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1 Introduction

This contribution is a resubmission of [1]. In the context of SI delivery for NR, many companies propose to reduce the amount of “always-on” broadcast of system information [2]~[11]. The part of system information which is not always broadcasted (called on demand SI in the paper) can be delivered to particular UE based on the UE’s trigger. Several approaches are proposed for how the UE explicitly requests on demand SI [2]. In the email discussion triggered in [12] on system information, the rapporteur listed these possible options for discussion, but no agreement was reached. In this contribution, we first give the generic procedure of on demand SI delivery, and then further analyze and compare these approaches in view of the observations in [2] and give our preference.

2 Discussion

2.1 Generic procedure of on demand SI delivery

On demand SI delivery mechanism enables the network to send certain part of system information only after triggered by UE. As a result, the procedure consists of two essential steps at least. The basic procedure is illustrated in Figure 1.

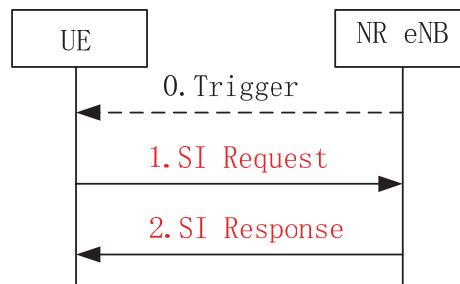


Figure 1: generic procedure of on demand SI delivery

Step 0 is optional and reflects a potential trigger from the network e.g. any indication of some SI update in any manner. It however indicates that the trigger at the origin of the on-demand SI is not necessarily only coming from the UE itself, but can also be the network.

In Step 1, the UE initiates on demand SI delivery procedure by sending the SI Request to the NR eNB. In the SI Request, some information which can help NR eNB to identify the SIBs UE is interested in may be included. The information may be the indexes of requested SIBs, UE capabilities etc.

Upon receiving the SI request, the NR eNB can send the SIBs in the SI Response (Step 2). SI Response can be dedicated signaling, groupcast (e.g. one UE requests and then the SI is delivered to a group of UEs via group SI-RNTI), or non-periodic broadcast.

Proposal 1: RAN2 should adopt the generic procedure in Figure 1 as a starting point for on demand SI delivery mechanism study.

In [2], several approaches for on demand SI delivery with different forms of the generic procedure in Figure 1 (omitting the optional network trigger) are discussed. We evaluate them in the following sections.

2.2 Evaluation criteria

In the email discussion [12], most companies agree that the observations listed in [3] need to be taken into account when RAN2 designs on demand SI acquisition mechanism.

Observations from [3]

Observation 1: On-demand SI delivery will reduce signalling overhead in the network side.

Observation 2: On-demand SI delivery will increase the number of uplink access and can cause uplink congestion when essential SI changes or when many UEs enter the same cell.

Observation 3: The congestion caused by on-demand SI delivery can delay other uplink access which might be more important than SI request

Observation 4: On-demand SI delivery may delay acquisition of updated system information so that could cause mismatched configuration between the network and the UE.

Observation 5: On-demand SI delivery will increase UE power consumption when UE frequently changes a cell.

Observation 6: The uplink message requesting SI delivery may need to include some UE capability information. Thus, the size of the initial uplink message would increase whenever NR introduces a new feature introducing a new SIB.

The observations can be summarized as following concerns:

- **UL congestion:** On-demand SI delivery will increase the number of uplink access and can cause uplink congestion when SI changes or when many UEs enter the same cell. The congestion caused by on-demand SI delivery can delay other uplink access which might be more important than SI request.
- **Delay of system information acquisition:** On-demand SI delivery may delay acquisition of updated system information leading to potential mismatched configuration between the network and the UE.
- **UE power consumption:** On-demand SI delivery will increase UE power consumption when UE frequently changes cell.
- **Future Extensibility:** The uplink message requesting SI delivery may need to include some UE capability information. Thus, the size of the initial uplink message would increase whenever NR introduces a new feature also introducing a new SIB.

Therefore, we propose:

Proposal 2: The potential on demand SI acquisition mechanisms can be carefully evaluated with respect to the following aspects: UL congestion, delay of system information acquisition, UE power consumption and Future Extensibility.

2.3 Evaluation

In this section, we evaluate the proposed approaches according to the aspects listed in proposal 2. The **UL congestion** is evaluated by the number of UL messages of each approach. More UL messages will cause more UL congestion. **Delay of system information acquisition** is evaluated by the number of total UL/DL messages when UE receives the interested system information. In addition, possible RACH collision is also taken into account as it will increase the delay of SI acquisition. **UE power consumption** is evaluated by the number of UL and DL messages of each approach; we assume UL transmission will consume more power than DL reception. **Future Extensibility** is evaluated by ease of introducing new information elements accessible through on demand SI.

a) Idle/inactive UE [2]

For idle/inactive UE, UE can use one of the following approaches to acquire the on demand SI:

Approach #1 (Figure 2): Request on demand SI after establishing RRC connection.

In this approach, an idle/inactive UE needs to perform RRC connection establishment/resume procedure to enter RRC_CONNECTED state first. Then the UE can request the system information by sending SI request message to the gNB, with indicator of the interested system information in the request message. gNB sends back the requested system information to the UE in SI response message, and then it may release the RRC connection of the UE.

Different from legacy LTE system, we assume the RRC establishment procedure is optimized in NR by omitting the following DRB establishment and security activation procedure if the purpose of entering RRC_CONNECTED state is SI acquisition only.

If preamble collision occurs in the first step, the UE may fail to enter the RRC_CONNECTED state. In this case, the failed UE needs to restart the whole procedure.

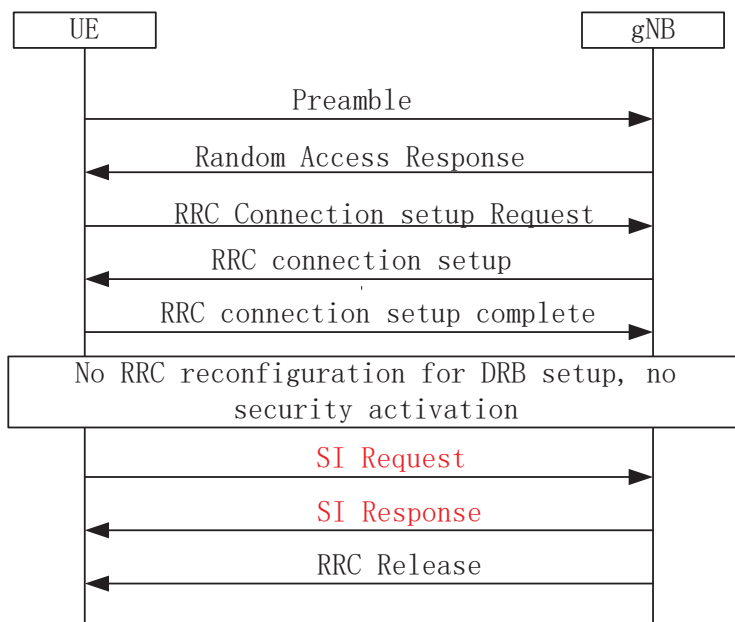


Figure 2

Approach #2 (Figure 3): Request other system information as part of system access procedure. In this approach, UE reuses the LTE RACH procedure. In the MSG3, UE sends SI request instead. And the gNB sends SI response in MSG4. Similar to approach#1, approach#2 also has a risk of preamble collision. If collision occurs, UE needs to restart the whole procedure.

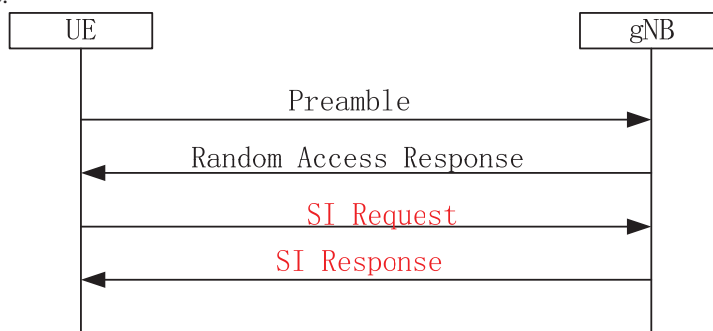


Figure 3

Approach #3 (Figure 4): Request other system information based on preamble transmission associated with requested information. In this approach, the network needs to reserve some preambles for on demand SI acquisition, each reserved preamble is mapped to a set of system information. And the mapping relationship between preambles and system information block groups is informed to UE before UE starts the procedure. When UE wants to acquire the system information, it sends the corresponding preambles to the gNB. Within UE's UL power limit, UE could send several (different) preambles in one UL transmission to require system information in more than one group. Compared with the above two approaches, approach #3 has better performance in some preamble collision cases, since it performs no contention resolution. For example, if more than one UE send the same preamble on the same RACH occurrence, as long as at least one is correctly detected by gNB, then all the UEs can receive the SI response from the gNB. Hence, collision risk is alleviated in approach#3.



Figure 4

Approach #4 (Figure 5): Request common system information based on preamble transmission and further requests other system information.

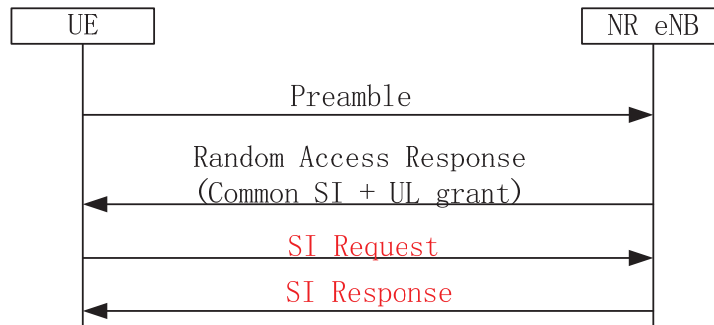


Figure 5

This approach is the combination of approaches #2 and #3, UE reuses the LTE RACH procedure. UE starts the procedure by sending the reserved preamble. In random access response, the gNB sends a subset of on demand SI (i.e. common on demand SI, FFS what information in common on demand) and UL grant to UE. If the UE only needs the common on demand SI, the procedure is over. Otherwise, the UE can further send the SI request according to the UL grant in RAR. And the gNB sends SI response in MSG4.

In this approach, there is no collision risk for common on demand SI. But for other on demand SI, there is collision risk. If collision occurs, UE needs to restart the whole procedure.

Table 1 Comparison of the different approaches (idle UE)

		<u>Approach 1</u>	<u>Approach 2</u>	<u>Approach 3</u>	<u>Approach 4</u>
UL congestion (Number of UL messages)		4(☹☹)	2(☹)	1(☺☺)	1 or 2(☺)
Delay of system information acquisition	Total number of UL/DL messages before UE receives the SI of interest	7(☹☹)	4(☹)	2(☺☺)	2 or 4(☺)
	collision risk	Yes(☹)	Yes(☹)	NO(☺)	NO for common on demand SI Yes for other on demand SI (☹)
UE power consumption (number of UL/DL messages)		4/4(☹☹)	2/2(☹)	1/1(☺☺)	1/1 or 2/2(☺)
Future Extensibility (ease of introducing new on demand SI)		Extend the SI request command(☺)	Extend the SI request command(☺)	Reserve more preambles (☹)	Extend the SI request command(☺)

In the four approaches, only approach 1 requires idle/inactive UE to leave idle/inactive state to acquire on demand SI. From the above table, we can see that approach 1 involves a long procedure and leads to the worst performance in all the aspects except future extensibility. Hence, we propose:

Proposal 3: It is not mandatory for an idle/inactive UE to leave current state to acquire on demand SI.

From the above table, we can see that among approaches 2/3/4, approach 3 has the best performance in all the aspects except future extensibility. The main drawback of approach 3 is it requires reserving some preambles. This will increase the collision probability of RACH procedure used for other purposes than on demand SI acquisition. However, we don't think it is a big problem if we can group the on demand SI properly and only reserve several preambles for demand SI acquisition.

Proposal 4: Approach 3 can be supported for idle/inactive UE to acquire on demand SI.

b) Connected UE

In Connected state, the UE may or may not have an UL grant. If it has an UL grant, it can directly use the generic procedure of Figure 1 where the SI request is sent over UL SCH. This provides flexibility in requesting some specific SI, similar to approaches 1/2/4 above. As a result, we propose:

Proposal 5: The generic procedure of Figure 1 can be directly used for Connected UEs with an UL grant, where the SI request is transmitted on granted resources.

For Connected UE without an UL grant, the UE may use either a scheduling request or the RACH procedure if it does not have scheduling request resource. These latter aspects are very much based on the legacy LTE though and we don't know yet what will exactly be the differences between SR and RACH procedures in NR. However, a preliminary observation is that approach 3 could be reused as well in that case. Given both approach 3 and the generic procedure are two steps procedures they have almost the same performance with regard to UL congestion, delay of system information acquisition, UE power consumption. As a result we suggest capturing the following as a starting point for Connected UEs without an UL grant:

Proposal 6: Approach 3 can be reused for Connected UEs without UL grant to acquire on demand SI.

3 Conclusion

In this paper, we evaluated the four potential approaches of on demand SI acquisition presented in [2] and [12]. And give the following proposals:

Proposal 1: RAN2 should adopt the generic procedure in Figure 1 as a starting point for on demand SI delivery mechanism study.

Proposal 2: The potential on demand SI acquisition mechanisms can be carefully evaluated with the following aspects: UL congestion, delay of system information acquisition, UE power consumption and Future Extensibility.

Proposal 3: It is not mandatory for an idle/inactive UE to leave current state to acquire on demand SI.

Proposal 4: Approach 3 can be supported for idle/inactive UE to acquire on demand SI.

Proposal 5: The generic procedure of Figure 1 can be directly used for Connected UEs with an UL grant, where the SI request is transmitted on granted resources.

Proposal 6: Approach 3 can be reused for Connected UEs without UL grant to acquire on demand SI.

4 References

- [1] R2-164811 On-demand System Information Delivery Mechanism CATT
- [2] R2-163371 System Information Signalling Design in NR Samsung
- [3] R2-164078 Observations about on-demand SI delivery mechanism LG
- [4] R2-163977 System Information Enhancements for NR Sony
- [5] R2-163470 System information in NR CATT
- [6] R2-163586 System information for standalone NR deployment Intel
- [7] R2-163853 System information handling in NR ETRI

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