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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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where:

x the first digit:

1 presented to TSG for information;

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y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

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In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

The present document captures the findings from the study item "Study on NR Network-controlled Repeaters" [2].

The SI includes the study and identification of side control information (i.e., beamforming information, Timing information, information on UL-DL TDD configuration, ON-OFF information and power control information) for network-controlled repeaters and corresponding L1/L2 signaling (including its configuration) to carry the side control information. The scope of the study also includes the study on the aspects (i.e., identification and authorization) of network-controlled repeater management

The study on NR network-controlled repeaters is to focus on the following scenarios and assumptions:

- Network-controlled repeaters are inband RF repeaters used for extension of network coverage on FR1 and FR2 bands, while during the study FR2 deployments may be prioritized for both outdoor and O2I scenarios.

- For only single hop stationary network-controlled repeaters

- Network-controlled repeaters are transparent to UEs

- Network-controlled repeater can maintain the gNB-repeater link and repeater-UE link simultaneously

NOTE1: Cost efficiency is a key consideration point for network-controlled repeaters.

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP RP-213700: " New SI: Study on NR Network-controlled Repeaters ".

[3] 3GPP TR 38.380: "Study on NR coverage enhancements".

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

NCR Network-controlled repeater

NCR-MT NCR-Mobile termination

NCR-Fwd NCR-Forwarding

C-link Control link

# 4 Introduction

Coverage is a fundamental aspect of cellular network deployments. Mobile operators rely on different types of network nodes to offer blanket coverage in their deployments. Deployment of regular full-stack cells is one option but it may not always be possible (e.g., no availability of backhaul) or economically viable.

As a result, new types of network nodes have been considered to increase mobile operators' flexibility for their network deployments. For example, Integrated Access and Backhaul (IAB) was introduced in Rel-16 and enhanced in Rel-17 as a new type of network node not requiring a wired backhaul. Another type of network node is the RF repeater which simply amplify-and-forward any signal that they receive. RF repeaters have seen a wide range of deployments in 2G, 3G and 4G to supplement the coverage provided by regular full-stack cells. In Rel-17, RAN4 specified RF and EMC requirements for such RF repeaters for NR targeting both FR1 and FR2.

While an RF repeater presents a cost effective means of extending network coverage, it has its limitations. An RF repeater simply performs an amplify-and-forward operation without being able to take into account various factors that could improve performance. Such factors may include information on semi-static and/or dynamic downlink/uplink configuration, adaptive transmitter/receiver spatial beamforming, ON-OFF status, and so on.

A network-controlled repeater is an enhancement over conventional RF repeaters with the capability to receive and process side control information from the network. Side control information could allow a network-controlled repeater to perform the amplify-and-forward operation in a more efficient manner. Potential benefits could include mitigation of unnecessary noise amplification, transmissions and receptions with better spatial directivity, and simplified network integration.

# 5 Modelling of network-controlled repeater

The Network-controlled repeater is modelled as Figure 5-1, which includes the NCR-MT and NCR-Fwd.

The NCR-MT is defined as a function entity to communicate with a gNB via a Control link (C-link) to enable exchange of control information (e.g. side control information at least for the control of NCR-Fwd). The C-link is based on NR Uu interface.

The NCR-Fwd is defined as a function entity to perform the amplify-and-forwarding of UL/DL RF signal between gNB and UE via backhaul link and access link. The behavior of the NCR-Fwd will be controlled according to the received side control information from gNB.



Figure 5-1: Conceptual model of network-controlled repeater

Additionally, at least one of the NCR-MT's carrier(s) should operate in the frequency band forwarded by the NCR-Fwd. And the NCR-MT and NCR-Fwd operating in the same frequency band is prioritized for the study.

As baseline, same large-scale properties of the channel, i.e., channel properties in Type-A and Type-D (if applicable), are expected to be experienced by C-link and backhaul link (at least when the NCR-MT and NCR-Fwd are operating in same frequency band).

For the transmission/reception of C-link and backhaul link by NCR,

- The DL of C-link and DL of backhaul link can be performed simultaneously or in TDM way

- The UL of C-link and UL of backhaul link can be performed in TDM way.

The multiplexing is under the control of gNB with consideration for NCR capability and simultaneous transmission of the UL of C-link and UL of backhaul link is also subject to NCR capability

# 6 Side control information

## 6.1 Beam information

For the backhaul link and C-link, both fixed beam and adaptive beam can be considered at NCR, where the fixed beam refers to the case that beam at NCR for both C-link and backhaul-link cannot be changed. Beam correspondence is assumed to apply for DL/UL of the backhaul link at NCR-Fwd, as well as the DL/UL of the C-link at NCR-MT.

As a baseline, the same TCI states as C-link are assumed for beams at NCR-Fwd for backhaul link if the NCR-MT's carrier(s) is operating within the frequency band forwarded by the NCR-Fwd. In case that the adaptive beams are adopted for C-link and backhaul link, the indication and determination of beams of backhaul link can be achieved by:

- Option 1: The beam of backhaul link is indicated by a new signaling. The new signaling is dynamic signaling and/or semi-static signaling (e.g., RRC signaling/ MAC CE) indicating a beam(s) from the set of beams of the C-link. This does not imply that the beam of backhaul link is always indicated by the new signaling

- Option 2: The beam of backhaul link is determined by a pre-defined rule, e.g., in slots/symbols with simultaneous DL receptions / UL transmissions in both C-link and backhaul link, the beam of backhaul link is the same as the beam of C-link. Otherwise, the beam of backhaul link follows one of the beams of the C link.

Other predefined rules are not precluded.

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

Regarding the access link beam indication, the beam of access link for NCR-Fwd is indicated by a beam index where both dynamic indication and semi-static indication, including semi-persistent indication, are considered

The time domain resource corresponding to an access link beam is explicitly determined based on the explicitly indicated time domain resources per beam indication. A single beam indication can indicate one or multiple beams. Different parameters may be indicated for semi-static or dynamic beam indication.

Beam correspondence is assumed for the DL/UL of the access link at NCR-Fwd, i.e., a DL beam and a UL beam on the access side which correspond to each other have the same beam index. The forwarding direction of an indicated beam in access link can be determined based on its corresponding time domain resource and the UL/DL TDD configuration. The forwarding behaviour (or the forwarding direction) of an indicated beam in access link in flexible symbols is separately discussed in clause 6.3.

## 6.2 Timing information

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

- The DL receive timing of the NCR-Fwd is aligned with the DL receive timing of the NCR-MT.

- The UL transmit timing of the NCR-Fwd is aligned with the UL transmit timing of the NCR-MT.

- The DL transmit timing of the NCR-Fwd is delayed after the DL receive timing of the NCR-MT (or the NCR-Fwd) by an internal delay;

- The UL receive timing of the NCR-Fwd is advanced before the UL transmit timing of the NCR-MT (or the NCR-Fwd) by an internal delay.

It is concluded that legacy UE mechanism is sufficient to achieve DL/UL timing for NCR-MT.

## 6.3 Information on UL-DL TDD configuration

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. On the flexible symbols based on the semi-static configuration (e.g., TDD-UL-DL-ConfigCommon, TDD-UL-DL-ConfigDedicated), the following behaviours of the NCR-Fwd are considered:

- Option 1: The NCR-Fwd is expected to be OFF or not forwarding over these symbols

- Option 2: The NCR-Fwd will follow the TDD operation determined by NCR-MT, i.e., determined by NCR-MT based on the received SFI indication or scheduling from gNB. It means that no new side control signalling is needed.

- Option 3: The NCR-Fwd will follow a new dynamic side control signalling of DL/UL forwarding over these symbols to NCR-Fwd

The same TDD UL/DL configuration is always assumed for backhaul link and access link. Additionally, the same TDD UL/DL configuration is assumed for C-link, backhaul link and access link if NCR-MT and NCR-Fwd operate in the same frequency band.

## 6.4 ON-OFF information

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

The NCR-Fwd is always expected to be "OFF" unless otherwise explicitly or implicitly indicated by the gNB. This applies regardless of the RRC state of NCR-MT. Indication (e.g., received when NCR-MT in RRC-connected) or DRX state of NCR-MT to control the ON-OFF behaviour of NCR-Fwd when the NCR-MT is in RRC-idle/inactive is not precluded.

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 side-control information (e.g., beam, DL/UL configuration, or PC information). It should be noticed that 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 in normative phase.

## 6.5 Power control information

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.

# 7 L1/L2 signalling for side control information

## 7.1 Signalling for side control information

### 7.1.1 Signalling for beam information

From the perspective of signaling design, both dynamic beam indication and semi-static beam indication are recommended for access link. The semi-static beam indication includes the semi-persistent indication.

The time at which the NCR applies an access link beam indication should be considered.

As for the time-domain granularity of the access link beam indication and determination, both slot-level and symbol-level granularity are recommended.

### 7.1.2 Signalling for timing information

For the signaling of the side control information of timing to align transmission/reception boundaries at the NCR, new signaling is unnecessary.

### 7.1.3 Signalling for UL-DL TDD configuration

For the signaling of information on UL-DL TDD configuration, if the NCR-MT can acquire its TDD configuration as legacy UEs or from OAM, new signaling may not be necessary. The same TDD UL/DL configuration is assumed for C-link and backhaul link and access link if the NCR-MT and the NCR-Fwd are in the same frequency band. Other cases, where new signaling may be necessary, can be discussed in normative phase.

### 7.1.4 Signalling for ON-OFF information

For an indication of NCR-Fwd ON-OFF for efficient interference management and improved energy efficiency, both dynamic and semi-static indication can be considered. Whether/how to handle the forwarding of broadcast and cell-specific signals/channels can be discussed in normative phase.

### 7.1.5 Signalling for power control information

Void

## 7.2 Configuration of signalling

For the configuration of signalling, the NCR-MT can obtain the necessary configuration for receiving the L1/L2 signaling of the side control information.

- Option 1: The necessary configuration is from RRC.

- Option 2: The necessary configuration is from OAM or hard-coded.

- Option 3: The necessary configuration is partially configured by RRC and partially configured by OAM or hard-coded.

The necessary configurations from RRC and/or OAM (or hard-coded) contain:

- The configurations of PHY channels to carry the L1/L2 signaling including

- The configurations for receiving PDCCH and PDSCH.

- The configurations for transmitting PUCCH, if needed.

- The configurations for transmitting PUSCH, if needed.

- The configurations of L1/L2 signaling including

- The configurations for DCI.

- The configurations for UCI, if needed.

- The configurations for MAC CE, if needed.

For the parameters in the necessary configurations for L1/L2 signaling, the existing parameters for PDCCH, PDSCH, PUCCH, PUSCH, DCI, UCI and MAC CE in Rel-17 are the baseline for further discussion.

# 8 Repeater management

## 8.1 Solution on repeater management

### 8.1.1 Solution 1

In this solution, the identification and authorization/validation of NCR device are done at RAN side. The general procedure of the solution 1 is illustrated in below figure:



Figure 8.1.1-1. Call flow for solution 1

Sequence of this solution:

1. The NCR firstly accesses to RAN and CN as a normal UE, no additional impact to NG-C interface. For example, the operator can allocate specific slice for NCR, and further identify the NCR based on the slice information. After authorized the NCR, the CN provides dedicated Allowed NSSAI to the gNB. Based on this information, the gNB be aware the NCR is authorized.

2. NCR identification can be implemented by reporting an NCR indicator in Msg5 (in addition to sending any NCR-related radio capability) and/or by reporting an NCR indicator (implicitly or explicitly) in UE's radio capability signaling.

3. If required, NCR validation is used to further check the validity of NCR, the details can be further discussed in normative phase. After AS security is established between the gNB and the NCR device, the NCR sends NCR credential information for NCR validation to the gNB via RRC message (e.g. UE Assistance Information). The NCR credential information are pre-allocated by the operator. After receiving the NCR credential information, the gNB validates the NCR device by checking its local stored information.

The validation steps (e.g. step 12 and step 13) are optionally performed based on the operator's requirement.

### 8.1.2 Solution 2

In this solution, the NCR is identified at RAN side and the authorization/validation are performed by local RAN OAM. CN is absent in this solution. The general procedure of the solution is illustrated in below figure:



Figure 8.1.2-1. Call flow for solution 2

Sequence of this solution:

1. NCR establishes RRC connection based on legacy signaling procedure (Msg1~Msg5), but the gNB will not establish NGAP signaling association for the NCR.

2. NCR identification can be implemented by reporting an NCR indicator in Msg5.

3. Different from Msg5 sent by a normal NR UEs, an OAM container is included in Msg5 and there is no NAS container. Based on the NCR indicator, the gNB applies NCR-specific handling, e.g. not to establish the NGAP association and forwards the OAM container to OAM.

4. The NCR authorization and validation is then performed between OAM and NCR. The information exchanged between OAM and NCR can be leveraged by an OAM container. Over Uu interface, the OAM container can be transferred via RRC message or via a DRB (which without PDU session). The security of OAM traffic can be provided by application layer security mechanism, such as SSH/TLS between the NCR and OAM. (Note that, the procedure for authorization/validation in OAM can be either specified or left to implementation)

### 8.1.3 Solution 3

In this solution, NCR identification is done at RAN side, and NCR authorization is done at CN side, similar to the handling of IAB-MT. The general procedure of the solution is illustrated in below figure:



Figure 8.1.3-1. Call flow for solution 3

Sequence of this solution:

1. During NG-C setup procedure, the AMF should inform the gNB whether it supports NCR, e.g. by including "NCR-supported" indicator in NG SETUP RESPONSE message.

2. NCR establishes RRC connection and NCR identification can be implemented by reporting an NCR indicator in Msg5 (in addition to sending any NCR-related radio capability) and/or by reporting an NCR indicator (implicitly or explicitly) in UE's radio capability signaling. The gNB selects an AMF which supports NCR function, and forwards the NCR indicator to the AMF.

3. AMF and other CN entities do further authorization, and provides "NCR authorized" to the gNB.

### 8.1.4 Solution 4

In this solution, NCR authorization is performed at CN side. The NCR authorization information is sent from the AMF to the gNB. Similarly to the handling of e.g. D2D, V2X, it seems appropriate for NCR authorization information to come from the UE subscription information in the 5GC (a trusted source of information). This information would be stored in the gNB in the UE context for the NCR-MT.The general procedure of this solution is illustrated in below figure:



Figure 8.1.4-1 Call flow for solution 4

Sequence of this solution:

1. The NCR first accesses the network as a normal UE.

2. AMF authorizes the NCR and sends the indication to gNB in the UE CONTEXT SETUP REQUEST message.

## 8.2 Specification impacts

The specification impacts for each solution are listed in Table 8.2-1.

 Table 8.2-1. Comparison of solutions.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Uu impact | RAN OAM impact | NG-C/NAS impact (Yes/No) | Authorization entity(RAN/ CN/OAM) | Support of full protocol stack in control plane (RRC, NAS)(Yes/No) | Inter-vendor interoperability | Security |
| Solution 1 | Yes1. Add NCR indicator in Msg5 and/or UE radio capability;2. Add NCR credential information in a UL RRC message (FFS on which RRC message) | NoNO: If NCR validation is not secured.YES: If secure NCR validation is needed. | No | CN(Uses slicing signaling to convey authorization information) | Yes | Yes | Uu uses legacy securityOptionally, NCR validation needs to be performed in RAN. |
| Solution 2 | Yes1. Add NCR indicator and OAM container in Msg5;2.a If RRC signalling is used for OAM traffic, add OAM container in UL RRC message (FFS on which RRC message, FFS on the need of DL RRC message).2.b If DRB is used for OAM traffic, define a new DRB type (e.g. not associated with PDU session).3. Further details on procedures impacts due to not having NAS are FFS and will be discussed in a potential WI. | YesRequires new OAM connectivity mechanism over RRC with NG-NR proxy function. | No | OAM | NoNAS is not needed for control plane | No(Whether a specific OAM for NCR is needed belongs to deployment implementation based on Operator's policy.) | No security on Uu.NCR authorization and validation needs to be secured via OAM. |
| Solution 3 | Yes1. Add NCR indicator in Msg5 and/or UE radio capability; | No | YesNCR-indication and authorization via NG-CNo NAS impact | CN | Yes | Yes | Uu uses legacy securityCN provides secure NCR validation.  |
| Solution 4 | No | No | Yes No NAS impactNCR authorization via NG-C | CN | Yes | Yes | Uu uses legacy securityCN provides secure NCR validation. |

Note: The remaining FFS will be addressed in normative phase.

# 9 Performance evaluation

Though there is no commonly agreed set of simulation assumptions in the study, in order to study side control information for NCR, evaluations have been performed in the submitted contributions and the following are observed:

- For access link beam information:

- For FR2:

- [R1-2203237] shows that the NCRs with beam information can improve the SINR performance for UEs especially at 5%-tile, 50%-tile SINR. Meanwhile, compared to the conventional RF repeater, the additional interference due to the introduction of repeater can be mitigated for the UEs with above 95%-tile SINR.

- [R1-2203578] shows that the SINR performance of the UEs is improved compared with the case when there is no repeater when the NCR-Fwd beam is fixed to steer towards the cell edge. For cell edge UEs, the SINR gain is 2.3 dB for the 10%-tile SINR. When the NCR-Fwd beam is steering dynamically towards the UE, the SINR performance of the UEs is further improved compared to the case of the fixed NCR-Fwd beam. For cell edge UEs, the SINR gain is about 6.3 dB for the 10%-tile SINR.

- [R1-2203921] shows that by introducing repeaters with beamforming, 2.34 dB, 6.15 dB, and 6.53 dB gain can be achieved at 5%-tile, 50%-tile, and 95%-tile SINR compared to the case of NR system without repeaters, respectively. In addition, 2.03 dB, 5.18 dB, and 6.53 dB gains at 5%-tile, 50%-tile, and 95%-tile SINR can be achieved compared to the case with conventional repeaters, respectively.

- [R1-2204653] shows that performance gain on SINR can be achieved by introducing semi-static repeater gain/power configuration, and additional performance gain can be achieved by introducing dynamic repeater gain/power configuration. More than 5 dB gain can be further achieved by using large SCI payload for beam control for large NCR-Fwd antenna configuration.

- [R1-2205047] shows that adaptive access-link beamforming will offer performance gain by providing a larger beamforming gain and reducing the interference due to use of narrower beams, e.g., the median SINR can improve by 11dB.

- [R1-2206927] shows that the NCR with beamforming has SINR gains over gNB only and conventional RF repeater. Compared with gNB only, NCR has SINR improvements of about 1.42 dB, 1.44 dB, and 3.06 dB at 5%-tile, 50%-tile, and 95%-tile SINR. NCR could improve the coverage compared with gNB only and deployment with conventional RF repeaters.

- [R1-2206055] shows that the SINR performance of the UEs is further improved compared with the case of the fixed NCR-Fwd access link beam when the NCR beam is set adaptively towards the serving UE. Especially for the cell edge UE, the UL SINR gain is about 6.3 dB at 10%-tile of CDF and DL SINR gain is 8 dB for 10%-tile of CDF.

- [R1-2205875] shows that based on the evaluation methodology defined for NR coverage enhancements [3], the performance of NCR is evaluated for FR2 assuming a target data rates of 25 Mbps for DL and 5 Mbps for UL, target ISD of 200m, gNB EIRP of 65 dBm, UE EIRP of 29 dBm, NCR with DL EIRP of 40 dBm and gain of 90 dB. The achieved ISD by gNB only can be up to 140×√3=242m for DL, and 100×√3=173m for UL. With NCR, the DL coverage can be extended to an ISD of 175×√3=300m, and the UL coverage can be extended to an ISD of 135×√3=233m.

- For FR1:

- [R1-2206018] shows that with indicated beam information, the SINR performance on FR1 in the O2I scenario are improved with around 5dB for 5%-tile SINR and 2dB for 50%-tile SINR after the deployment of NCR over gNB only, and NCR provides SINR gain compared to conventional RF repeater in all cases. According to the deterministic simulation based on Ray-tracing (RT) with realistic outdoor maps, NCRs with beam information can also improve the SINR performance on FR1 with 3dB gain for 5%-tile SINR and around 7 dB gain for the minimum value of SINR over gNB only.

- [R1-2206957] shows that NCR can provide SINR gains for more than 80% of indoor UEs in case that side control information (SCI as defined in clause 6.1) with 4 bits are used for beam information compared to the conventional repeater while the UE SINR with gNB only case (from 0%-tile SINR to 40%-tile SINR) is around 1 dB better than the case with either NCR or conventional repeaters.

- [R1-2205875] shows that based on the evaluation methodology defined for NR coverage enhancements [3], the performance of NCR is evaluated for FR1 assuming a target data rates of 10 Mbps for DL and 1 Mbps for UL, target ISD of 500m, gNB EIRP of 70 dBm, UE EIRP of 26 dBm, NCR with DL EIRP of 32 dBm and gain of 65 dB. The achieved ISD by gNB only can be up to m for both UL and DL. The target coverage for FR1 can be achieved with BS only.

- For the ON-OFF information used to control the ON-OFF behaviour of NCR-Fwd:

- [R1-2203237] shows that NCRs with ON-OFF information can mitigate the interference for high SINR UEs while maintain the performance of low SINR UEs, and also ON-OFF information can provide efficient interference management in FR1.

- [R1-2203578] shows that about 9.8dB gain can be achieved for the 10%-tile UEs on the SINR performance after introducing ON-OFF indication.

- [R1-2203921] shows that additional gain is observed for the repeater by both applying beamforming and on/off management compare to the NR system with the repeater only applying beamforming.

- [R1-2205047] shows that about 2 dB gains on median SINR can be achieved by introducing dynamic on-off information.

- For the power control information used to control the behaviour of NCR-Fwd for the DL of access link and/or UL of backhaul link:

- [R1-2203133] shows that for the uplink transmission via NCR, a fixed NCR amplifying gain may lead to interference to the gNB or NCR UL coverage loss. For the downlink transmission via NCR, a fixed NCR amplifying gain may lead to NCR-Fwd saturation or NCR DL coverage loss.

- [R1-2203578] shows that the optimal system performance can be achieved when repeater's gain is set to a proper value.

- [R1-2204653] shows that dynamic repeater gain/power control can provide additional SINR gain over semi-static repeater gain/power configuration.

- [R1-2204642] shows that the gain control is needed for self-interference management due to repeater oscillation.

10 Conclusion

RAN1 has studied the side control information for NCR with corresponding signalling (including its configuration). The SI phase is completed in RAN1 and the following are recommended to be specified as part of Rel-18 NCR WI from RAN1's perspective:

- Beam information as side control information

- ON-OFF information as side control information

- UL-DL TDD configuration and NCR's behaviour over flexible symbols.

Based on RAN3 analysis, the 4 candidate solutions may be further discussed pending confirmation from SA3 and SA5. With the captured content in TR38.867, RAN3 believe the SI phase is completed.

Based on RAN2 analysis, early identification (via Msg1 or Msg3) for NCR is not needed. From security point of view, the feasibility of NCR validation procedure in solution 1 and the feasibility of solution 2 will be decided by SA3 in potential WI. With the captured content in TR38.867, RAN2 believe the SI phase is completed. Down selection of all captured solutions may take place in potential WI phase based on the feedback from other groups.

Annex A:
Cost evaluations

Two companies provided cost analysis results for network controlled repeaters in [[R1-2205875](file:///C%3A%5CUsers%5Cyounsun%5CDocuments%5C3GPP%20documents%5CRAN1%20tdocs%5CTSGR1_110%5CDocs%5CR1-2205875.zip)] and [[R1-2206018](file:///C%3A%5CUsers%5Cyounsun%5CDocuments%5C3GPP%20documents%5CRAN1%20tdocs%5CTSGR1_110%5CDocs%5CR1-2206018.zip)]. Note that there was no RAN1 conclusion or observation with reference to cost analysis of network controlled repeaters.

Annex B:
Change history

|  |
| --- |
| **Change history** |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2022-05 | RAN1#109e | R1-2205231 |  |  |  | TR Skeleton | 0.0.0 |
| 2022-05 | RAN1#109e | R1-2205496 |  |  |  | Capture the agreement in RAN1#109e | 0.1.0 |
| 2022-08 | RAN1#110 | R1-2208314 |  |  |  | Capture the agreement in RAN1#110 with conclusion for RAN1; Capture the endorsed TP from RAN3 and RAN2  | 0.2.0 |
| 2022-09 | RAN#97e | RP-222323 |  |  |  | For one step approval to RAN#97e plenary | 1.0.0 |
| 2022-09 | RAN#97e |  |  |  |  | TR under change control further to RAN approval as part of Rel-18 | 18.0.0 |