH preambles are associated to different beams (SS Block occasion), even for the Msg1 SI request. The association of (P)RACH resources to different SS Block occasions could then be similar as the one for the normal RACH procedure.

Proposal 11 **At Msg1 based SI request method, it shall be possible to determine the best DL beam(s) for the Msg2 transmission based on the PRACH preamble/PRACH resource used for Msg1.**

2.6 SI scheduling information for on-demand SI

In this section, we show and example ASN.1 structure that supports the agreements taken in earlier meetings. Small additions allow the NW to indicate whether an SI-Message is available by regular broadcast or only upon request, whether the UE shall use Msg1 or Msg3 and, in case of the former, how to send the Msg1.

Table 1: Example ASN.1 structure for the SchedulingInfo in SIB1 to support on-demand SI

```
SchedulingInfoList ::= SEQUENCE (SIZE (1..maxSI-Message)) OF SchedulingInfo

SchedulingInfo ::=  SEQUENCE {
    si-Periodicity          ENUMERATED {rf8, rf16, rf32, rf64, rf128, rf256, rf512},
    sib-MappingInfo         SIB-MappingInfo,
    si-MessageValueTag      INTEGER (0..3),
    si-RequestInfo          SI-RequestInfo          OPTIONAL
}

SIB-MappingInfo ::= SEQUENCE (SIZE (0..maxSIB-1)) OF SIB-Type

SIB-Type ::=                        ENUMERATED {
                                        sibType3, sibType4, sibType5, sibType6,
                                        sibType7, sibType8, sibType9, sibType10,
                                        sibType11, sibType12-v920, sibType13-v920,
                                        sibType14-v1130, sibType15-v1130,
                                        sibType16-v1130, sibType17-v1250, sibType18-v1250,
                                        ..., sibType19-v1250, sibType20-v1310, sibType21-v14x0}

SI-RequestInfo  ::= SEQUENCE {
    msg1-Request    SEQUENCE {
        si-PRACH-Preamble               INTEGER (0..63)     OPTIONAL,
        si-PRACH-Config                 PRACH-Config        OPTIONAL
    }                                                       OPTIONAL
}
```

The UE is supposed to interpret and use this information as follows:

- If the optional field *si-RequestInfo* is absent
  - the SI-Message is provided by regular SI broadcast, i.e., the UE shall not request it.
- else, if the *si-RequestInfo* is present,

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