3GPP TSG RAN WG1 #110 R1-220xxxx

**Toulouse, France, August 22 – 26, 2022**

Source: Moderator (ZTE)

Title: Summary of AI 9.8.1 on Side control information to enable NCR

Agenda Item: 9.8.1

**Document for: Discussion and Decision**

# **Introduction**

According to the companies’ inputs in RAN1#110 meeting, discussion on following essential aspects are summarized as below:

* Side control information: Beam information
* Side control information: ON-OFF information
* Side control information: TDD information
* Side control information: Timing information
* Side control information: PC information

Companies are encouraged to provide the inputs for corresponding topics.

# **Topic-1 Beam information**

## **Company view (Round-1)**

In RAN1#109e, it has agreed that:

***Agreement***

*At least for FR2, beam information is beneficial and recommended as the side control information for network-controlled repeater to control the behaviour of NCR at least for access link*

* *FFS: Detailed mechanism of indication.*
* *Note: There are no supporting evaluation results on FR1 at this point to reach similar conclusion*

Regarding the inputs to justify the benefits on FR1, in this meeting, [ZTE, CMCC,ETRI, Rakuton] highlights that the beam information should also be recommended for FR1. The performance improvement for FR1 is also justified by the simulation results from [ZTE, ETRI] as below:

* [Source-1, ZTE] shows that with indicated beam information, the SINR performance on FR1 in the O2I scenario have been dramatically improved with deployment of NCR, and NCR provides obvious SINR improvement compared to legacy RF repeater in all cases. NCRs with beam information can also improve the SINR performance on FR1 in realistic outdoor scenario.
* [Source-2, ETRI] shows that a small payload of SCI (e.g. 4 bits) can provide SINR gains for more than 80% of indoor UEs. And the side effect from repeater at FR1 can be resolved by a proper CSI feedback and scheduling in the practical environments. Besides, dynamic repeater gain/power control can provide additional SINR gain over semi-static repeater gain/power configuration in FR1 as well as in FR2.

However, as highlighted by [Huawei],

* [Source-3, Huawei] The target coverage for FR1 can be achieved without NCR while the target coverage performance can only be achieved with NCR for FR2. NCR provides much more coverage extension benefits for FR2 than FR1.

In addition, additional results from [CMCC] to justify the benefits on FR2 is also provided as:

* [Source-4, CMCC] The NCR with beamforming has a valid SINR gains over gNB only and legacy RF repeater. Compared with gNB only, NCR has a SINR improvement about 1.42 dB, 1.44 dB, and 3.06 dB at 5%-tile, 50%-tile, and 95%-tile CDF. NCR could improve the coverage and SINR of the UE compared with gNB only and deployment with legacy RF repeaters.

Then, from FL’s perspective, according to the inputs, it’s reasonable to make the same recommendation on FR1 and also fine to capture all inputs into TR 38.867.

***Proposal 1-1:*** *For FR1, beam information is also beneficial and recommended as the side control information for network-controlled repeater to control the behaviour of NCR at least for access link*

Companies are encouraged to share your views.

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| Companies | Comments and Views |
| Samsung | Ok with the proposal. Note that the support of FR1 does not mean that extra standard work is needed on the top of FR2 beam indication design. |
| Apple | We are fine with the proposal |

***Proposal 1-2:*** *Capturing following observations into TR 38.867:*

* *For FR1:*
* *[Source-1, ZTE] shows that with indicated beam information, the SINR performance on FR1 in the O2I scenario have been dramatically improved with deployment of NCR, and NCR provides obvious SINR improvement compared to legacy RF repeater in all cases. NCRs with beam information can also improve the SINR performance on FR1 in realistic outdoor scenario.*
* *[Source-2, ETRI] shows that a small payload of SCI (e.g. 4 bits) can provide SINR gains for more than 80% of indoor UEs. And the side effect from repeater at FR1 can be resolved by a proper CSI feedback and scheduling in the practical environments. Besides, dynamic repeater gain/power control can provide additional SINR gain over semi-static repeater gain/power configuration in FR1 as well as in FR2.*
* *[Source-3, Huawei] The target coverage for FR1 can be achieved without NCR while the target coverage performance can only be achieved with NCR for FR2. NCR provides much more coverage extension benefits for FR2 than FR1.*
* *For FR-2:*
* *[Source-4, CMCC] The NCR with beamforming has a valid SINR gains over gNB only and legacy RF repeater. Compared with gNB only, NCR has a SINR improvement about 1.42 dB, 1.44 dB, and 3.06 dB at 5%-tile, 50%-tile, and 95%-tile CDF. NCR could improve the coverage and SINR of the UE compared with gNB only and deployment with legacy RF repeaters.*

Companies are encouraged to share your views.

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| Companies | Comments and Views |
| Samsung | Ok to capture the observation. |
| Apple | Generally Ok to capture the observation. Perhaps for source-1, ZTE, it might be more meaningful to capture some concrete values for gains rather than just saying “dramatically improved” |

Meanwhile, to enable the proper operation of NCR-Fwd, discussion on NCR’s capability on beam information is also proposed by companies:

* Adaptive beam vs Fixed beam for backhaul link

In RAN1#109e, both of them are supported.

**Agreement**

*Both fixed beam and adaptive beam can be considered at NCR for both C-link and backhaul-link.*

* *FFS: the mechanism for indication and determination of beam.*
* *Note: Fixed beam refers to the case that beam at NCR for both C-link and backhaul-link cannot be changed.*

According to the contribution in this meeting,[Fujitsu, CATT, xiaomi, Apple] propose that both fixed beam and adaptive beam at NCR should be supported, while [Samsung, CMCC] mention the support of these two options is subject to NCR’s capability, and a capability information should be reported to gNB to distinguish those two methods[CMCC]. [Ericsson] proposes that architecture with shared repeater-MT and repeater-Fwd antennas on the BS-side should be prioritized such that NCR-Fwd beamforming can rely on NCR-MT beamforming using the legacy UE beamforming framework.

* Beam information, e.g., at least for access link

As highlighted by companies including NCR [ZTE, vivo, CATT, NEC, Intel, xiaomi, China Telecom, CMCC, CEWit, Ericsson], the capability should be defined regarding the NCR’s beam for access link. The detailed information includes the number of supported beams should be considered [ZTE, vivo, CATT, NEC, Intel, xiaomi], [CATT, NEC, Intel] mention that the beam width, beam direction, and beam type can also be considered, and [Ericsson] mentions the reciprocity/non-reciprocity and coherent/non-coherent codebooks can also be reported. Besides, the maximum number of beams for access links is also concerned by companies [Huawei, CATT]

Then, from FL’s perspective, the following proposal is proposed:

***Proposal 1-3:*** *Following aspect can be considered as the NCR capability*

* *Characteristic of beam at NCR-Fwd for backhaul link:*
  + *Adaptive beam or fixed beam for backhaul link at NCR-Fwd*
* *Characteristic of Beam at NCR-Fwd for access link including number of supported beams, beam type, number of simultaneously operated beam.*

Companies are encouraged to share your views.

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| Companies | Comments and Views |
| Samsung | Support the proposal in general.  Suggest to modify the proposal as “*Characteristic of beam at NCR-Fwd for backhaul link at least including…*” and “*Characteristic of Beam at NCR-Fwd for access link at least including…*”, in view of extensive set of manufacture declarations agreed in RAN4 for the Rel-17 NR FR1/FR2 repeater (R4-2211151), which can be further discussed in the normative phase of Rel-18 NCR. |
| Pivotal commware | We are not against adaptive, as long it is not mandated that this functionality needs to be “run-time” (as that would add implementation burden). Having it **Configurable** (ahead of time, at the slow time scale, perhaps as Operator sees it fit) rather than **Adaptive** would be our wording of choice. |
| Apple | For the “beam type” for access link, it would be good to clarify what exactly it entails. Otherwise, it is quite a broad term. Is the intention here to state narrow or wide beam? |

More specifically, to enable the proper indication of beam information in the side control information, details, e.g., mechanisms of beam determination and indication for each links, are also highlighted:

* ***NCR-UE link (i.e., access link)***

In RAN1#109e, the following agreement is achieved

***Agreement***

*In the access link beam indication, an access link beam can be indicated by:*

* *Option 1: A beam index*
  + *FFS: How to indicate the corresponding time domain resource of the beam.*
* *Option 2: An index of a source RS (e.g. a TCI-like indicator)*
  + *FFS: The definition of the source RS.*
  + *FFS: How to indicate the corresponding time domain resource of the beam.*
  + *FFS: The definition of the association between the source RS and the beam.*
* *Note: The above does not imply that the NCR can or cannot generate and transmit reference signals to a UE or receive and process reference signals from a UE.*

*RAN1 to select one of the two options, combine the two options, or select both options in RAN1#110*

Then, regarding the remaining FFS on how to indicate the applicable time of beam indication, following options shared by companies can be considered:

* Option1: Implicitly aligned with the beam indication. [ZTE, CMCC, Intel, DCM]. In this way, the beam will be applied over the time resource until another indication
* Option2: Explicitly indicate the starting time unit and duration for each beam

In this way, these parameters can be indicated via additional field, e.g., SLIV. [ZTE, Intel, Samsung]

* + Additional, for semi-static configuration (e.g., beam pattern or periodically beam indication), additional indication of the information including periodicity is also needed.

Then, from FL’s perspective, following proposal is provided:

***Proposal 1-4:****The time domain resource corresponding to an access link beam can be determined with following options:*

* + *Option 1: Explicitly indicating the starting time unit, the duration (e.g., via SLIV) and/or periodicity per beam indication*
  + *Option 2: The corresponding time domain resource is from one beam indication to another beam indication.*

*Note: One or multiple beams (e.g., beam pattern over consecutive time resources) can be indicated per beam indication.*

Companies are encouraged to share your views.

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| Companies | Comments and Views |
| Samsung | In principle, we are supportive of the two options mentioned by FL. In terms of option 1, another way to indicate time domain resource is slot index (which is already specified for Rel-17 IAB).  Also, another option can be considered here is implicit time domain resource indication, e.g., NCR determines the symbols/slots for SSB/PRACH according to SSB index information. The symbols/slots for the SSB/PRACH can be obtained from system information.  Hence, we suggest the following modification.  ***Proposal 1-4:****The time domain resource corresponding to an access link beam can be determined with following options:*   * + *Option 1: Explicitly indicating time domain resource (e.g., via SLIV, slot indexes) and/or periodicity per beam indication*   + *Option 2: The corresponding time domain resource is from one beam indication to another beam indication.*   + *Option 3: Implicit time domain resource determination (e.g., NCR determination of the symbols/slots for SSB/PRACH/PDCCH for SI, paging, etc. based on SSB index indication)*   *Note: One or multiple beams (e.g., beam pattern over consecutive time resources) can be indicated per beam indication.* |
| Pivotal Commware | We are supportive of Option 1: A beam Index.  W.r.t Option 2 “Note”: We think that having multiple beams on Access side adds too much to complexity. (Even, most gNBs today do not have this capability). |
| Apple | We are generally fine with the moderator’s proposal.  One question for clarification – in addition to the time domain resources for beam, it also needs to know whether the indicated beam on corresponding time domain resources is for uplink reception from UE or downlink forwarding to UE. Do we need to discuss this under this proposal or have separate proposal/discussion? In our view, UL/DL TDD configuration can implicitly be used for that. |

Regarding how to represent the beam information, two options (beam index or source RS ID) including definition of RS, according to contributions in RAN1#110 meeting, following views are share by companies:

* [Spreadtrum, ZTE,Fujitsu, NEC,Intel, Qualcomm, Ericsson] prefer the beam index is used to indicate the beam for access link due to less impact on specification and overhead;
* [InterDigital, Lenovo, Apple, China Telecom] support the source RS index can be used for the beam information of access link.
* [Samsung, CAICT,vivo, China Telecom, LG] support both two options can be supported for the beam of access link.

Besides, as for the option 2 (i.e., the source RS index), the mapping relationship between index and beam for the access link should be defined and known by gNB [Samsung, ZTE, LG]. [Samsung] highlights that the association (e.g., the association between wide beam and narrow beam) between the beams for access link should be known by the gNB and NCR, where the association of the beams for access link can be provided by gNB to NCR, or provided by NCR to gNB, or predefined with specific rules.

Then, from FL’s side, regarding the down-selection between Option-1 and Option-2, it’s obvious that at least Option-1 with beam index is recommended as majority for beam indication and details including association between beams and index/RS can be discussed in 9.8.2

Companies are encouraged to share your views.

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| Companies | Comments and Views |
| Samsung | It is understood that option 1 is majority view and we are fine to support it. Also, we would like to point out the benefit of option 2 in some case such as the beam indication of SSB / PRACH. For example, option 2 can be used for the beam indication of PRACH occasion (for forwarding), where the SSB index associated with the PRACH occasion can be used as source RS. In this case, the use of beam index is unnecessary. |
| Pivotal Commware | Support Option 1: Beam Index. |
| Apple | In our view, both options are fundamentally same. Basically, in option 1, a fixed set of logical beam indices are used to indicate, while in option 2, the index of DL RS can be reused for beam indication. Also, we would like to ask for clarification that is it the common understanding that for both options the spatial filter used by NCR is up to implementation (i.e., gNB simply indicates logical index, bur physical directivity of beam is up to NCR implementation)? If this is the case, then in our view option 2 is preferable as it can reuse the existing TCI framework.  Another aspect related to beam indication (we also discussed in our contribution) is if we should consider configuring NCR’s wide area of coverage. In our view, it is beneficial if gNB can configure NCR to have beams indicated within a specific coverage area. This would allow to also avoid unnecessary interference outside the desired coverage area. Otherwise, with logical beam indication, it will be completely up to NCR’s implementation |

Regarding whether to support slot-level and/or symbol-level beam indication, [vivo] support at least symbol-level access link beam indication. Further, [vivo] highlights that single symbol level or symbol group level indication can be FFS. [Fujitsu,CATT,Intel, Samsung] both slot-level and symbol-level can be supported.

From FL’s perspective, it’s straightforward to support both slot and symbol level (Option-3) as recommendation. The details and potential down-selection can be considered in 9.8.2.

Companies are encouraged to share your views:

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| Companies | Comments and Views |
| Samsung | Ok to support both slot and symbol level beam indication. |
| Pivotal Commware | We support Option 1: Slot Level. We think Symbol level adds to much complexity. |
| Apple | Our first preference is symbol level indication, but additionally we are also fine with both slot level indication |

As agreed in RAN1#109e e-meeting, both semi-static and dynamic beam indication can be studied considering different NCR’s deployment scenario. Based on this agreement, [vivo, Sony, CATT, CMCC, Fujitsu, Xiaomi, Samsung] propose both semi-static and dynamic access link beam indication should be supported. Further, [CATT, Xiaomi, Samsung] highlights that semi-static configuration is indicated at least for broadcast transmission, while dynamic indication can be used for UE specific transmission.

As for the signaling of semi-static and dynamic indication, [xiaomi] mentions that at least RRC signaling can be used for semi-static beam indication, and dynamic signaling such as repeater control information can be used for dynamic beam indication.

Moreover, [CATT] propose that dynamic indication can override the semi-static configuration for broadcast transmission, while it cannot override the semi-static configuration for UE-specific transmission.

Then, from FL’s perspective, both dynamic and semi-static are recommended for beam indication as agreed in last meeting, additional details can be considered in 9.8.2 if any.

Companies are encouraged to share your views:

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| Companies | Comments and Views |
| Samsung | Ok to support both dynamic and semi-static beam indication. |
| Pivotal Commware | We support semi-static. We think dynamic would add complexity. |
| Apple | We support both dynamic and semi-static beam indication |

* ***gNB-NCR link (including c-link and backhaul link)***

In last meeting, it has been agreed that both fixed beam and adaptive beam can be considered for the C-link and backhaul link of NCR.

Considering the details for these two options, [Apple] mentions that the fixed beam can be regarded as baseline, and it can be hard coded or determined based on SSB and/or CSI-RS. For the adaptive beam indication, reusing legacy UE beamforming framework for NCR-MT can be considered [vivo, CATT, Samsung, sharp, Ericsson, IntelDigital, China Telecom, CEWit]. More specifically, the adopted legacy beam indication mechanism can be considered as following:

* Rel-15/16 beam indication mechanism should be adopted as basic assumption, while Rel-17 unified beam indication is an optional feature;
* [Samsung] proposes that both Rel-15/16/17 beam indication framework (i.e., unified TCI framework) can be considered
  + [Sharp] mentions that the same beam management’s methods in Rel-17 can be applied and reused for NCR C-link and backhaul link.

Regarding the implicit/explicit beam indication of NCR backhaul link, following views are shared by companies:

* [ CATT, NEC, Intel, Qualcomm, Apple, China Telecom] support that additional signaling is needed to indicate the beam information of backhaul link
* [Huawei, Nokia, MediaTek, Sharp, Ericsson, CAICT] support the implicit indication of backhaul link beam configuration.
* [ZTE,Vivo,Sony, Samsung, Lenovo, LG, Fujitsu, xiaomi, InterDigital, NEC, Intel] support both explicit and implicit scheme.

More specifically, [Samsung] highlights that for explicit indication, TCI ID or RS ID can be considered for beam indication of backhaul link. While for implicit indication mechanism, except follow the beam on C-link, a default beam can be considered[Fujitsu, xiaomi, Intel, LG, Ericsson, Vivo], e.g., beam for CORESET#0 [Fujitsu, xiaomi], the TCI state QCL’d with SSB identified by NCR-MT during initial access[Intel], the latest beam/TCI used by NCR-MT[Intel, LG], the most recent PDSCH TCI state[Ericsson], the DL beam of backhaul link can follow the configured TCI state for PDCCH or indicated TCI state for PDSCH on the control link, while the UL beam of backhaul link follows the UL beams of C-link.[Vivo]

Moreover, [NEC] mentions that a relationship between the beam of NCT-MT and backhaul beams of NCT-Fwd should be predefined or pre-configured. And though there is an agreement that the same assumption of beam correspondence is applied for DL/UL of the backhaul link at NCR-Fwd as the DL/UL of the C-link at NCR-MT, [Samsung] highlights that for backhaul link beam indication, and the case that the beam correspondence of NCR-Fwd does not hold should be considered. [CMCC] highlights that the self-interference issue should be considered for the beam determination and indication of backhaul link.

Then, from FL’s perspective, indication of beam for backhaul link seems necessary based on majority’s inputs. Details of signalling design can be considered in 9.8.2.

Companies are encouraged to share your views:

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| Companies | Comments and Views |
| Samsung | We are supportive of the indication of beam for backhaul link. |
| Pivotal Commware | We support fixed beam that can be hard coded, or OEM configured. If adaptive (we prefer “configurable” to “adaptive”), we support additional signalling to indicate the beam info.  Regarding reusing “legacy signalling” beamforming framework for NCR-MT: As we pointed out in our contribution R1-2205813, the legacy signalling would not be sufficient in NSA cases, nor in FR1 + FR2 SA cases. |
| Apple | We prefer fixed beam indication for backhaul link. However, if justified, we are also fine to consider adaptive beam indication as well. |

* ***Others***

The following aspects related to the beam information are also proposed by companies:

* [vivo] proposes to study the necessity to introduce beam restriction, to alleviate the potential interference due to the auto-excitation of NCR

For this issue, from FL’s perspective, it can be implemented by gNB’s scheduling on beam indication if the some beam are not preferred.

* [Qualcomm] proposes that multi-beam NCR operation, where NCR may be able to forward DL signals (or receive UL signals) to (or from) multiple beam directions on the access link, can be considered in RAN1.

From FL’s perspective, it’s up to the assumption on NCR’s capability as above.

Companies are encouraged to share your views:

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| Companies | Comments and Views |
| Samsung | Open to discuss multi-beam NCR operation. As mentioned by the FL proposal 1-3 for NCR capability, if the number of simultaneously operated beam reported by NCR is more than one, this aspect need to be considered. |
| Pivotal Commware | We think single beam would be a good start. As mentioned earlier, even many gNBs today do not have multi-beam capability. |
| Apple | As commented in one of our previous comments, we are also open to consider coverage region control by gNB to serve specific regions or avoid interference in certain regions. In our view, it is beneficial if gNB can configure NCR to have beams indicated within a specific coverage area. This would allow to also avoid unnecessary interference outside the desired coverage area. Otherwise, with logical beam indication, it will be completely up to NCR’s implementation |

# **Topic-2 ON-OFF information**

## **Company view (Round-1)**

For the ON-OFF information, potential solutions in either explicit or implicit ways are highlighted as below in RAN1#109e:

**Agreement**

*ON-OFF information is beneficial and recommended for network-controlled repeater to control the behaviour of NCR-Fwd.*

* *FFS: Detailed mechanism of ON-OFF indication and determination*
* *FFS: explicit indication or implicit indication of ON-OFF information*

**Agreement**

*The following options can be considered to indicate the ON-OFF information from gNB to NCR for controlling the behaviour of NCR-Fwd:*

* *Option 1: Explicit indication with on-off state (e.g., via dynamic or semi-static signalling) or on-off pattern (e.g., periodic/semi-static ON-OFF pattern or new DRX-like pattern for ON-OFF)*
* *Option 2: Implicit indication via the signalling for other information (e.g., beam, DL/UL configuration, or PC information)*
  + *Note: This example does not imply that PC information is necessary or not.*
* *Other solutions (e.g., potential combination of explicit and implication solution) can be further discussed.*

Agreement

*For indication of NCR-Fwd ON-OFF for efficient interference management and improved energy efficiency, both dynamic and semi-static indication can be considered*

* *FFS: RAN1 to consider whether/how to handle the forwarding of broadcast and cell-specific signals/channels.*

In this meeting, according to the contributions, following views are shared by companies to further prioritize the candidates including:

* [Nokia, Intel, CMCC, CAICT, vivo, Sony, Apple, Panasonic, NEC, Samsung, Fujitsu, LGE, Lenovo, InterDigital, CEWiT, IITK, ZTE] support explicit indication.
  + [Sony, CMCC, Apple, vivo, ZTE] support single or multiple on-off states indication
  + [vivo, Sony, CMCC, Lenovo] support explicit pattern based on-off indication
  + [Sony, Apple] support DRX-like indication
* [Huawei, Sony, Fujitsu, Interdigital, Panasonic, NEC, Xiaomi, China Telecom, Samsung, MediaTek, CEWiT, IITK, Qualcomm, Apple, LGE, Ericsson ] support implicit indication determined by other side control information:
  + Beam information: [Huawei, Sony, Xiaomi, China Telecom, MediaTek, Qualcomm, Apple, LGE, Ericsson]
  + Power control information: [Huawei, Panasonic, Sony]
  + TDD UL/DL information: [Sony]

Moreover, [LG, CATT, Interdigital] mentions that it is not desirable for NCR-Fwd to operate as always ON.

From FL’s perspective, both options can be considered to control the DL and UL behavior of NCR-Fwd in normative phase. In addition, as the default state for NCR-Fwd, to avoid unnecessary interference, the NCR-Fwd should be set as “OFF” until the reception of side control information.

***Proposal 2-1:*** *As the default state, the NCR-Fwd is expected to be “OFF” before the reception of indication for ON-OFF.*

Companies are encouraged to share your views.

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| Companies | Comments and Views |
| Samsung | Support.  The NCR is controlled by the gNB, so in the absence of any gNB indication, the NCR should be OFF. It can be further discussed whether dedicated gNB indication for ON/OFF is needed, or whether other indications can be used to determine ON/OFF. |
| Pivotal Commware | We are OK with Proposal 2-1. Support explicit pattern based on-off indication or explicit TDD UL-DL pattern. |
| Apple | In principle, we are fine with proposal, but would propose following update to capture both implicit and explicit indication:  ***Proposal 2-1:*** *As the default state, the NCR-Fwd is expected to be “OFF” , unless otherwise explicitly or implicitly configured/indicated by network* |

Regarding another leftover issue on how to handle the forwarding of broadcast and cell-specific signals/channels, [Huawei, vivo, Fujitsu] propose that the broadcast and cell-specific signals (e.g., SSB, PRACH)/channel forwarding can be always activated. Also, [LG, CATT, Interdigital] mentions that it is not desirable for NCR-Fwd to operate as always ON. From FL’s perspective, the forwarding of broadcast and cell-specific signal/channel can be either controlled by pre-defined pattern or by assumed to be ON always as pre-defined rule as listed in following proposal:

***Proposal 2-2:*** *Forwarding of broadcast and cell-specific signals/channels (e.g. SSB, PRACH, common DCI) by NCR-Fwd is controlled by following option:*

*Option-1: The NCR-Fwd’s behaviours over corresponding time domain resource is indicated by explicitly signalling*

*Option-2: The NCR-Fwd is assumed as “ON” over the corresponding time domain resource once the NCR-Fwd is “ON” from default state.*

Companies are encouraged to share your views.

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| Companies | Comments and Views |
| Samsung | Support to consider the two options, and suggest to add another option and an FFS as follows.  ***Proposal 2-2:*** *Forwarding of broadcast and cell-specific signals/channels (e.g. SSB, PRACH, common DCI) by NCR-Fwd is controlled by following option:*  *Option-1: The NCR-Fwd’s behaviours over corresponding time domain resource is indicated by explicitly signalling*  *Option-2: The NCR-Fwd is assumed as “ON” over the corresponding time domain resource once the NCR-Fwd is “ON” from default state.*  *Option-3: The NCR-Fwd is by default “ON” over the corresponding time domain resource, but the gNB can turn OFF the NCR-Fwd using semi-static or dynamic ON/OFF indication.*  *FFS: whether corresponding time resources include all SSB indexes or only SSB indexes that are configured/determined for NCR-Fwd operation.* |
| Pivotal Commware | Option 1 and 2 are both reasonable (to have timing for NCR FWD on-off), however, we do not understand Proposal 2-2 in how would NCR-FWD know how to differentiate been cell specific and other channels (other than having preconfigured timing to be on and off)?  Also, what would be the purpose of having NCR only forwarding SSBs/common signals and nothing else? |
| Apple | The intention of this proposal is a bit unclear to us. Why do we explicitly need to capture this only for broadcast and cell-specific channels/signals. Most likely, NCR may not need to know specifically which channel/signal is forwarded. |

Moreover, [Intel, China Telecom, OPPO] mention the time domain granularity of on-off information, where [Intel, OPPO] propose that the granularity of on/off can be symbol-level or slot-level, [China Telecom] proposes that slot-level ON-OFF indication can be considered and symbol-level ON-OFF indication is not supported. From FL’s perspective, following proposal can be considered:

***Proposal 2-3:*** *Slot-level on-off indication is supported for NCR-Fwd.*

Companies are encouraged to share your views

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| Companies | Comments and Views |
| Samsung | OK with the proposal |
| Pivotal Commware | Agree with Proposal 2-3. |
| Apple | In our view, both slot level and symbol level on-off should be supported. Especially for implicit ON-OFF indication, if we rely on beam indication and if we agree for both slot and symbol-level beam indication, then it should imply both symbol-level as well as slot-level on-off for NCR-Fwd as well |

Regarding others including:

* [Spreadtrum] highlights that the behavior of NCR-Fwd after receiving “OFF” control information, i.e., whether the “OFF” control information applies only to the UL or DL transmission of the NCR-Fwd or it applies to both UL and DL transmission should be specified firstly.
* [Samsung] supports RB-specific (or RB-group-specific) ON-OFF indication when considering the frequency domain resources.
* [Qualcomm] proposes that a repeater supporting multiple passbands may have the capability to selectively forward signals in different passbands, i.e, support frequency-selective forwarding (or frequency-selective ON-OFF information) should be further studied.
* [Ericsson] proposes that on-off state of NCR-Fwd can follow the RRC state of NCR-MT when NCR-MT is in inactive or idle state.

Companies are encouraged to share your views.

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| Companies | Comments and Views |
| Samsung | Open to discuss RB-group-specific / frequency-selective ON-OFF. From interference management perspective, it is preferred that gNB can control the ON-OFF state of the NCR-Fwd on different RB groups or passbands based on the configuration or scheduling decisions, to avoid amplification of noise and interference in non-scheduled RBs or passbands. |
| Pivotal Commware | RB selective or frequency selective forwarding would assume baseband processing. This adds to complexity, latency and of course cost. |
| Apple | We also support frequency-selective ON-OFF |

# **Topic-3 TDD configuration**

## **Company view (Round-1)**

For the TDD configuration, in RAN1#109e, the following agreement has achieved with pending FFS on the flexible symbols:

**Agreement**

*For the TDD UL/DL configuration of network controller repeater:*

* *At least semi-static TDD UL/DL configuration is needed for network-controlled repeater for links including C-link, backhaul link and access link.*
  + *FFS: handling of flexible symbols*
* *Note1: The same TDD UL/DL configuration is always assumed for backhaul link and access link*
* *Note2: The same TDD UL/DL configuration is assumed for C-link and backhaul link and access link if NCR-MT and NCR-Fwd are in the same frequency band.*

In this meeting, majority re-iterate that dynamic TDD via DCI is not preferred for the deployment of NCR since it increases signaling overhead, complexity and cost. However, [Fujitsu, Panasonic, CAICT, LGE] share the view that the NCR should be able to support both semi-static and dynamic slot configurations for flexible scheduling. Then, from FL’s perspective, based on the discussion in last meeting, we need to focus on the NCR’s behavior over flexible symbol. And regarding this topic, following views are shared by companies:

* Option 1: Unspecified NCR behavior or left to gNB/NCR implementation in flexible symbols
  + Support: Intel (unspecified NCR behavior as Rel-17 RF repeater), ETRI (by NCR implementation), MediaTek (blindly forward both DL and UL signals), Ericsson (up to the gNB to not schedule flexible symbols with conflicting indications in an NCR and associated UE)
* Option 2: Specify a default behaviour over flexible
  1. Alt-1: NCR forwarding is not required in flexible symbols:
     + Support: Fujitsu, CATT, CMCC, Apple, KDDI, ZTE
  2. Alt-2: NCR-Fwd is set to off
     + Support: Huawei/HiSilicon (OFF if not indicated by Option 3,Alt-1), vivo (OFF if not indicated by Option 3,Alt-1), LGE (OFF if not indicated by Option 3,Alt-1), Samsung (OFF if not indicated by Option 3, Alt-2), ETRI
* Option 3: Enable dynamic indication of DL/UL
  1. Alt-1: Further dynamically indicate them to a DL/UL direction
     + Support: Huawei/HiSilicon (DCI 2\_0), vivo (DCI 2\_0), LGE (DCI 2\_0 or SCI), Sony (DCI 2\_0 or new SCI), InterDigital (SCI), ETRI (DCI 2\_0), Sharp (SCI)
  2. Alt2: Indicate a DL/UL direction jointly with other side control information
     + Support: Qualcomm, Samsung ( jointly with a dynamic beam indication in a same L1/L2 signaling)

Among the above options, Option-1 is feasible but may introduce unexpected amplified noise/interference since no mandatory behavior of NCR’s defined. Regarding the Option-2, the alt-2 can be achieved if the OFF-state is explicitly over these symbols under same framework as highlighted in section-3. However, during these flexible, other operation including DL-UL switching, timing adjustment are also expected, which is different as behavior in purely OFF state. For Option-3, actually, it’s same as Dynamic TDD in either Alt-1 or Alt-2, as discussed before, the behavior is limited to enable the dynamic TDD. Then, From FL’s perspective, the Alt-1 in Option-2 can be considered as the baseline:

***Proposal 3-1:*** *For the flexible symbol, no forwarding behavior is expected for the NCR-Fwd over these symbols.*

Companies are encouraged to share your views and if there are concerns, please directly propose the corresponding updates.

|  |  |
| --- | --- |
| Companies | Comments and Views |
| Samsung | Do not support.  There is no such thing as “no forwarding behavior” for a Repeater. Once the NCR is ON, the NCR applies the amplification gain to any incoming signal – the NCR cannot select not to amplify-and-forward in certain symbols/slots when it is ON.  Alt-1 of Option 2 (set to OFF) can be considered as baseline, but it limits the gNB scheduling. When gNB decides to choose a flexible symbol for DL or UL scheduling, the gNB sends a DL scheduling assignment or an UL grant to the corresponding UE Accordingly, the gNB indicates the beamforming information to the NCR, so can jointly indicate the DL/UL link direction to the NCR. |
| Pivotal Commware | We support Proposal 3-1. Perhaps, this would be going back to semi-static: Define UL and DL symbols, or OEM configurable. Then, operator/OEM defines how they want to handle flex: maybe as UL only or DL only.  Turning NCR-FWD off during flex adds unnecessary tight switching mode times. |
| Apple | In our view, both the alt1 and alt 2 can be combined under option 2. Basically, for flexible symbols, no forwarding is expected and NCR-Fwd can be OFF. |

Regarding the proposal from [CEWiT/IITK] that in addition to providing the TDD configuration, the gNB should specify to which links (e.g., control link, backhaul link or access links) the TDD configuration is applicable. From FL’s perspective, it has already concluded that in RAN1#109e that same TDD configuration is always assumed for both backhaul and access link.

[Fujitsu, Ericsson, ZTE, Intel] also mentions that the TDD UL-DL configuration dedicated to NCR-Fwd is not necessary. From FL’s perspective, we can conclude it in 9.8.2.

Meanwhile, [Pivotal Commware, AT&T] highlights the issue of TDD configuration acquisition in three scenarios including EN-DC~~, N~~SA in same FR and ~~N~~SA in different FRs. [Intel] proposes that the NCR-Fwd has same large-scale property for backhaul links and control link(s) and same TDD configuration for different carriers. From FL’s perspective, since we already concluded to focus on the in band case in RAN#96, no additional optimization is expected in this release.

Companies are encouraged to share your views.

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| Companies | Comments and Views |
| Samsung | If Proposal 3-1 is adopted as is (Option 1 or 2), we prefer to support NCR-specific TDD configuration. |
| Pivotal Commware | As we mentioned in R1-2205813, it is important to recognize how would NCR get the tdd info. Having custom, NCR – geared DCI to communicate that info would be one solution, out-of-band/OEM/preconfiguring would be another. And then, there is a hybrid approach. |
| Apple | In our view, same TDD configuration can be assumed for all the NCR links and it can be cell-specific. |

# **Topic-4 Timing information**

## **Company view (Round-1)**

In RAN1#109e, there is following FFS on the impact of internal delay on the timing relationship of NCR-Fwd:

**Agreement**

For the timing of NCR, the following assumption is considered as baseline:

* The DL receiving timing of the NCR-Fwd is aligned with the DL receiving timing of the NCR-MT.
* The UL transmitting timing of the NCR-Fwd is aligned with the UL transmitting timing of the NCR-MT.
* FFS: the impact of internal delay on the following timing relationships:
  + The DL receiving timing and DL transmitting timing of the NCR-Fwd
  + The UL transmitting timing and UL receiving timing of the NCR-Fwd

Regarding this issue, [Huawei, ZTE, vivo, Fujitsu, NICT,CATT, Panasonic ,Intel, Lenovo, Apple, Ericsson] highlights that the DL transmitting timing and UL receiving timing of the NCR-Fwd is up to NCR’s implementation without extra signalling. [Huawei/HiSilicon, ZTE, vivo, Intel, Samsung, LGE] further highlight that the DL transmitting timing of the NCR-Fwd is the DL receiving timing of the NCR-Fwd adding with DL internal delay while the UL receiving timing of the NCR-Fwd is the UL transmitting timing of the NCR-Fwd subtracting with UL internal delay. In addition, [Samsung] proposes that the same internal delay for DL and UL can be assumed.

However, [Sharp] mention that some side information may be necessary for RACH procedure and separate TA adjustment at NCR.

Thus, from FL’s perspective, we can conclude that no additional signalling is expected to control the timing relationship due to the internal delay, and the following proposal is provided to describe the NCR-Fwd’s behaviour:

***Proposal 4-1:*** *For the timing of NCR, the following assumption can be considered and captured into TR 38.867.*

* *The DL transmitting timing of the NCR-Fwd is delayed after the DL receiving timing of the NCR-MT (or the NCR-Fwd) by the internal delay;*
* *The UL receiving timing of the NCR-Fwd is advanced before the UL transmitting timing of the NCR-MT (or the NCR-Fwd) by the internal delay.*
* *The same internal delay for DL and UL of the NCR-Fwd is assumed.*

Companies are encouraged to share your views and if there are concerns, please directly propose the corresponding updates.

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| Companies | Comments and Views |
| Samsung | Support the proposal. |
| Pivotal Commware | Support Proposal 4-1. |
| Apple | Support |

Meanwhile, many companies [Nokia, ZTE, Samsung, vivo, CEWiT/IITK,LGE, NTT DOCOMO] share the views that the internal delay information is necessary for the gNB configuring appropriate guard intervals needed for DL-UL switching and timing adjustment, so they support that the internal delay should be reported to the gNB.

Thus, from FL’s perspective, the following proposal is recommended:

***Proposal 4-2:*** *The value of internal delay is reported to the network as NCR capability.*

Companies are encouraged to share your views and if there are concerns, please directly propose the corresponding updates.

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| Companies | Comments and Views |
| Samsung | Support the proposal. |
| Pivotal Commware | Support the Proposal 4-2. |
| Apple | We are fine to consider the possibility of reporting internal delay by NCR |

# **Topic-5 Power control information**

## **Company view (Round-1)**

Regarding the power control, the essential remaining issue is whether to enable this feature for NCR in Rel-18. According to the inputs, it can be found that:

* [Huawei, Spreadtrum, ZTE, vivo, Fujitsu, CATT, CMCC, MediaTek, CEWiT, IITK, Qualcomm, Lenovo, LGE, KDDI, Ericsson(only for self-oscillation)] still prefer to support this feature for NCR, while [Sony, Intel, Samsung, NTT DOCOMO, Apple] prefer to deprioritize the power control information.
* [ZTE, Panasonic, Fujitsu, OPPO, CATT, KDDI] support the semi-static indication mechanism of amplifying gain, while [Huawei, NCE, ETRI] supports the dynamic power control. [LGE] supports both semi-static and dynamic power control.
* [Apple] highlights that it is beneficial to apply power control for both UL and DL, and common set of power control parameters or separate set of power control parameters can be considered. [vivo] mentions that power control based on the MT’s RSRP feedback on the C-link can be considered, assuming that C-link and backhaul link satisfy the average gain assumption.

Then, from FL’s perspective, following is proposed as trade-off:

***Proposal 5-1*** *Semi-static indication of power control information is beneficial and recommended to control the behaviour of NCR-Fwd for both DL of access-link and UL of backhaul-links.*

Companies are encouraged to share your views and if there are concerns, please directly propose the corresponding updates.

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| Companies | Comments and Views |
| Samsung | We do not support power control information as side control information by following reasons:  For coverage enhancement, we think it is not beneficial to increase gain for coverage which may cause additional interference. Coverage enhancement scheme in the spec is enough.  For interference management, gNB already has capability to combat interference.  For oscillation, we think passive and active cancellation technique can reduce the impact of oscillation. So, it can be left for implementation.  Therefore, we need more justification to introduce power control. |
| Pivotal Commware | We do not support Power Control as semi-static configurable parameter. We do support max gain/max EIRP as OEM/Operator/out-of-band configurable parameter.  As we pointed out in R1-2205813 through two examples (UL and DL) power control needs to act at a fast scale, and only NCR itself is in the position to accomplish that (such as, reduce gain immediately to mitigate oscillation). We also think it can be left to implementation. |
| Apple | We are fine to support the proposal |

Regarding the FFS in the agreement achieved in last meeting:

**Agreement**

*The controlling of the amplifying gain of NCR-Fwd is considered to enable the power control of NCR-Fwd if PC is recommended as side control information for NCR in Rel-18*

* *FFS: Controlling of the transmission power of NCR-Fwd*

[Huawei, ZTE, vivo, Fujitsu, MediaTek, LGE, KDDI] propose that amplifying gain control is sufficient and equivalent to transmission power control, so there is no need to additionally support amplifying gain control. However, [Spreadtrum, CMCC] still prefer to support both amplifying gain control and transmission power control.

From FL’s perspective, we can conclude that controlling of amplifying gain is sufficient for power control of repeater.

Companies are encouraged to share your views.

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| Companies | Comments and Views |
| Pivotal Commware | For the reasons already mentioned, we do not support outside control of NCR gain, but we support capping the gain or EIRP to what Operator considers desirable. So, OEM configurable parameter as max gain/max EIRP. |
| Apple | We are fine to consider amplifying gain for power control of repeater |

Meanwhile, other aspects related to the power control information are also proposed by companies including:

1. [Huawei, Panasonic, CEWiT, IITK, LGE] considers the beam specific power control information is beneficial. [Panasonic] mentions that a repeater should report the current transmission power on each beam/direction to the gNB to help the gNB to better schedule the UEs or avoid using certain beams. Besides, the repeater could be configured with minimum signal power threshold for each beam/direction, thus the repeater could identify the link failures and stops amplifying if the perceived power is below the threshold.
2. [Nokia] highlights that it may be beneficial for the NCR to indicate saturation and/or oscillation states to the parent gNB so that appropriate gain levels can be configured

In addition,

* Regarding [ETRI]’s proposal to capture the observation into TR 38.867, it has conducted by rapporteur in the last draft [R1-2206017](file:///C:\Users\younsun\Documents\3GPP%20documents\RAN1%20tdocs\TSGR1_110\Docs\R1-2206017.zip).
* Regarding [Qualcomm]’s propose to study the power control mechanisms of NCR-MT’s and remote UE’s UL signals in case of FDM-based transmission of UL of backhaul link and C-link, from FL’s perspective, legacy mechanism can be directly used if different RF chains are expected for C-link and F-link to enable the FDM-based transmission (e.g., as NCR’s capability). Otherwise, TDM-based is still the baseline as agreed in RAN1#109e.
* Regarding [Qualcomm]’s propose to enable the gNB should to determine the NCR’s output power operating region (gain-limited vs TX power-limited) for both backhaul and access links, from FL’s perspective, once the controlling of amplify gain is supported, the output power operation region can also be controlled.

Companies are encouraged to share your views on the necessity of above issues.

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| Companies | Comments and Views |
| Pivotal Commware | Regarding 1: NCR is transparent to UE. If signal is weak, UE will never act on or report that beam to gNB. Among beams NCR forwards, UE will pick the best one.  Regarding 2: This loop would be too slow to work efficiently. NCR must be able to deal w/ oscillation itself. |
|  |  |

# **Others**

In addition, some other aspects are highlighted by companies including:

* Issues-1: cost comparison cross different techniques
* [Source-1, Huawei] To achieve the same target coverage, NCR-based network deployment requires many more additional nodes than IAB-based network deployment. The equipment cost of NCR must be significantly lower than IAB node in order to be more cost efficient compare to IAB based deployment.
* [Source-2, ZTE] shown that lower cost can be achieved by deploying NCRs for coverage enhancement compared to IAB due to the lower equipment cost (e.g., <30%) and site cost (e.g., < 50% compared to IAB node).

From FL’s perspective, this aspect is out of scope and different views are shared among companies in previous discussion. Then, no additional action is expected.

* Issues-2: Multiple pass-band of NCR-Fwd.
* As highlighted that NCR-MT only has a single carrier in R18 [Fujitsu], while NCR-Fwd can support multiple carriers [Intel, LG, NEC]. [Spreadtrum] also highlights that architecture of Type 1-C repeater in the current specification can be regarded as NCR-Fwd, then the capability of processing two or more passbands simultaneously should be supported at least in FR1.

While [Sony] hold the opposite view that Multi-band NCRs and multi-FR NCRs are not studied in R18.

* In addition, [LG] highlights that whether side control information is indicated independently or commonly for the multi-carrier within same frequency band should be studied.

From FL’s perspective, we already concluded that for signalling design, we will focus on the in-band mode. If multiple pass-bands are available at NCR-Fwd, the potential forwarding behaviour at NCR-Fwd side can be done by implementation if same configuration, e.g., TDD, timing and beam, can be assumed cross all pass-band. No further optimization is expected in this release.

* Issues-3: Fallback mode of NCR

Regarding the operation mode of NCR, [Spreadtrum] proposes that the function of fallback mode from NCR to Rel-17 RF repeater should be supported in R18 NCR. When R18 NCR operates in fallback mode, NCR-MT is shut down by gNB and not expected to receive any side control information except mode switching signaling from gNB, and NCR-Fwd works as Rel-17 RF repeater without the control of NCR-MT.

From FL’s perspective, it can be achieved by implementation once the signalling design for SCI is concluded. The NCR can be configured to perform the amplifying and forwarding if the SCI is indicated via semi-static way. No further consideration is needed.

Companies are encouraged to share your views if any

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| Companies | Comments and Views |
| Pivotal Commware | Respectfully, for the fallback to Rel17 RF repeater, it is not only that NCR-MT is shut down. No intelligence whatsoever (including tdd UL-DL schedule) is assumed to be known or available to RF repeater (as per RAN4 WI). RF repeater is much simpler, as just grab-and-amplify, and generally transmits in both UL and DL direction, if there is an input/signal. So, the fallback would assume large architectural and HW changes.  Therefore, we oppose the fallback mandate. |
|  |  |

# **Proposals for discussion at GTW sessions**

# **Conclusion**

# **Appendix**

R1-2205813 Power Control and Side Control Information for NCRs Pivotal Commware, AT&T

R1-2205875 On the side control information and performance evaluation for NCR Huawei, HiSilicon

R1-2205939 Discussion on side control information to enable NR network-controlled repeaters Nokia, Nokia Shanghai Bell

R1-2206001 Discussion on side control information to enable NR network-controlled repeaters Spreadtrum Communications

R1-2206018 Discussion on side control information for NCR ZTE

R1-2206055 Discussion on side control information to enable NR network-controlled repeaters vivo

R1-2206128 Additional considerations on side control information to enable NR network-controlled repeaters Sony

R1-2206174 Discussion on side control information for NR network-controlled repeaters Fujitsu

R1-2206183 Discussions on side control information for NR network-controlled repeaters InterDigital, Inc.

R1-2206208 Side control information for network-controlled repeaters NICT and Toyota InfoTechnology Center

R1-2206330 Discussion on side control information for NCR OPPO

R1-2206413 Side control information to enable NR network-controlled repeaters CATT

R1-2206435 Discussion on side control information for network-controlled repeaters Panasonic

R1-2206478 Discussion on side control information to enable NR network-controlled repeaters NEC

R1-2206597 Discussion on Side control information to enable NR network-controlled repeater Intel Corporation

R1-2206656 Discussion on side control information to enable NR network-controlled repeaters Xiaomi

R1-2206698 Discussion on side control information for network-controlled repeaters China Telecom

R1-2206840 Side control information to enable NR network-controlled repeaters Samsung

R1-2206927 Discussion on side control information to enable NR network-controlled repeaters CMCC

R1-2206957 Discussion on side control information for network-controlled repeater ETRI

R1-2206981 Side control information for network-controlled repeaters MediaTek Inc.

R1-2207075 Discussion on Side control information to enable NR network-controlled repeaters CEWiT, IITK

R1-2207120 Discussion on side control information for NCR Rakuten Mobile, Inc

R1-2207127 Discussion on side control information to enable NCR operations Sharp

R1-2207247 On side control information for network controlled repeaters (NCR) Qualcomm Incorporated

R1-2207297 Discussion on side control information for network-controlled repeater Lenovo

R1-2207300 Discussion on side control information to enable NR network-controlled repeaters CAICT

R1-2207345 Discussion on side control information for NR network-controlled repeaters Apple

R1-2207366 Discussion on side control information for NCR LG Electronics

R1-2207420 Discussion on side control information to enable NR network-controlled repeaters NTT DOCOMO, INC.

R1-2207460 Discussion on side control information to enable NR network-controlled repeaters KDDI Corporation

R1-2207680 Control information for enabling NCR Ericsson