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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

Next Generation Networks – Frameworks and functional architecture models

Distributed service networking relay functions

Recommendation ITU-T Y.2082

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ITU-T Y-SERIES RECOMMENDATIONS

GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

GLOBAL INFORMATION INFRASTRUCTURE	
General	Y.100–Y.199
Services, applications and middleware	Y.200–Y.299
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899
INTERNET PROTOCOL ASPECTS	
General	Y.1000–Y.1099
Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	Y.1300–Y.1399
Interworking	Y.1400–Y.1499
Quality of service and network performance	Y.1500–Y.1599
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	Y.1700–Y.1799
Charging	Y.1800–Y.1899
IPTV over NGN	Y.1900–Y.1999
NEXT GENERATION NETWORKS	
Frameworks and functional architecture models	**Y.2000–Y.2099**
Quality of Service and performance	Y.2100–Y.2199
Service aspects: Service capabilities and service architecture	Y.2200–Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250–Y.2299
Enhancements to NGN	Y.2300–Y.2399
Network management	Y.2400–Y.2499
Network control architectures and protocols	Y.2500–Y.2599
Packet-based Networks	Y.2600–Y.2699
Security	Y.2700–Y.2799
Generalized mobility	Y.2800–Y.2899
Carrier grade open environment	Y.2900–Y.2999
FUTURE NETWORKS	Y.3000–Y.3499
CLOUD COMPUTING	Y.3500–Y.3999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T Y.2082

Distributed service networking relay functions

Summary

Recommendation ITU-T Y.2082 specifies the architecture for relay function (RF), in support of application layer routing optimization for performance improvement and network address translation (NAT)/firewall traversal in the environment of distributed service networking (DSN) as described in Recommendation ITU-T Y.2080.

Application layer routing optimization means the usage of application layer relays to change the route of data packets. Considering the case that the default transport layer route is congested, better performance can be achieved through application layer routing optimization.

The main objectives of this Recommendation are to specify:

- Functional entities of RF
- Information flows related to RF
- Reference points related to RF.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.2082	2013-08-13	13	11.1002/1000/11974-en

Keywords

Distributed service networking, DSN, functional architecture, relay, relay function, RF.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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Table of Contents

Recommendation ITU-T Y.2082

Distributed service networking relay functions

1 Scope

This Recommendation specifies relay function (RF) support for network address translation (NAT)/firewall traversal and application layer routing optimization for service performance improvement in distributed service networking (DSN). Furthermore, it defines functional entities of RF, information flows related to RF, and detailed reference point descriptions related to RF.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Y.2080] Recommendation ITU-T Y.2080 (2012), *Functional architecture of distributed service networking*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 control node [b-ITU-T Y.2000-series Sup.10]: A DSN node which provides service control functionalities.

3.1.2 distributed service networking (DSN) [b-ITU-T Y.2206]: An overlay networking which provides distributed and manageable capabilities to support various multimedia services and applications.

3.1.3 DSN node [b-ITU-T Y.2206]: A node used in DSN providing distributed functionalities, including distributed routing and distributed storage.

3.1.4 network address translation (NAT) [b-ITU-T Y.2111]: The operation by which IP addresses are translated (mapped) from one address domain to another address domain.

3.1.5 point of presence (POP) [b-ITU-T Y.2081]: A point representing one or several DSN nodes, which supports DSN users in accessing services directly without having intermediate DSN nodes.

3.1.6 reference point [b-ITU-T Y.2012]: A conceptual point at the conjunction of two non-overlapping functional entities that can be used to identify the type of information passing between these functional entities.

3.1.7 relay node (RN) [ITU-T Y.2080]: A DSN node which relays data packets in order to improve node reachability and quality of service (QoS) by changing the original route of the packets. The data can be voice data, video data, etc.

3.1.9 user profile [ITU-T Y.2080]: In the context of the DSN functional architecture, a collection of information that specifies the subscribed services and access privileges related to a DSN service user. The data in the user profile is called user profile data.

NOTE – A user profile may include the following attributes: user ID and other data related to authentication and authorization, user preferences, service status, service class, usage and/or contribution information, or subscriber accounting characteristics, etc.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 functional entity: An entity that comprises an indivisible set of specific capabilities. Functional entities are logical concepts, while groupings of functional entities are used to describe practical, physical implementations.

3.2.2 relay: A procedure to forward data packets from one entity to another entity according to a given policy.

NOTE – In the context of this Recommendation, relay is used to achieve NAT/firewall traversal and QoS improvement.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

DSN Distributed Service Networking

EF End-user Functions

ID Identifier

MMTel Multimedia Telephony

NAT Network Address Translation

POP Point Of Presence

RF Relay Functions

RLF Resource Location Functions

RN Relay Node

RT-FE Relay Transport Functional Entity

RTT Round Trip Time

SCF Service Control Functions

TOCF Traffic Optimization Control Functions

TQM-FE Transport Quality Measurement Functional Entity

UE User Equipment

5 Conventions

The following conventions apply:

1) The meaning of Functions is as follows:

Functions: In the context of DSN architecture, "Functions" are defined as functional groups composed of functional entities. It is represented by the following symbol:

Functions

6 Overview of relay functions

RFs support relaying of particular application traffic for DSN nodes to achieve NAT/firewall traversal and quality of service (QoS) improvement. One or more relay node (RN) entities can be inserted into the data path to improve network performance. RF supports the following functions:

- NAT or firewall traversal

  When one or more DSN nodes involved in DSN service are behind the NAT/firewall, RF can be used to support NAT/firewall traversal enabling those DSN nodes to communicate with other DSN nodes.

- Routing optimization

  When the default route cannot meet the desired QoS requirements for DSN services, communicating parties can set up an alternative data path through RNs to improve network performances, e.g., packet loss rate, delay, jitter. It is also possible to set up multiple data paths through RNs to provide backups in case the main path is interrupted or congested.

Figure 6-1 shows the position of RF in DSN functional architecture as defined in [ITU-T Y.2080].

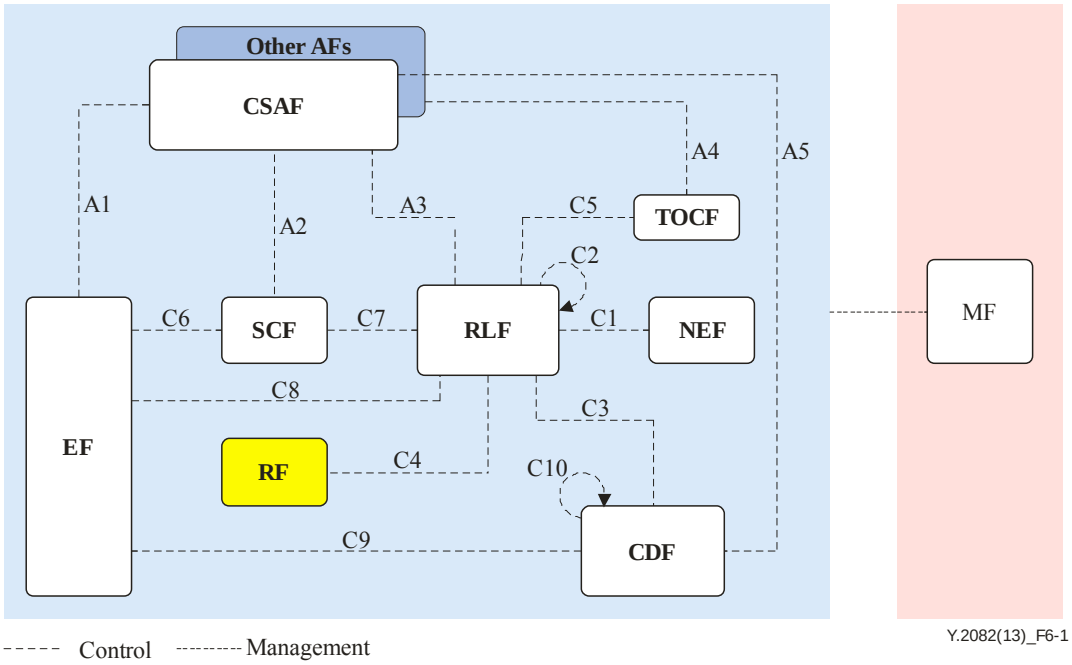

Figure 6-1 – The position of RF in DSN functional architecture

7 RF functional architecture

7.1 Architecture framework

Figure 7-1 describes the RF functional architecture with functional entities and relevant reference points. RF consists of the following FEs:

- RT-FE (relay transport functional entity).
- TQM-FE (transport quality measurement functional entity).

The detailed functions of RT-FE and TQM-FE are described in clause 7.2.

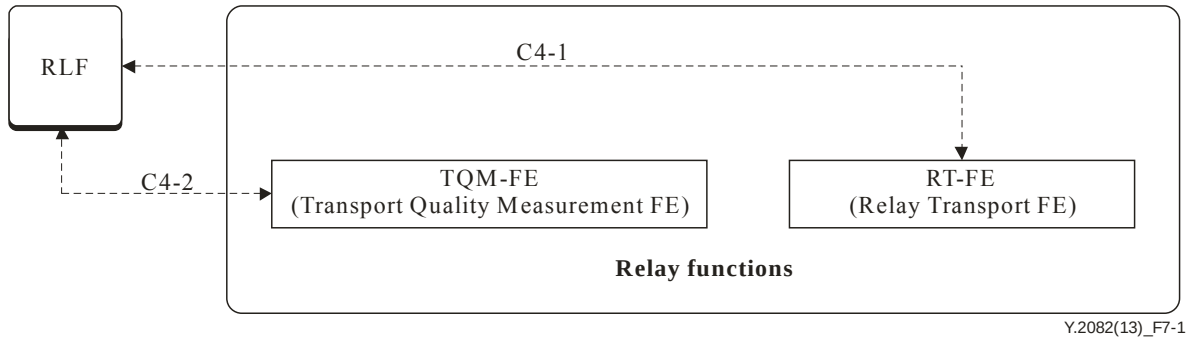

Figure 7-1 – Relay functions functional architecture

7.2 Functional entities

7.2.1 Relay transport functional entity

RT-FE is a functional entity that relays the data packet between DSN nodes. RT-FE also reports flow statistics and RN status to a resource location function (RLF). The functions performed by RT-FE include the following:

- RT-FE registers RN to RLF.
- RT-FE reserves resource for data packet relay.
- RT-FE relays data packets for DSN nodes, including DSN nodes behind NAT/firewall.
- RT-FE validates the legality of a DSN node when the DSN node sends data packet to RT-FE.
- RT-FE buffers relayed data packets.
- RT-FE reports relay task results (e.g., the duration and flow statistic) to RLF.
- RT-FE forwards data packets from one input to several outputs.
- RT-FE monitors RN status and reports status information to RLF. Status information includes CPU usage, memory usage, disk usage, and network interface usage, etc.
- RT-FE monitors events and reports event related information to RLF when it occurs.

  NOTE – For example, an event includes the case when an RN load reaches a given threshold.

7.2.2 Transport quality measurement functional entity

TQM-FE is a functional entity that performs QoS measurement for the data path starting from or ending by it. The functions of TQM-FE include the following:

- TQM-FE receives measurement instructions from RLF and reports these measurement results as required by RLF.
- TQM-FE measures the QoS parameters (e.g., delay, delay jitter, packet loss rate) on application flows.

- TQM-FE can initiate a new measurement flow with a certain packet pattern to another TQM-FE to measure the application's QoS parameters, when requested by RLF.

  NOTE – TQM-FE uses different connection methods for different types of measurements, e.g., TCP connections for measuring TCP QoS parameters, and UDP connections for measuring UDP QoS parameters.

8 Procedures

This clause describes how RFs interact with other DSN functions to provide relay services. The procedures in this clause apply for conversational services such as multimedia telephony (MMTel) or video conferencing.

8.1 Relay procedures

8.1.1 General relay procedure

Figure 8-1 shows the general relay procedure. The detailed relay procedures are illustrated in the following clauses in 8.1.

The service control function (SCF) handles the service request and sets up the relay path between EFs. EFs may or may not be aware of the RN inserted into the data path.

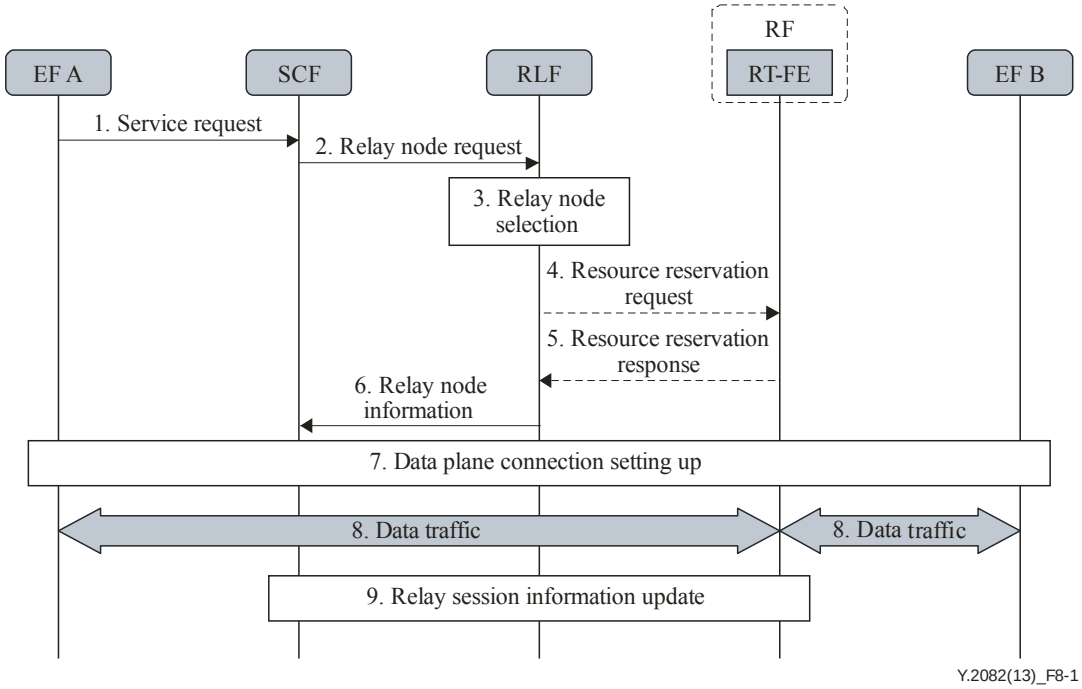

Figure 8-1 – General relay procedure

1. EF A sends service request (e.g., the Invite message in a SIP session) to SCF to request DSN services.
2. SCF sends RN request to RLF (which is in charge of managing RNs).

   NOTE 1 – Based on the user profile (e.g., whether the user has subscribed to the relay service), the requested service type, and the current access status of EF A or EF B (e.g., whether there are NAT/firewall devices), the SCF may determine that an RN is needed.
3. Based on the EF addresses and the requested service, RLF locates and selects one or more suitable RNs for this request.

4. Optionally, RLF may send a resource reservation request to RT-FE in the selected RNs to reserve relay resources.
5. RT-FE reserves necessary resources and returns the information (e.g., the allocated port) about reserved resources.
6. RLF returns the information of selected RNs to SCF.
7. SCF sets up the data plane connection by informing EF A and EF B of the data plane addresses that they should connect to. One or more RNs could be inserted into the data path.
8. EF A and EF B send data packets to each other through relay path.
9. During the relay service, or after the relay service has been finished, RT-FE sends relay session information to RLF. RLF may forward the relay session information to SCF.

NOTE 2 – A relay session is the process by which RN(s) relay packets for a given set of DSN nodes. The process includes relay resource reservation, connection set up, and data packet forwarding. A relay session is identified through the relay session ID.

NOTE 3 – Relay session information includes the source/destination addresses, the RN ID, the amount of traffic relayed, and the duration of the relay session.

8.1.2 Relay node selection procedures

In the processes of RN selection, there are several factors to be considered, such as RN capabilities, round-trip time (RTT) values, etc. These factors can be classified into following three categories.

1) Network capabilities, including RTT, available bandwidth, IP address type, etc.
2) System capabilities, including cumulative online time, join/leave frequency, etc.
2) Physical capabilities, including available processing power, available memory space, available disk space, etc.

As different services require different kinds of capabilities, the selection procedure takes into account the service type and QoS requirements. For example, a latency-sensitive service such as MMTel or video conferencing, will first take into consideration the network capabilities related to delay in the selection of RNs.

8.1.2.1 Relay node selection procedure based on TOCF optimization

Figure 8-2 shows the RN selection procedure based on TOCF optimization.

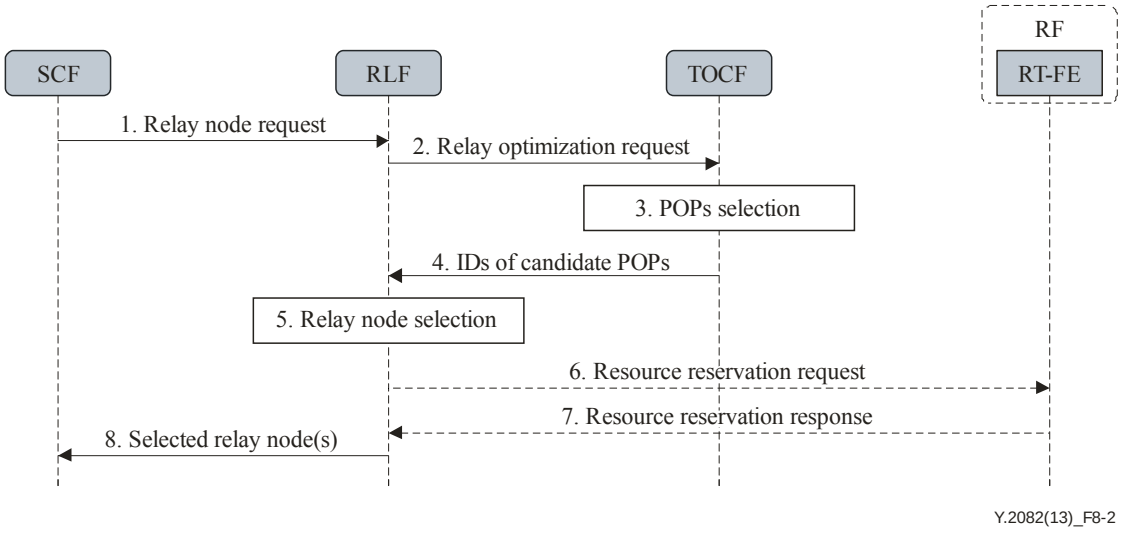

Figure 8-2 – RN selection procedure based on TOCF optimization

1. SCF sends RN request to RLF, which indicates the IP addresses of source node and destination node, service type, and QoS requirement.
2. RLF sends relay optimization request to TOCF for the IDs of the candidate POPs that represent the potential RNs that can meet the QoS requirement. The message includes IP addresses of the source node and the destination node.
3. TOCF selects the candidate POPs based on topology information, traffic information and optimization policies. For example, TOCF can select POPs that have the lowest costs for paths connecting the source and destination node.
4. TOCF returns the IDs of the candidate POPs to RLF.
5. Based on the service type and QoS requirement, RLF further refines the RN selection policy and selects one or more RNs from the full list of candidate POPs.

   NOTE 1 – Based on the QoS requirement, RLF sets the threshold for each capability. The RN capabilities are collected by RLF before the relay selection procedure. RNs that meet the capability thresholds will be selected as candidates. For conversational services that are delay-sensitive, the network capabilities of the RNs may be considered first.
6. RLF sends resource reservation request to the selected RN(s).
7. RN(s) return resource reservation response to RLF.

   NOTE 2 – Step 6 and step 7 are optional if the RN request in step 1 does not specify a QoS requirement.
8. RLF returns the information of the selected RN(s) to SCF.

8.1.2.2 RN selection procedure based on RLF optimization

Figure 8-3 shows the RN selection procedure based on RLF optimization.

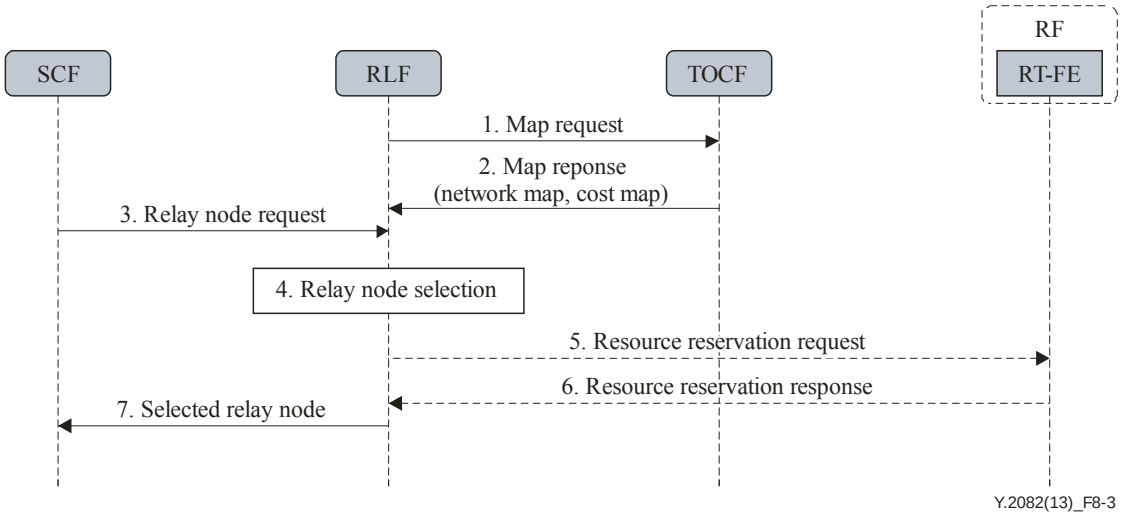

Figure 8-3 – RN selection procedure based on RLF optimization

1. RLF requests network map and cost map from TOCF periodically.

   NOTE 1 – Network map is the mapping between the IP address and the ID of POP. Cost map is the mapping between a pair of POPs and its cost value.
2. TOCF responds with network map and cost map to RLF.

   NOTE 2 – Step 1 and step 2 are executed periodically.
3. SCF sends RN request to RLF, which indicates the IP addresses of source node and destination node, service type, and QoS requirement.

4. Based on network map and cost map, RLF selects the candidate POPs, and then, based on the service type and QoS requirement, RLF further refines the RN selection policy and selects one or more RNs from the full list of candidate POPs.

   NOTE 3 – Based on the QoS requirement, RLF sets the threshold for each capability. The RN capabilities are collected by RLF before the relay selection procedure. RNs that meet the capability thresholds will be selected as candidates. For conversational services that are delay-sensitive, the network capabilities of the RNs may be considered first.

5. RLF sends resource reservation request to RT-FE of the selected RN(s).

6. RT-FE returns resource reservation response to RLF.

   NOTE 4 – Step 5 and step 6 are optional if the RN request in step 3 does not specify a QoS requirement.

7. RLF returns the information of selected RN(s) to SCF.

8.1.2.3 Relay node selection procedure for data traffic from one source to multi-destinations

Figure 8-4 shows the procedure where data packets are relayed from the source user equipment (UE) to its destination UEs, which can be used in the service like video conferencing. One or more RNs can be selected for different destinations.

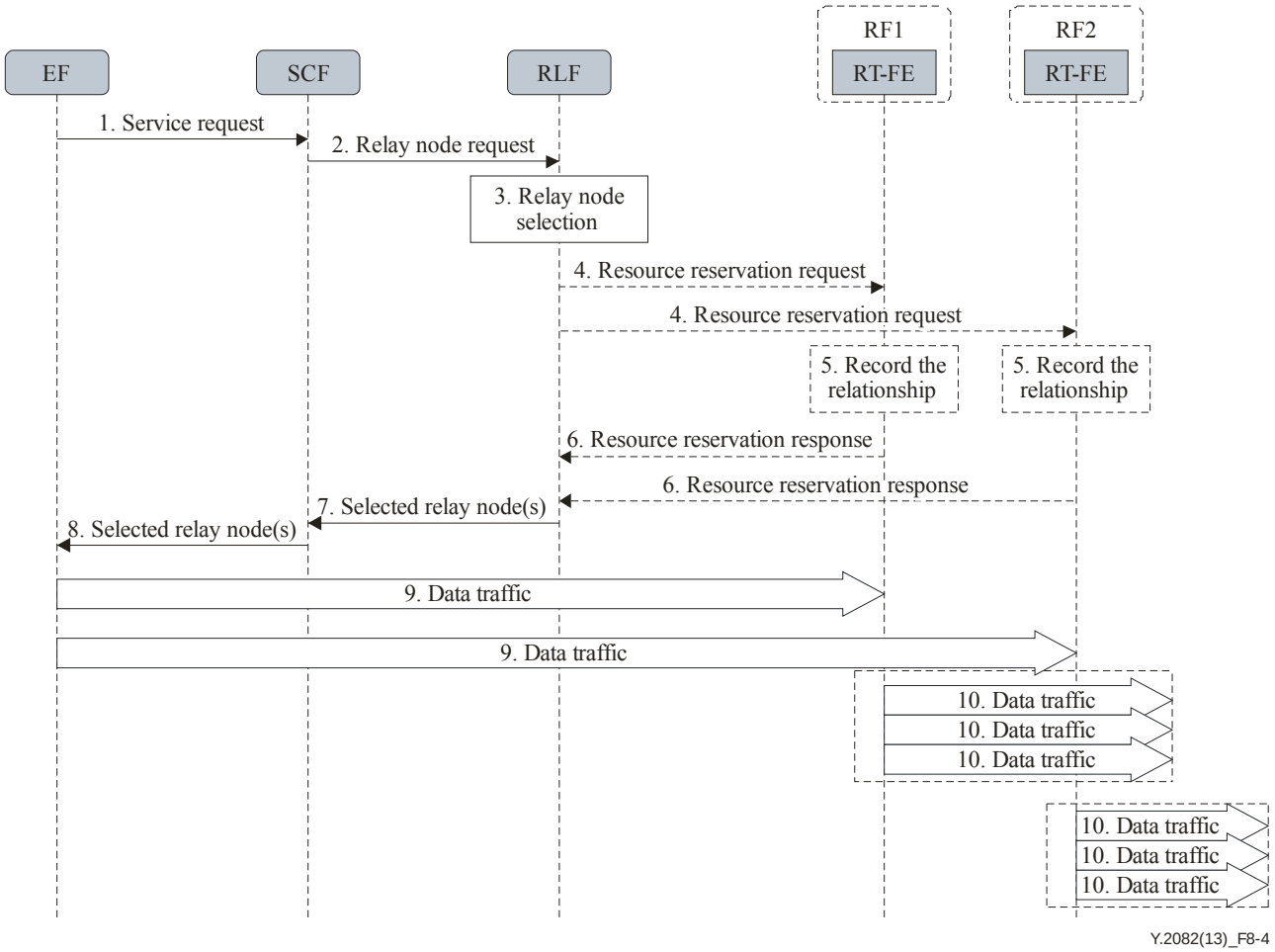

Figure 8-4 – RN selection procedure for data traffic from one source to multi-destinations

1. EF sends the service request to SCF to request DSN services.
2. SCF sends the RN request to RLF, which indicates the IP addresses of source node and destination node(s), service type, and QoS requirement.

   NOTE 1 – Based on user profile (e.g., whether the user has subscribed to the relay service), the requested service type, and the current access status of EF A or EF B, the SCF may determine that RN is needed.
3. RLF selects the appropriate RN(s) that may provide relay services for several destination nodes. For example, RF1 is responsible for relaying packets from source node to some of the destination nodes, and RF2 is responsible for relaying packet from source node to the remainder of the destination nodes.

   NOTE 2 – RN selection may be based on TOCF optimization or RLF optimization, as described in clauses 8.1.2.1 and 8.1.2.2 separately.
4. RLF sends resource reservation request to RT-FE of the selected RN(s).
5. RT-FE(s) reserve resources (e.g., port, bandwidth) for this session, and records the mapping between the source node and its destination nodes.
6. RT-FEs returns resource reservation response to RLF.
7. RLF returns the information of selected RN(s) to SCF.
8. SCF sends response to EF with RN(s) information.
9. EF sends data packets to each RN.
10. RN(s) send copies of received data packets to multiple destination nodes.

8.1.3 Data plane connection procedures

Because an RN can be accessed by many consumers' UEs, it is necessary to design a mechanism to establish a secure relay path for each session. A relay session ID mechanism is used for this secure relay path establishment. Clauses 8.1.3.1, 8.1.3.2 and 8.1.3.3 provide an introduction of how this mechanism works. Clauses 8.1.3.4 and 8.1.3.5 particularly emphasize the multi-relay path set-up and update procedures.

8.1.3.1 Session set-up

Figure 8-5 illustrates the session set-up procedure for secure relay path establishment. The relay session ID is delivered to participators during session negotiation.

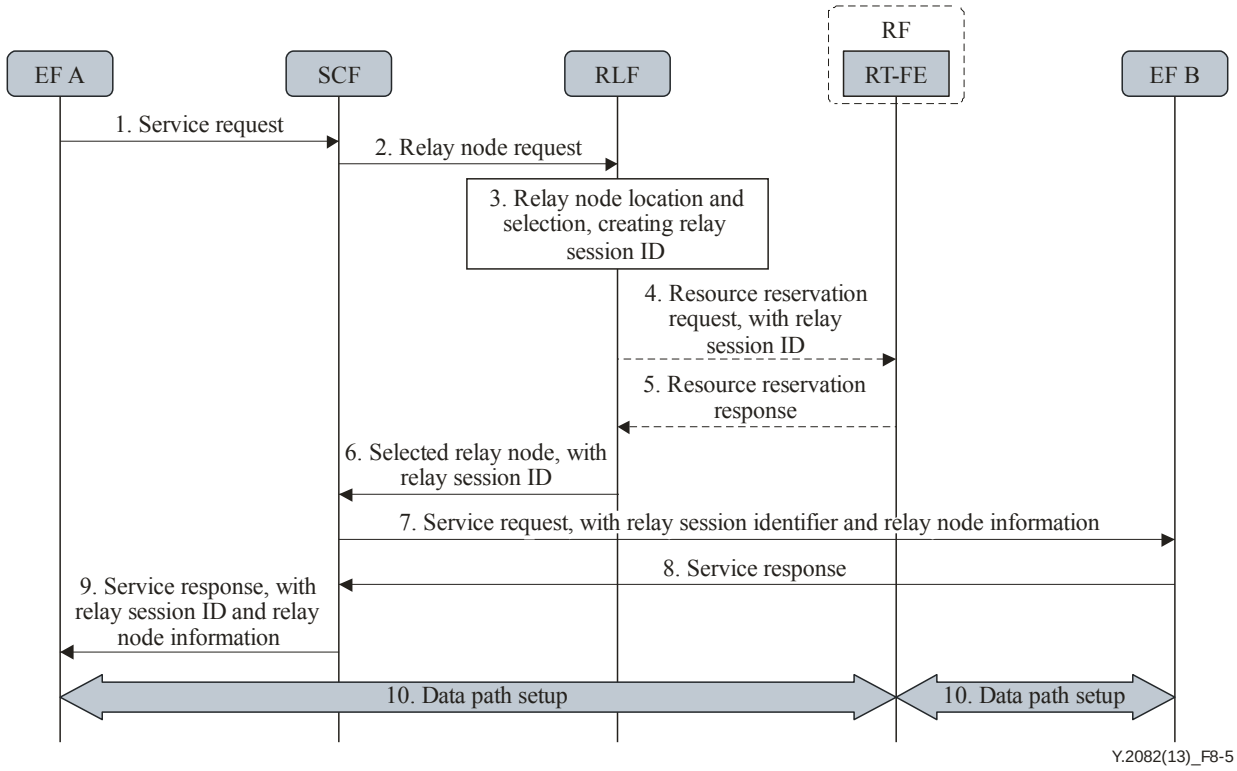

Figure 8-5 – Session set-up procedure for secure relay path establishment

1. EF A sends service request to SCF to request DSN services.
2. SCF sends relay request to RLF to request relay services.

   NOTE – Based on user profile (e.g., whether the user has subscribed to the relay service), the requested service type, and current access status of EF A or EF B, the SCF may determine that RN is needed.
3. Based on the EF addresses and the requested service, RLF locates and selects one or more suitable RNs for this request. At the same time, RLF generates a relay session ID for this session.
4. RLF sends resource reservation request to RT-FE of RN to reserve relay resource. The relay session ID is included in the resource reservation request.
5. RT-FE reserves necessary resources and returns the information about reserved resources in response message to RLF. RT-FE stores the received relay session ID for data path set-up.
6. RLF returns the information of the selected RN(s) to SCF. The relay session ID is included in the response message.
7. SCF forwards the service request to EF B, with the relay session ID received from RLF. SCF replaces EF A's data plane address with reserved resources in RN.
8. EF B responds to the service request from SCF, by sending a service response message that includes its data plane information, i.e., IP address, port, codec, back to SCF.
9. SCF transfers the service response message to EF A, with the relay session ID received from RLF. SCF replaces EF B's data plane address with reserved resources in RN.
10. EF A and EF B begin to set up data path.

8.1.3.2 Data path set-up for data traffic from one source to single destination

Figure 8-6 illustrates the flows of data path set-up for data traffic from one source to single destination.

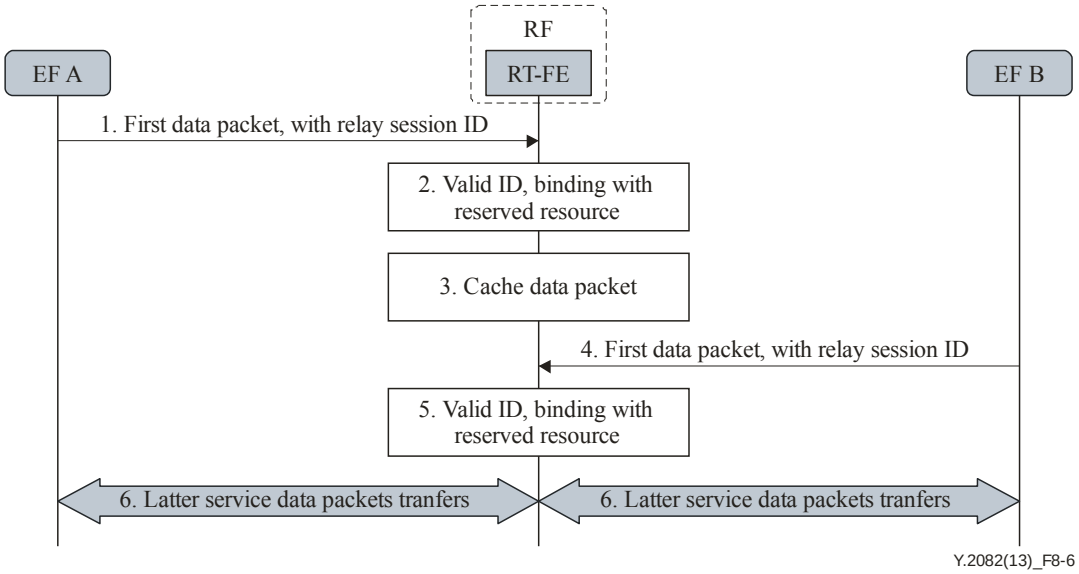

Figure 8-6 – Data path set-up for data traffic from one source to single destination

NOTE 1 – It is assumed that the procedures before the data path set-up (i.e., steps 1 through 9 in clause 8.1.3.1) have been completed.

NOTE 2 – It is assumed that RT-FE receives the first data packet from EF A. There is a similar flow if RT-FE receives the first data packet from EF B instead.

1. EF A sends the first data packet to RT-FE of RN, with relay session ID.
2. RT-FE receives the first service data packet from EF A. Based on the relay session ID from RLF, it validates the relay session ID in the received packet. If the relay session identifier is valid, RT-FE binds EF A's data plane information with its reserved resource on RT-FE.
3. RT-FE caches EF A's service data packets until RT-FE gets EF B's data plane information.
4. EF B sends the first data packet to RT-FE, with relay session ID.
5. RT-FE receives the first service data packet from EF B. Based on the relay session ID from RLF, it validates the relay session ID in the received packet. If the relay session identifier is valid, RT-FE binds EF B's data plane information with its reserved resource on RT-FE.
6. EF A and EF B transfer their latter data packets to each other via RT-FE. The data path set up is complete between EF A and EF B.

8.1.3.3 Data path set-up for data traffic from one source to multi-destinations

Figure 8-7 illustrates the flow to set up data path for data traffic from one source to multi-destinations.

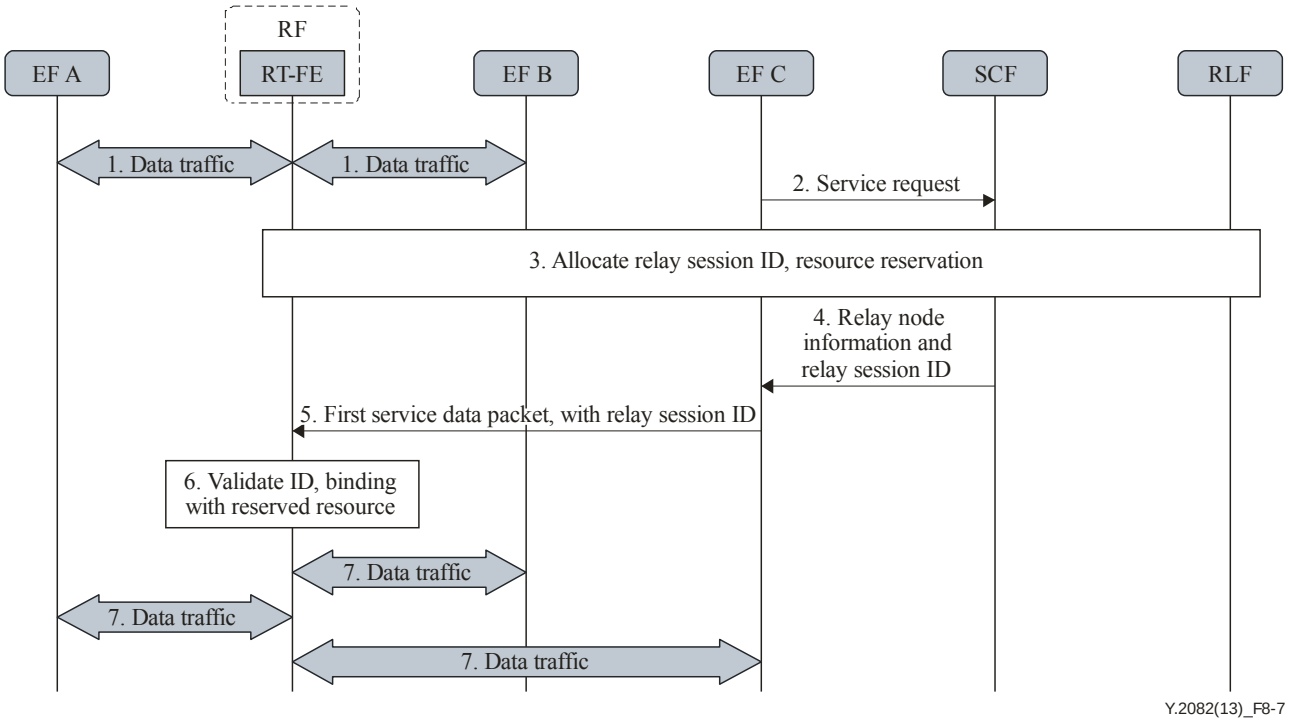

Figure 8-7 – Service data path set-up for data traffic from one source to multi-destinations

1. EF A and EF B have already set up a data plane path using RT-FE of a RN.

   NOTE 1 – Step 1 can be completed by the procedure in clause 8.1.3.2.

2. EF C sends a service request to SCF to join the communication session between EF A and EF B.
3. Based on the profile of EF C and the on-going session, SCF determines that EF C can join this session. SCF requests RLF to reserve relay resources on RN, and the relay session ID is included in the resource reservation request. SCF may use the same relay session identifier used by EF A and EF B, or request RLF for a new relay session identifier.
4. SCF sends a response to EF C with the RN information and the relay session ID.
5. EF C sends its first data packet to RT-FE with session ID.
6. RT-FE receives the first data packet from EF C. Based on the relay session ID from RLF, it validates the relay session ID in the received packet. If the relay session ID is valid, RT-FE binds EF C's data plane information with its reserved resource on RT-FE.
7. RT-FE relays the packets from EF A, EF B or EF C to each other. The actual relaying rules (e.g., which EF's packet should be relayed to which set of output ports) are determined by the service profile of the session.

   NOTE 2 – This procedure can work for the video conferencing use case. However, application level commands, such as "hold", should be handled by applications on UEs.

8.1.3.4 Multi relay path set-up and update

Figure 8-8 shows the multi relay path set up and update procedure.

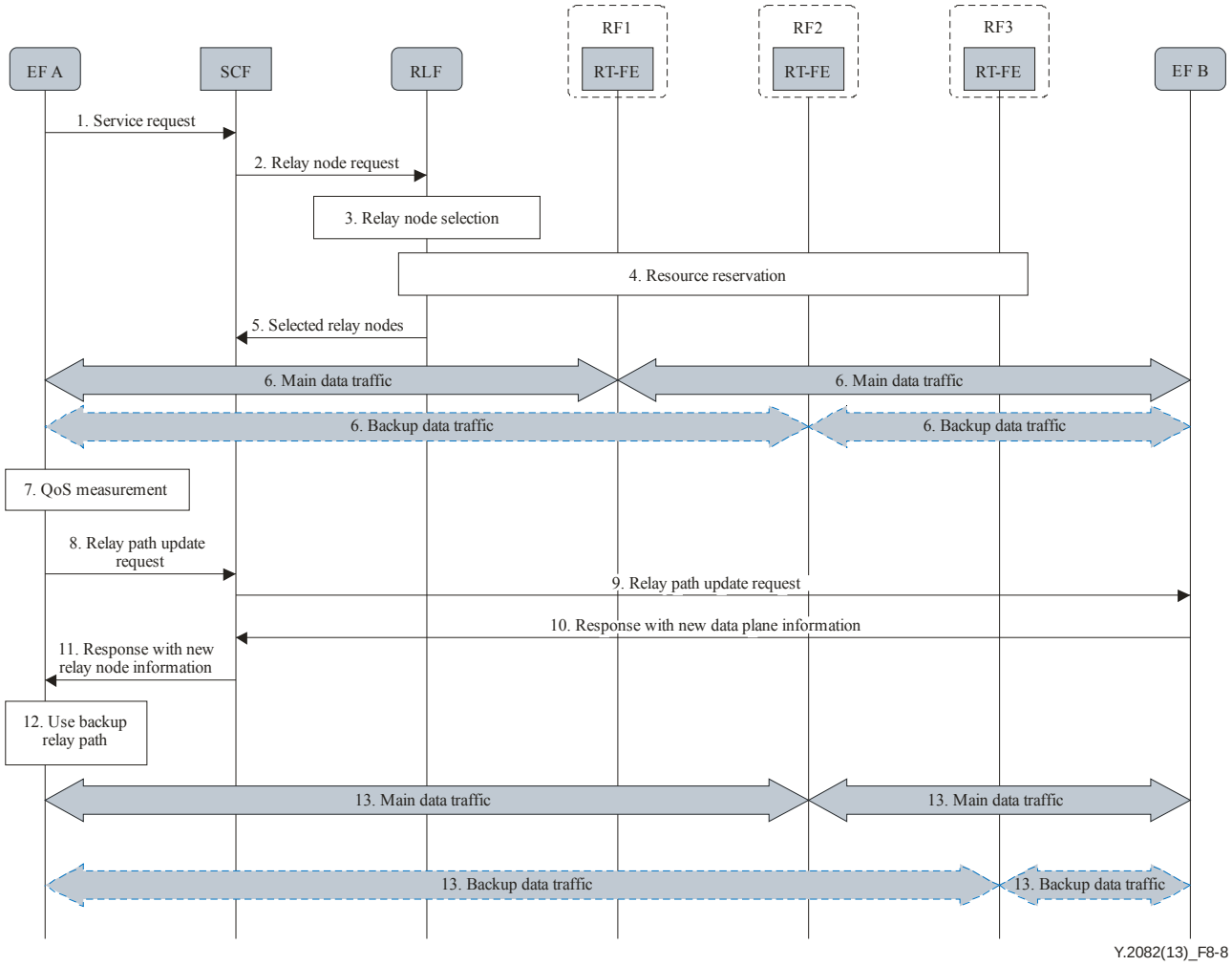

Figure 8-8 – Multi relay path set-up and update procedure

1. EF A sends service request to SCF to request DSN services.
2. Based on the service profile or the location of EF A, SCF determines that multiple relay paths should be prepared for the requested service. Multiple relay paths may be used to achieve better QoS, or for regions with poor connections for example. SCF sends relay request to RLF to request for RNs.
3. Depending on the EF addresses and the requested service, RLF locates and selects multiple suitable RNs for this request.
4. Optionally, RLF reserves resources in the selected RNs.
5. RLF returns the information of the selected RNs to SCF. SCF selects one RN to build the main relay path, and others to build backup path.
6. Multiple relay paths are set up under the control of SCF. One is designated as the main path and the others are designated as backup paths to be used when a backup path is able to provide better QoS than the original main path.
7. EF measures the QoS and will request for relay path change when the QoS drops below a given threshold for a given time.

NOTE 1 – EF can be EF A or EF B. In this procedure, it is assumed that EF A initiates the request for relay path change.

8. When QoS drops below threshold (i.e., becomes bad), EF A sends relay path update request to SCF. EF A inserts its new data plane information and the current QoS measurement results in the request message.
9. SCF sends the relay path update request to EF B, with the new RN information.

   NOTE 2 – SCF determines whether the QoS can be improved by switching to a new relay path. SCF may require QoS information from RLF to determine whether any existing backup relay path can provide better QoS than the main path. For this step, it is assumed that the QoS can be improved by changing to a backup relay path.
10. EF B responds to SCF with new data plane information.
11. SCF sends a response to EF A with the new RN information.
12. EF A begins using the backup relay path to transfer traffic, and stops sending data packet through the main path.
13. The original backup traffic path now functions as the main relay path, and one of the other relay paths is selected as the new backup path.

8.1.3.5 Multi relay path update failure

Figure 8-9 shows the multi relay path update failure procedure.

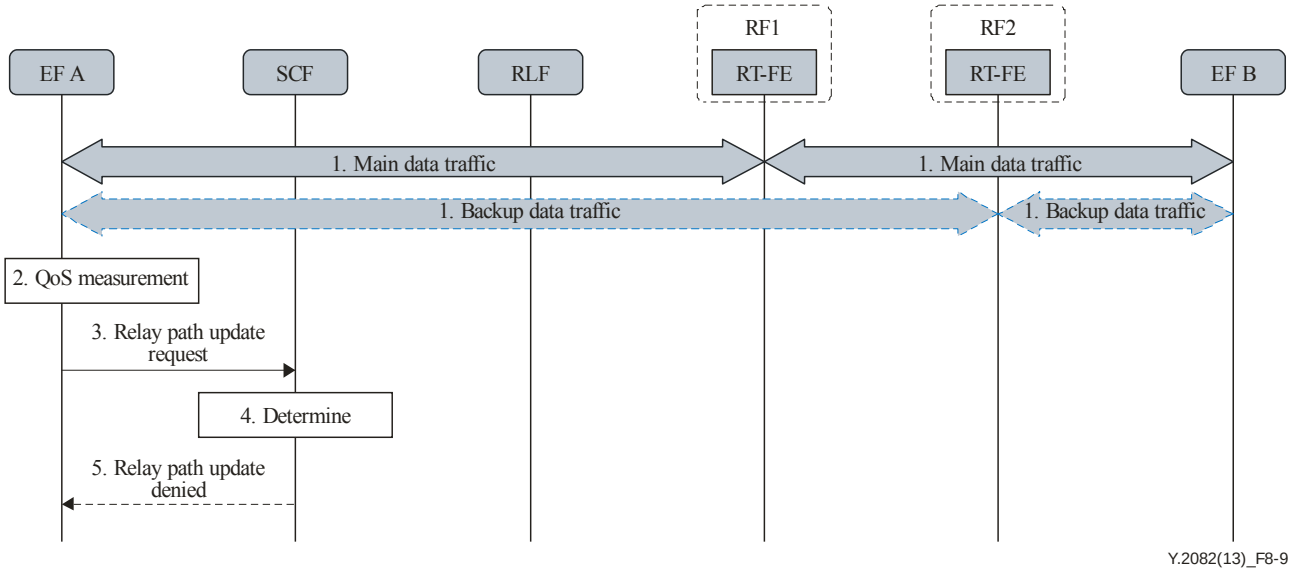

Figure 8-9 – Multi relay path update failure procedure

1. Multiple relay paths are set up under the control of SCF. One is designated as the main path and the other is designated as backup path to be used if it is able to provide better QoS than the original main path.
2. EF measures the QoS and will initiate a request for relay path change when the QoS drops below a given threshold for a given time.

   NOTE 1 – EF can be EF A or EF B. In this procedure, it is supposed that EF A initiates the request for relay path change.

3. When QoS drops below threshold (i.e., becomes bad), EF A sends relay path update request to SCF. EF A inserts its new data plane information and the current QoS measurement results in the request message
4. SCF determines that the QoS cannot be improved by switching to a new relay path.

   NOTE 2 – Although resource in the backup RN has been reserved, this does not ensure good QoS between UEs, as other parts of the path (e.g., wireless access) may cause QoS deterioration. SCF may require QoS information from RLF to determine that, because the QoS deterioration is caused by other parts of the path (e.g., wireless access), switching to a new relay is not helpful.
5. SCF denies the relay path switch request.

   NOTE 3 – The data path is maintained until session termination. Other mechanisms for QoS enhancement are out of the scope of this Recommendation.

8.1.4 Information update procedures

8.1.4.1 Relay session information update

Control nodes collect relay session information that may be used for billing or accounting. This relay session information includes the source/destination addresses, the RN ID, the amount of traffic relayed, and the duration of the relay session.

Figure 8-10 shows the relay session information update procedure.

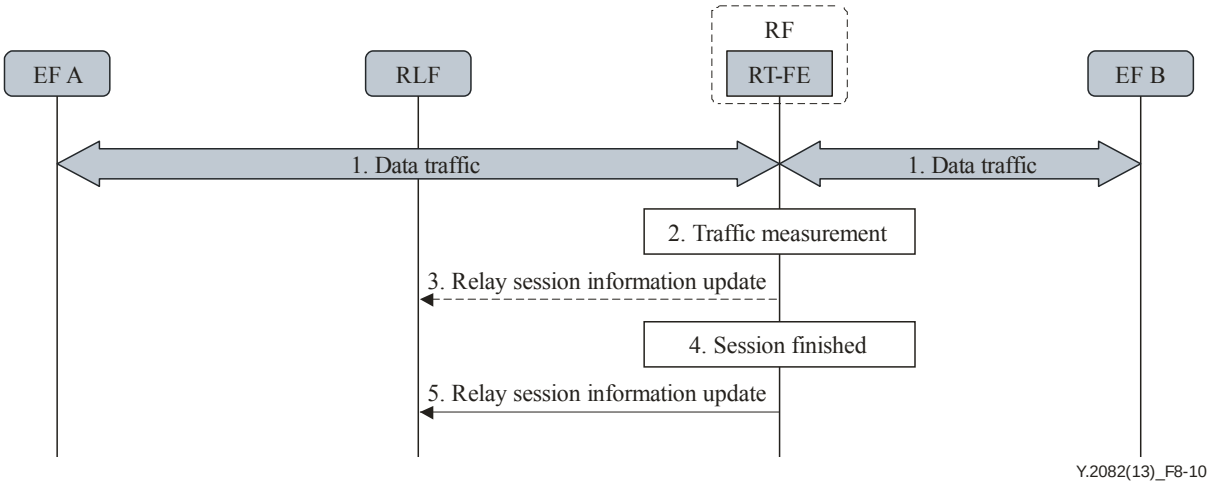

Figure 8-10 – Relay session information update

1. EF A and EF B are connected through the RN and send data packets to each other.
2. RT-FE measures relayed traffic passing through the RN.
3. During the session, RT-FE may send relay session information update message to RLF.
4. RT-FE detects that the session has been terminated.

   NOTE – RT-FE determines session termination by notification from SCF, or by noting the time of data traffic interruption.
5. RT-FE sends the relay session information update message summarizing the relay task for this session to RLF.

8.2 Relay node management procedures

8.2.1 Relay node registration

RN registers itself to RLF with its own status information, including its capabilities, which is used by the RLF to help in RN selection. Figure 8-11 shows the RN registration procedure.

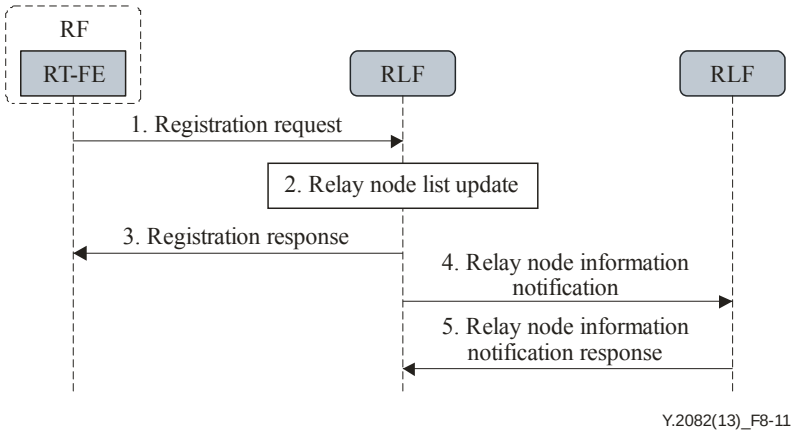

Figure 8-11 – RN registration procedure

1. RT-FE sends registration request to RLF, including the address of the RN and the capabilities of the RN.
2. RLF updates the RN list information based on the registration request it received.
3. RLF returns the registration response to RT-FE.
4. RLF informs other RLFs of the newly joined RN by the RN information notification message.
5. Other RLFs return a response to the RN information notification to RLF.

   NOTE – Step 4 and step 5 are optional according to different deployment scenarios. When there are multiple RLFs, the RLF that receives registration information can propagate the information to other RLFs.

8.2.2 Relay node status information report

Figure 8-12 shows the flows of reporting RN status to RLF. There are three types of reports. The first type is a periodic report, where the RT-FE is responsible for reporting RN status periodically to the RLF to which it registers. The second type is an on-demand report. RLF can request a registered RT-FE to report its node status on-demand. Upon receiving the request, RT-FE should report the requested information. The third type is an event-driven report. When predefined events have occurred, these events should be reported by RT-FE to RLF.

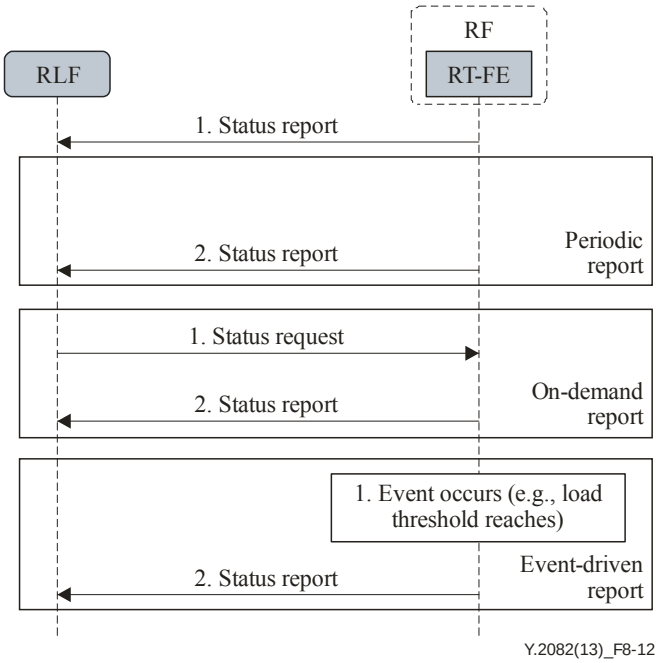

Figure 8-12 – Relay node status information report procedure

Periodic report:

1. RT-FE sends the status report to RLF.
2. After a predefined interval, RT-FE sends the status information again to RLF.

On-demand report:

1. RLF requests status information of RN.
2. Upon receiving the report request from RLF, RT-FE responds with the requested information.

Event-driven report:

1. A predefined event to be reported to RLF has occurred.
2. Upon recognizing the event, RT-FE should report the event to RLF.

8.3 QoS measurement procedures

Before or during the RN selection procedure, RLF may need to gather the QoS measurement of the relay path. The QoS measurement of a relay path includes: the RTT of the path, the one-way delay of the path, the available bandwidth of the path, the delay jitter of the path, and the packet loss rate of the path. TQM-FE may set up a new connection for measurement when necessary.

Figure 8-13 shows the procedure of QoS measurement of the relay path.

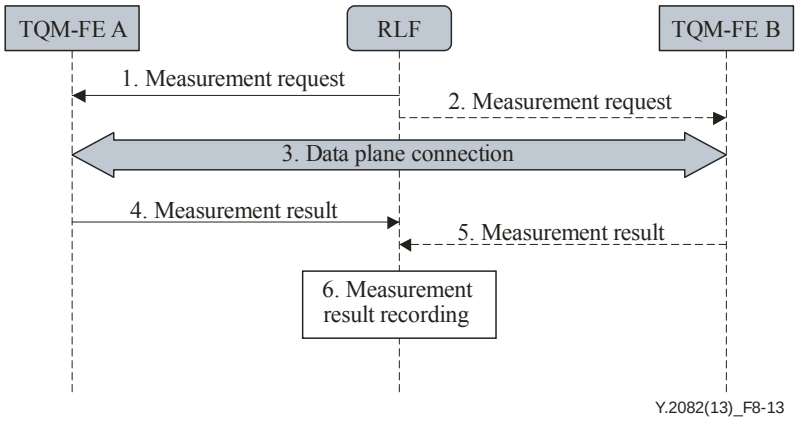

Figure 8-13 – QoS measurement of the relay path

1. RLF sends measurement request to TQM-FE A to request measurements. The request includes: the address of TQM-FE B, connection parameters (e.g., connection types, passwords), the type of requested QoS information, the desired measurement methods, and the requested measurement times, duration and frequency, etc.

   NOTE 1 – TQM-FE may be in RN or in UE. The UE that is capable of using relay services may include TQM-FE (in itself) to support QoS measurements.

2. Optionally, RLF may also send a measurement request to TQM-FE B.

   NOTE 2 – When the requested measurement is simple and consumes few resources (e.g., ping-like measurements), end-terminal B may always be ready for other nodes to connect for such simple operations. In this case, RLF does not need to notify TQM-FE B.

3. Based on the information in measurement request, TQM-FE A sets up a data plane connection to TQM-FE B when there is no existing connection. These two TQM-FEs exchange data packets based on the instructions in measurement request in order to gather the requested QoS measurements.
4. TQM-FE A returns measurement results to RLF. The measurement results include the gathered QoS information, timestamp, whether the measurement is successful, etc.
5. Optionally, TQM-FE B can also return measurement results to RLF.
6. RLF records the QoS information.

9 Reference points

RT-FE interacts with RLF via the reference point C4 to register itself, perform node status reports, and accept resource reservation requests.

TQM-FE interacts with RLF via the reference point C4 to accept measurement tasks and report measurement results.

9.1 Reference point C4

Reference point C4 is the control interface between RLF and RT-FE/TQM-FE.

9.1.1 Registration

Table 9-1 lists the parameters included in the registration request sent from RT-FE to RLF to register itself to RLF.

Table 9-1 – Parameters used for registration request

Parameters	Parameter description
Node ID	The identifier of the RN.
Certification	The certification used to authenticate the RN. Detailed format of this certification depends on implementation.
Capability	The capability of the RN. Attributes: – System: CPU (central processor unit), MEM (memory) size, bandwidth, IP address. – NAT/firewall traversal: whether the RN supports NAT/firewall traversal, protocols. – One to More: whether the RN supports relaying the data traffic from one source to multi-destinations. – Measurement capability: the capability of QoS measurement.
Address List	Address List is used to list the addresses of the RN. Attributes: – Count: The number of addresses in the list. The Address List includes one or more items of Address, which is the address of the RN. Address: – Type: address type, can be public, local, etc. – IP Address.

Table 9-2 lists the parameters included in the registration response sent from RLF to RT-FE to respond to the registration request.

Table 9-2 – Parameters used for registration response

Parameters	Parameter description
Registration Status	The status acknowledge of the registration: Value: OK/Not Acceptable.
Status Report Period	Status report period. The value is set to 0 to indicate no need for periodic status report.

9.1.2 Status report

Table 9-3 lists the parameters included in the status report request sent from RLF to RT-FE to inform the RN to report its status.

Table 9-3 – Parameters used for status report request

Parameters	Parameter description
Node ID	The identifier of the RN.
Status Report Period	Status report period. The value is set to 0 to indicate no need for periodic status report.

Table 9-4 lists the parameters included in the status report sent from RT-FE to RLF to report the node status.

Table 9-4 – Parameters used for status report

Parameters	Parameter description
Node ID	The identifier of the RN.
Uptime	The time since the RN has booted.
Task Count	The number of relay tasks completed by the RN.
Task List	Task List is used to list the tasks that the RN is currently working on. Attributes: – Count: The number of tasks in the list The Task List includes one or more items of Task, which is the task that the RN is currently working on, including relay tasks and measurement tasks. Task: – Task ID: The task identifier assigned by RLF or by the RN itself.
Address List	Address List is used to list the addresses of the RN. Attributes: – Count: The number of addresses in the list. The Address List includes one or more items of Address, which is the address of the RN. Address: – Type: address type, can be public, local, etc. – IP Address.
Resource State	The status of the resource usage of the RN. Attributes: – Bandwidth: the free bandwidth of the RN. – CPU: the CPU load of the RN. – Memory: the free memory that can be used by the relay task. – Free Ports: the number of free ports that can be used for Relay.

9.1.3 Resource reservation

Table 9-5 lists the parameters included in the resource reservation request sent from RLF to RT-FE to reserve resources for relay tasks to RT-FE.

Table 9-5 – Parameters used for resource reservation request

Parameters	Parameter description
Task ID	The task identifier assigned by RLF.
Node ID	The identifier of the RN to which the task is assigned.
Task type	The type of the task, e.g., one source to single destination, one source to multi-destinations, etc.
Security credential	Security information related to the relay task, e.g., the hash of the password or the public key.

Table 9-5 – Parameters used for resource reservation request

Parameters	Parameter description
Source List	Source List is used to list the sources for this relay task. Attributes: – Count: The number of sources in the list. The Source List includes one or more items of Source, which are the source nodes of the relay task. Source: – Source ID: Source identity. – IP Address: Source IP address and port. – QoS: the QoS for the relay task, e.g., bandwidth. – Connection Type: the connection type for the relay task, e.g., TCP/UDP, active/passive. – Security Credential: Security information related to the source node, e.g., the hash of the password or the public key.
Destination List	Destination List is used to list the destinations for this relay task. Attributes: – Count: The number of destinations in the list The Destination List includes one or more items of Destination, which is the relay destination of the relay task. Destination: – Destination ID: Destination identity. – IP Address: Destination IP address and port. – QoS: the QoS for the relay task, e.g., bandwidth. – Connection Type: the connection type for the relay task, e.g., TCP/UDP, active/passive. – Security Credential: Security information related to the destination node, e.g., the hash of the password or the public key.

Table 9-6 lists the parameters included in the resource reservation response sent from RT-FE to RLF.

Table 9-6 – Parameters used for resource reservation response

Parameters	Parameter description
Task Status	The status acknowledge of the task: Value: OK/Not Acceptable.
Resource List	Resource List is used to list the resource reserved for this relay task. Attributes: – Count: The number of resources in the list. The Resource List includes one or more items of Relay Resource, which is the resource reserved by the RN. Relay Resource: – IP address: Reserved IP address and port for the source or destination. – Node ID: the ID of source or destination node related to the Resource.

9.1.4 Measurement

Table 9-7 lists the parameters included in the measurement request sent from RLF to TQM-FE to assign measurement tasks to TQM-FE.

Table 9-7 – Parameters used for measurement request

Parameters	Parameter description
Task ID	The task identifier assigned by RLF. This identifier is returned in the measurement result feedback.
Node ID	The identifier of the RN to which the task is assigned.
Repeat	Flag indicating whether the task is periodical or not. Value: TRUE/FALSE.
Period	The period of the task in units of milliseconds (ms). TQM-FE should execute the task once for each period. For non-periodic tasks, the default value is set to 0.
Task List	Task List is the list of measurement tasks assigned to TQM-FE at the same time. Attributes: – Count: The number of subtasks in the list. The Task List includes one or more items of Destination, which is the measurement destination of a single task. Destination: – Destination ID: Destination identity. – IP Address: Destination IP address and port. – Connection Type: the connection type for the relay task, e.g., TCP/UDP, active/passive. – Security Credential: Security information related to the destination node, e.g., the hash of the password or the public key. – Parameters: the parameters to be measured, e.g., RTT, throughput, loss, jitter.

Table 9-8 lists the parameters included in the measurement response sent from TQM-FE to RLF.

Table 9-8 – Parameters used for measurement response

Parameters	Parameter description
Task Status	The status acknowledge of the task: Value: OK/ Not Acceptable.

Table 9-9 lists the parameters included in the measurement result report sent from TQM-FE to RLF to report measurement results to RLF.

Table 9-9 – Parameters used for measurement result report

Parameters	Parameter description
Node ID	The identifier of the RN.
Task ID	The task identifier assigned by RLF.
Address	The address of the RN used for the measurement. Attributes: – Type: address type, can be public, local, etc. – IP Address: the address and port.

Table 9-9 – Parameters used for measurement result report

Parameters	Parameter description
Result List	Result List is used to report multiple results to the RLF at the same time. Attributes: – Count: The number of measurement results in the list. The Result List includes one or more items of measurement result. Result: – Destination identity. – IP Address: Destination IP address and port. – State: the state of the measurement, connection success or cannot connect to the destination. – RTT: the RTT of the link. – Throughput: the throughput of the link. – Loss: packet loss rate of the link. – Jitter: The averages of the deviation from packet mean latency. – Timestamp: the time that the measurement is taken.

The report does not need response.

9.1.5 Relay session information report

Table 9-10 lists the parameters included in the relay session information report sent from RT-FE to RLF to report relay session information to RLF.

Table 9-10 – Parameters used for relay session information report

Parameters	Parameter description
Node ID	The identifier of the RN.
Task ID	The task identifier assigned by RLF.
Task Result	The status of task. Value: Success/Timeout.
Task Type	The type of the task, e.g., one source to single destination, one source to multi-destinations, etc.
Duration	The duration of the task.
Throughput	Total amount of traffic that the RN has relayed.
Timestamp	The time of the relay session information.

This report does not need response.

Security mechanisms (e.g., source authentication, integrity protection), should be included when sending this report.

Appendix I

Relay algorithms introduction

(This appendix does not form an integral part of this Recommendation.)

Relay algorithms have been studied for several years, and attracted more attention in academic and industry fields. According to different deployment scenarios, different algorithms should be taken into consideration. As an example, one relay algorithm is introduced below in brief.

I.1 Description of GNG algorithms

As shown in Figure I.1, a grade-based neighbour group (GNG) relay node selection algorithm is proposed to aim at quality improvement and network address translation (NAT) traversal with low overhead. According to the node location, all neighbouring nodes form a group based on the GNG. Therefore, many groups can be established, and each group will select one or more surrogate nodes to deal with QoS measurement. The surrogate for each group will maintain some of its neighbouring groups' information, and measure the round-trip time (RTT).

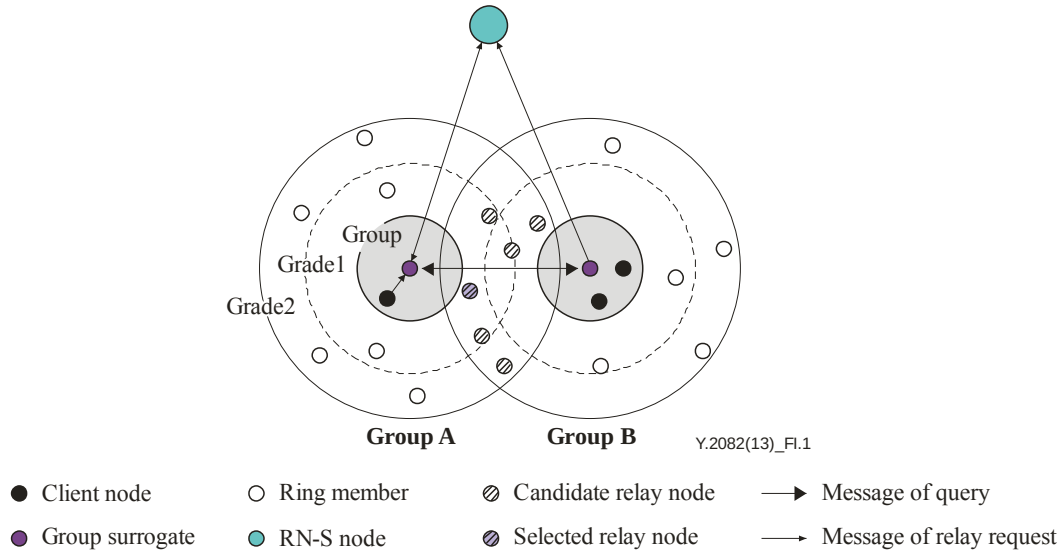

Figure I.1 – GNG relay node selection algorithm

I.1.1 GNG system structures and node operations

The following three types of nodes are defined in GNG protocol.

1) Relay node server (RN-S)

RN-S, which can be implemented as RC-FE in the RF framework, is normally a powerful, dedicated, and always-on server used for processing relay nodes' joining requests, maintaining all surrogate information, making relay node selections, etc.

RN-S plays critical roles and stores important information in GNG algorithm. RN-S provides the following functions and services to make the entire system strong and intelligent:

– Collect the autonomous system (AS) information and build an up-to-date AS graph.

– Accept all relay nodes' registration; registration information includes state information, bandwidth, continuous online time, node processing power and other related information.

– Collect the surrogates' measurement results, such as round-trip time between different groups.

– Execute relay node selection algorithm, request the related relay resource, such as the port number of data transport.
– Select new surrogates for group upon surrogate failures.
– Assign the measurement tasks to the surrogates.

2) Group surrogates

Group surrogate nodes are powerful and stable with high bandwidth network connections within a group. There can be one or more surrogates within one group.

Group surrogates volunteer themselves to provide the following services:

– Periodically measure the QoS between closed groups, including RTT, bandwidth, etc.
– Report the measurement results to the RN-S.

3) Relay node

Relay nodes can be end hosts or servers deployed by operators, and are responsible for relaying traffic packets.

In GNG, relay nodes have the following duties:

– Become surrogates in their groups, if they are the only nodes in their groups.
– Periodically publish their nodes' information to RN-S.
– Registration to the RN-S to become a relay node.
– Relay media packets.

I.1.2 Relay nodes selection procedure

The general procedure of relay node selection in GNG is introduced here. As shown in Figure I.2, when the QoS cannot satisfy the needs of UEs, or UEs are behind NAT, they will request for relay node support to improve the QoS or provide NAT traversal. Relay request will be sent to RN-S. The specific GNG relay process is shown in Figure I.2 below, and includes the following steps.

Step 1: RN-S receives relay request between UE1 and UE2.

Step 2: RN-S queries the groups of UE1 and UE2, $UE1 \in GroupID\ 1, UE2 \in GroupID\ 2$, looks up each group's surrogate, and initiates the relay assemblage $R = \{\Phi\}$.

Step 3: If Group1 ID does not equal Group2 ID, then RN-S chooses relay nodes in the group neighbouring relay list.

Step 4: Based on collected information of relay overlay, such as: traffic load conditions and reliabilities of the nearby relay nodes, as well as RTTs and packet loss rates of the relay paths corresponding to these nearby relay nodes, RN-S picks the most suitable relay nodes for UEs.

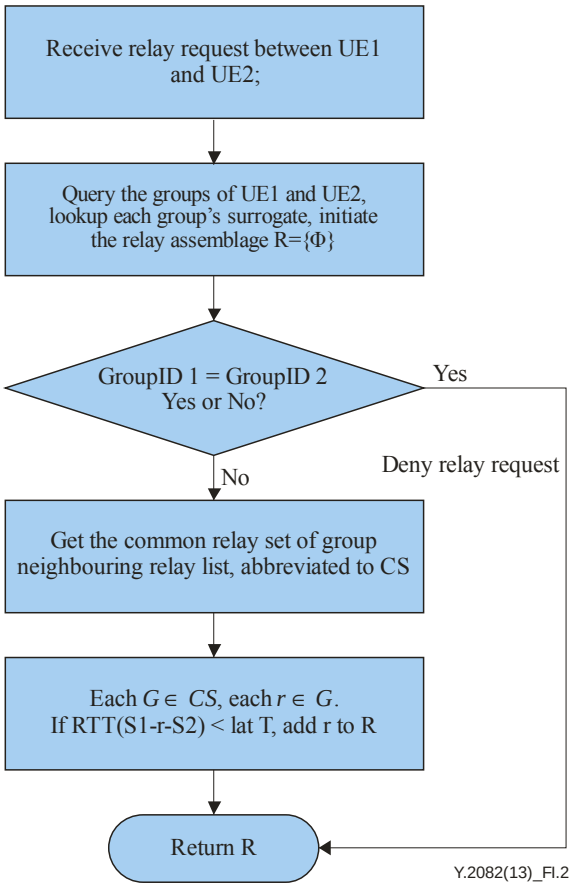

Figure I.2 – GNG relay procedure

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