3GPP TSG-RAN WG2 Meeting #115-e R2-21xxxxx

Electronic Meeting, 16th-27th, 2021

**Source: ZTE Corporation, Sanechips**

**Title: Report for [Post114-e][243][MUSIM] Gap handling**

**Agenda item: 8.3.3**

**Document for: Discussion and Decision**

# Introduction

In RAN2#114-e, the following email discussion was allocated for MUSIM Gap handling:

* [Post114-e][243][MUSIM] Gap handling (ZTE)

Scope: Discuss gap handling (periodic/aperiodic, periodicity, etc.).

Intended outcome: Discussion report

Deadline: Long

We’d like to discuss this issue in two phases as below

Phase 1: Scenarios discussion for switching without leaving connected state and Network/UE’s action during the scheduled Gap **Deadline Wednesday 30th June**

Phase 2: Gap handling details, e.g. Gap configuration assistance information and Gap configuration Details **Deadline: Long**

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# Discussion

In the below discussion, we assume UE was at connected state at network A and the switch target is noted as network B.

## Issue 1: Scenarios discussion for switching without leaving connected state

According to the companies contributions [2][3][4][5][6][7][8][9][10][12][13][16] in the last meeting, the below scenarios and the corresponding events are mentioned for switching without leaving connected state:

* Scenarios 1: Periodic switching, including SSB detection/paging reception, serving cell measurement, neighboring cell measurement including intra-frequency,inter-frequency and inter-RAT measurement;
* Scenarios 2: Aperiodic (one-shot) switching without transmission at network B, including SI receiving;
* Scenarios 3: Aperiodic (one-shot) switching with both transmission and reception at network B but will not enter RRC-connected state in NW B (e.g. no RRC connection Resume/Setup) at network B, including On-demand SI request;
* Scenarios 4: Aperiodic (one-shot) switching and enter into connected state (e.g. with RRC connection Resume/Setup) at network B, including Registration, SMS, RAU, busy Indication, etc.

For the scenario 1/2, according to the contributions companies share the common understanding that it shall be allowed to keep UE at connected state at network A. However for the scenario 3/4, it also requires UE do some transmission at network B, companies have different views on whether the UE is allowed to keep connected state at network A. Thus we’d like to clarify below 2 questions:

Note: Here we only discuss whether the UE is allowed to keep connected state at network A, it doesn’t mean that the UE must initiate the switching notification procedure without leaving RRC connected for these scenarios.

**Q1.1: For each scenario above, whether UE is allowed to keep at connected state at network A?**

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| **Scenarios**  **Yes/No**  **Companies** | **Scenario1** | **Scenario2** | **Scenario3** | **Scenario4** | **Comments** |
| **OPPO** | **Yes** | **Maybe No** | **Maybe No** | **No** | **For scenarios 1, apart from paging, SSB burst is no longer than 5ms, existing measurement gap is enough to cover all the measurement cases. As for paging, even if there is a time gap between paging DCI and paging PDSCH, the gap is usually acceptable for UE to keep connected mode in network A.**  **For scenarios 2, assume we can also ignore the time gap between SI DCI and SI PDSCH like paging, but considering the SI window can be very long(SI repetition is allowed during SI window), we’re not sure whether UE can still maintain connected mode in network A for the worst SI reception case in network B, i.e. UE fails to receive SI message several times during one SI window.**  **For scenarios 3, compared to scenarios2, on demand SI reception will take more time, the situation is more challenging.**  **For scenarios 4, maintaining two RRC in MUSIM UE is challenging considering Dual Tx/Dual Rx is out of R17 WID scope.** |
| **Huawei, HiSilicon** | **Yes** | **Yes** | **No** | **No** | **For Scenario 4:**  **As analysed in our paper [4], for this scenario, the UE should leave RRC connected in NW A considering that:**   1. **based on RAN2 previous agreement in #112e, it is clear that having two RRC connections simultaneously in two NWs is not considered in Rel-17.**  **There is no need to have exceptional case for**  **scheduling gap.** 2. **neither the instant of activity in NW B nor the duration of the UE’s stay in NW B is predictable which means that the UE cannot provide an accurate scheduling gap length to NW A that exactly match the time duration of UE’s activity in NW B.** 3. **The benefit to keep UE in *RRC\_CONNECTED* in NW A over transition to *RRC\_INACTIVE* state with respect to the service interruption time seems trivial, especially considering that the UE may still need to perform RACH to recover UL synchronization even being kept in *RRC\_CONNECTED* state.**   **For Scenario 3:**  **It has the similar issue with the scenario 4 that the time duration for the UE to acquire the on-demand SI in NW B is not predictable. which means it is difficult for the UE to provide an accurate gap length to the NW A. So the simplest way is the UE leave RRC connected state in NW A when it initiate the on-demand SI acquisition procedure.** |
| **Apple** | **Yes** | **Yes** | **Yes** | **No** | **For Scenario 1, a SSB/Paging reception, Scell/Ncell measurements should be possible to do in the gaps without impacting the RRC CONNECTED state on NW A.**  **For Scenario 2 and 3, the issue is only with Single Rx/Single Tx devices, which in our view needs to be addressed. For Dual Rx/Single Tx devices atleast in principle SI receive on NW B, while staying on CONNECTED state in NW A should not be an issue. For Single Rx/Single Tx devices, this depends on the longest possible interruption in RRC CONNECTED state operation in NW A that is tolerable.**  **For Scenario 4, agree that the interruption in time domain to CONNECTED state activity in NW A would be longer, and will also require both SIM instances to be in RRC CONNECTED state which is outside the scope of the current R17 WID.** |
| **China Telecom** | **Yes** | **Yes** | **Maybe Yes** | **Maybe Yes** | **Scenarios 1 and 2 are typical use cases for scheduled gap. Since only reception from NW B in these scenarios, the time needed is less than scenarios 3 and 4. Keeping in connected state at network A is reasonable.**  **For scenarios 3 and 4, it depends whether NW A and UE can keep synchronized and the QoS tolerance for no scheduling during the gap. If the answer is YES, the connected state could be maintained.**  **We should specify the UE behaviour in case UE is not able to return to network A before the gap duration expired,** |
| **CATT** | **Yes** | **Yes** | **Yes** | **No** | **For Scenario4,agree with other companies that UE staying in connected mode in both network A and network B is not in the scope of the R17 WID.** |
| **ZTE** | **Yes** | **Yes** | **Yes** | **No (or considered with lower priority)** | **Considering the time schedule of this WID, scenario 4 can be not considered in this WID or with lower priority** |
| **Nokia** | **Yes** | **Yes** | **Yes** | **May be** | Scenario 1 is essential for having idle mode operation in network B to avoid packet loss at NTWK-A for the basic operation.  Scenario 2 is extension of first scenario which will be required only in mobility and SI update scenario. It is possible to extend the base solution for this scenario without major impacts.  Scenario 3 and Scenario 4 will require the scheduling gap to consider stopping the uplink transmission also. Scenario 4 requires the UE to instantiate RRC context and PS instance at all layers for both USIM simultaneously. At physical layer scenario 4 can be supported by TDM. But higher layer support of dual stack operation needs to be investigated. If it is possible maintaining the UE in CONNECTED state can be considered as there is benefit over leaving and resuming the connection just for short signalling procedure |
| **Qualcomm** | **Yes** | **Yes** | **Yes** | **Probably No** | Whether the UE stays in Connected in NW A should depend on how much it impacts the tx/rx in NW A connection. If the gap is small enough (less than, say to cause RLF in normal operation), then what the UE does on the other side should not matter. With this in mind, Scenarios 1/2/3 should be feasible in most cases while Scenario 4 is unlikely to be completed in a reasonable gap duration. Please note that we are not going to define these scenarios in the specification and the UE should not need to tell NW A what it is going to do during the gap. The reason/cause could be just “for MUSIM purposes”. |
| **vivo** | **Yes** | **Yes** | **Yes** | **Yes** | **To minimize the impact to ongoing service in NW-A, we prefer to keep UE in RRC\_CONNECTED state in NW-A while UE performing the above activities (assumed to be short in time) in NW-B.** |
| **MediaTek** | **Yes** | **No** | **No** | **No** | For scenario 2, SI periodicity could be long and it is unclear that whether UE could maintain the network A sync if switching to network B for long time.  For scenario 3, the time to complete on-demand SI receiving is unpredictable by the UE.  For scenario 4, The time that network B request be in connected mode is also unpredictable. Better not to have two RRC Connection. |
| **Samsung** | **Yes** | **Yes** | **May be**  **(Depend on how much the maxium gap period can be and how UE and network A are expected to behave)** | **May be**  **(Depend on how much the maxium gap period can be and how UE and network A are expected to behave)** | In general, we think that RAN2 should strive to design a generic signalling mechanism to cater for any kind of task performed at network B.  For scenarios 1/2, we understand that the only difference comes from whether a certain idle mode task recurs at time intervals or not without performing transmission at network B. From a signalling point of view, such charateristics of periodic and aperiodic (one-shot) switching can be simply/easily handled by allowing to indicate whether each gap requires a certain periodicity or not. Considering that i) it is hard to categorize all idle mode tasks into periodic switching and ii) it is not appropriate to forbid/exclude aperiodic (one-shot) idle mode tasks for switching without leaving connected state, we do not see any rationale/benefit to not support scenarios 1/2.  For scenarios 3/4, it would be good to first clarify how UE and network A are expected to behave during the configured gap. In our view, it is preferable that UE suspends any transmission at network A during the configured gap, which implies that network A is not also required to receive (transmit) any dedicated message from (to) UE. If so, we believe that scenarios 3/4 and scenarios 1/2 are more or less the same except that the expected gap period of formal scenario is longer than that of latter scenario from network A perspective. Since it is up to network A whether to configure/allow a certain gap requested by UE and accordingly a smart UE implementation will cautiously decide whether to perform switching without leaving connected or switching for leaving connected, it sounds reasonable to support scenarios 3/4 in case the gap period is sufficiently enough to perform from a UE side. Otherwise, the side effect is that UE is always mandated to perform switching for leaving connected, which unnecessarily restricts UE implementation. In short, we are under the impression that both scenarios 3/4 depend on how much the gap period can be in the specification.  Note that our understanding is that for all the events related to scenario 4, network B will make the UE transit RRC\_IDLE or RRC\_INACTIVE just after completion of the procedure in most cases.  Regarding busy indication itself, we are not sure whether UE will implement it in real field if UE shall leave connected state in network A to perform it i.e. seems contractiory with the purpose of busy indication. |

**Q1.2: Besides the above 4 scenarios, whether there are any other scenarios/events that may also require switching procedure without leaving connected state in network A?**

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| **Companies** | **Yes/No** | **Comments** |
| Nokia | Yes | Applicability of above scenarios for UE in EN-DC/MR-DC at NTWK-A also should be considered. Because NSA or MR-DC are important deployment architecture for NR. |
| Qualcomm |  | We are open to considering MR-DC, especially given the co-existence of EN-DC and NR SA in the near future. For this case, the gap may be needed only at the SCG if the UE has separate RF and BB resources for LTE and NR. |
| MediaTek |  | We understand that MR-DC (in network A) is not precluded in above scenario. But we should not invent per CG measurement gap without RAN4 guide. |
| Samsung |  | We wonder whether periodic RNAU can be considered as periodic switching alike scenario 3. |

## Issue 2: Network/UE’s action during the MUSIM scheduled Gap

There are different Gap types during the legacy measurement gap discussion/spec, e.g. measurement Gap, autonomous Gap. Furthermore, in #112e meeting, it was also agreed that

* 2: The Sub-Case 3-2, i.e. Dual-RX/Single-TX UE stays in RRC\_CONNECTED mode in NW A while performing reception and transmission in NW B(in RRC\_ CONNECTED or during RRC setup/resume period ), is not considered in the WI from RAN2 viewpoint. Scheduling gap is not excluded.
* Capability change is not precluded by proposals.

Based on this agreements, during the gap, the UE may be suspended without any scheduling at network A or go on Tx/Rx at network A with reduced capabilities. Furthermore, during MUSIM discussion, there are also periodical Gaps and aperiodical Gaps.

Thus before we go to the detail discussion on gap handling in phase 2, we want to clarify which kind of gaps can be considered for each scenario listed above. For discussion convenience, first we would like to summary the gap types and the related network/UE’s action as below:

* **Gap Type 1a: Autonomous gap**
  + Similar to the autonomous gap defined for CGI reporting; network does not know the exact time occasions (within gap duration) that UE switches to network B, as long as UE fulfills the minimum transmission requirement.
* **Gap Type 2a: Normal periodical gap**
  + UE does not transmit or receive during the periodical gap duration;
* **Gap Type 2b: Normal aperiodical gap** 
  + UE does not transmit or receive during the aperiodical gap duration;
* **Gap Type 3a: Periodical gap with reduced capability:** 
  + UE can be scheduled by network A during the periodical gap duration, but with reduced capability (, details are FFS).
* **Gap Type 3b: Aperiodical gap with reduced capability:** 
  + UE can be scheduled by network A during the aperiodical gap duration, but with reduced capability (e.g. reduced MIMO layers, details are FFS).

**Q2.1: Which kind of gaps shall be supported for the each scenario listed above?**

* Scenarios 1: Periodic switching, including SSB detection/paging reception, serving cell measurement, neighboring cell measurement including intra-frequency,inter-frequency and inter-RAT measurement;
* Scenarios 2: Aperiodic (one-shot) switching without transmission at network B, including SI receiving;
* Scenarios 3: Aperiodic (one-shot) switching with both transmission and reception at network B but will not enter RRC-connected state in NW B (e.g. no RRC connection Resume/Setup) at network B, including On-demand SI request;
* Scenarios 4: Aperiodic (one-shot) switching and enter into connected state (e.g. with RRC connection Resume/Setup) at network B, including Registration, SMS, RAU, busy Indication, etc.

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| **Scenarios**  **Gap Types**  **Companies** | **Scenario1** | **Scenario2** | **Scenario3** | **Scenario4** | **Comments** |
| **OPPO** | **Gap Type 1a/ Gap Type 2a** | **Maybe invalid(SeeQ1.1),**  **If justified, maybe Gap Type 1a/ Gap Type 2a is sufficient** | **Maybe invalid(SeeQ1.1),**  **If justified, maybe Gap Type 1a/ Gap Type 2a is sufficient** | **Invalid case** | **As analysed in Q1.1, if it’s impossible to keep UE in connected mode in network A for Scenario2 and Scenario3, there is no other use case to apply**  **Aperiodic gap, so Aperiodic gap should not be considered in R17.**  **More addition, we never discuss Gap Type 3a and Gap Type 3b before, and Gap Type 3a and Gap Type 3b are more like a network implementation compared to Gap Type 2a and Gap Type 2b, we think there is no need to consider Gap Type 3a and Gap Type 3b.** |
| **Huawei, HiSilicon** | **Gap Type 2a** | **Gap Type 2a** | **Not supported** | **Not supported** | **For Scenario1, it is clear to use Gap Type 2a. For Scenario2, the events are triggered conditionally, once the Scenario2 events are triggered, UE needs to perform DL activities in NW B periodically until the activities end.**  **We think Type 3a/3b is applicable for the UE with single TX/Dual RX. However, we didn’t discussed Type 3a/3b before and hence further study is needed.** |
| **Apple** | **Gap Type 1a / Gap Type 2a** | **Gap Type 1a / Gap Type 2a would be sufficient (but the gap need not be periodic, as SI reception does not continue indefinitely)** | **Gap Type 1a / Gap Type 2a would be sufficient (but the gap need not be periodic, as SI reception does not continue indefinitely)** | **Gap would not address this case, as the requirement would be to establish a full-fledged RRC CONENCTION with NW B** | **An aperiodic gap for SI read (for scenario 2 and 3) would be beneficial, as the SI reading is not as periodic as IDLE/INACTIVE DRX. Also if it is apriori known by the UE, the maximum length of such aperiodic gap that the NW A can tolerate to sustain the RRC CONNECTION on NW A, then the maximum length of such aperiodic gaps can be suitably dimensioned.** |
| **China Telecom** | **Gap Type 2a**  **Gap Type 3a** | **Gap Type 2b**  **Gap Type 3b** | **Gap Type 2b** | **Gap Type 2b** | **For periodic gap, network needs to know the exact time occasion about the gap for scheduling. We prefer Gap Type 2a compared with Gap Type 1a.**  **For UE with single Tx/ dual Rx, UE can still perform reception/transmission with reduced DL MIMO layer in NW A during the gap in scenarios 1 and scenarios 2.**  **However, UE has the flexibility for the choice of gap types if one gap can be utilized for multiple scenarios.** |
| **CATT** | **Gap Type 2a** | **Gap Type 2a** | **Gap Type 2b** | **Not supported** |  |
| **ZTE** | **Gap Type 2a** | **Gap Type 1/2a** | **Gap Type 1/2b** |  | **For the MIB/SIB1/SI receiving, the UE may need to detect the related SI several times until successfully decoding. Thus, similar to the CGI reporting, the autonomous Gap can be adopted, or adopt a periodic Gap with limited repetition times.** |
| Nokia | 2A with possible adaptation and flexibility for actual switching within the gap.  3A for Dual RX | 2B with changes for adaptation  3B For Dual RX/TX | 2B with changes to consider uplink and downlink gaps simultaneously.  3B with Dual RX/TX | See Q2.2 | Primary focus of this discussion is to define the gap types for single TX/RX where the gap means complete silence at the leaving network.  Gaps with partial activity is possible for extended capability. This requires additional/separate discussion point in next phase. We propose to consider the gap handling for these UE types also in next phase. |
| Qualcomm | 2A | 2B | 2B | Possibly 2B, if the scenario is supported. | Reduced capability is not in the scope of Rel-17. Also, gap type 1A was not clear to us so didn’t put it as an option. |
| **vivo** | **Gap Type 2a/Gap Type 3a** | **Gap Type 1a/Gap Type 2b** | **Gap Type 1a/Gap Type 2b** | **Gap Type 1a/Gap Type 2b** | **For Scenario1, as the gap pattern is predictable and can be informed to NW-A, we see no benefit to allow autonomous gap in this scenario.**  **For Scenario2,3,4, it is not easy to determine the duration of gap. Gap type 1a(i.e. autonomous gap) is suitable for these scenarios. Besides, we think gap type 2b is also needed in case the network wants to configure the start time and maximum duration of the gap.** |
| MediaTek | Gap Type 2a | Not support or gap Type 1a / 2a | Not supported | Not supported |  |
| Samsung | Gap type 2a | Gap type 2b | Gap type 2b | Gap type 2b | We are not sure how Gap tpye 1 a works for MUSIM purpose. Besides, we wonder whether it leads to any specification impact i.e. it only brings unnessarily complexity.  Regarding Gap type 3a/3b, it may depend on how UE and network A are expected to behave during the gap as mentioned eailier but to us it seems simpler to not support reduced capability in this release. |

**Q2.2: Besides the above gap types, whether there are any other Gap types that need to be considered, if there are, which scenarios (e.g. scenarios 1~4 listed above) can be applied to?**

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| **Companies** | **Yes/No** | **Comments (Applied to which scenarios)** |
| Nokia | Yes | Scenario 4 may require different type of gap which requires both TX/RX gap along with some changes to higher layer operations. |
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Besides the Gap type, there are also different Gap granularity during the legacy gap discussion, e.g. per UE level, per FR level, per band level, per Cell level. Per UE level means this Gap would affect all of the serving cells of this UE, while the per FR level means this gap only affect the corresponding frequency range. Similarly, the per band level/ cell level means this Gap only affect the scheduling of the corresponding band/Cell. Thus, to make clear, it’s better to clarify the MUSIM scheduled gap level.

**Q2.3: Which granularity of gap should be considered for the MUSIM scheduled gap?**

1. **per UE level: the gap affects (the scheduling of) all of serving cells of UE in network A;**
2. **per FR level: the gap only affects (the scheduling of) all serving cells on corresponding frequency range (e.g. FR1, FR2) in network A;**
3. **per band level: the gap only affects (the scheduling of) all serving cells on corresponding band in network A;**
4. **per Cell level: the gap only affects (the scheduling of) corresponding cell(s) in network A;**

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| **Companies** | **Gap granularity**  **1~4** | **Comments** |
| OPPO | per UE level | To simplify the discussion, per UE level gap should be the baseline, further discussion is needed for other gap types. |
| Huawei, HiSilicon | per UE level | For the Type 2a gap, we think per UE level gap is enough. |
| Apple | Per UE level | Agree with Oppo that it is simple to keep it at per UE level. If there is a need for any other type of granularity, than that needs to be discussed. |
| China Telecom | Per band level | When UE tune away partial of Rx chains for activities in USIM B, the affected carrier in USIM A may vary in terms of different band combinations of USIMA and USIMB. So it would be better that the gap can also be configured per band. |
| CATT | Per UE level | Agree with above companies that per UE level gap can work well. |
| ZTE | Per UE level | Agree with OPPO that it is simple to keep it at per UE level. |
| Nokia | Per UE level | As the gap configuration is specific to UE and configured via dedicated signalling the gap granularity needs to be at UE level. Other types can be discussed during online meeting. We propose to restrict the second phase considering per UE level gap as working assumption. A per UE level gap can still be limited to FR/band of the given UE. |
| Qualcomm | Per CG or band level | Per UE level may be too conservative if the collision of the UE resources are specific to certain bands or SCG only, especially for EN-DC. |
| vivo | per UE level and per FR level | According to the bullet of switching notification in the WID, UE with dual-RX Single-TX needs to be considered. For a UE supporting per FR gap, it has the capability to communicate with NW-A in FR2 while monitoring paging in NW-B. Hence, per FR gap should be configured if applicable to minimize the impact to user experience in NW-A. Otherwise, per UE gap should be used. |
| MediaTek | Per UE level | Per band level and per Cell level is new design NR. We don’t know whether this is reasonable to have the new types without RAN4 input. Per UE gap should be the baseline. |
| Samsung | Per UE level | Same view with others. |

# Summary

TBD**.**

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# Annex: Agreements for switching notification

#112e

* RAN2 will evaluate short/long time switching in this WI
* 1a: The sub-Case 3-1 is supported in WI, i.e., the switching/leaving and returning procedure in 5GS/NR when UE is in RRC\_CONNECTED includes the case where Dual-RX/Single-TX UE is in RRC\_CONNECTED state in NW A while performing only reception in NW B (i.e., in RRC\_idle State and RRC inactive state).
* 1b: For Sub-Case 3-1, whether the Rx capability coordination between UE and NW is needed can be decided after the RRC-based switching/leaving and returning procedure is defined.
* 2: The Sub-Case 3-2, i.e. Dual-RX/Single-TX UE stays in RRC\_CONNECTED mode in NW A while performing reception and transmission in NW B(in RRC\_ CONNECTED or during RRC setup/resume period ), is not considered in the WI from RAN2 viewpoint. Scheduling gap is not excluded.
* FFS if/how to ensure UE doesn't disconnect from RRC\_CONNECTED during busy indication
* Capability change is not precluded by proposals.

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| * Switching procedure can be used to notify network A that the UE has a preference to leave RRC\_CONNECTED state in network A. * The switching procedure can be used to notify network A that the UE has a preference to be kept in RRC\_CONNECTED state in network A while temporarily switching to network B. |

#113bis

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| UE notification on network switching for multi-SIM   * RRC signalling is used for switching procedure without leaving RRC\_CONNECTED state in network A for UE temporarily switching to network B as a baseline. FFS on additional need of MAC signalling. |

#114

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| * RRC signaling for network switching without leaving RRC\_Connected state should allow multiple configurations of periodic “gaps” with different parameters (e.g. periodicities and durations). FFS is multiple can be active at the same time. FFS if multiple aperiodic gaps are supported. * UE provides assistance information to the gNB of NW A in Connected state based on the configuration of USIM of NW B for the gNB to determine the necessary switching parameters. Up to network what is the action based on UE assistance information. FFS what assistance information is needed. |