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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Smart Body Area Network (SmartBAN).

Modal verbs terminology

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Executive summary

The present document defines technical specifications for relay functionality for ETSI SmartBAN. The specifications extend the general Medium Access Control (MAC) framework defined for SmartBAN by a two-hop communication within a SmartBAN.

The relay functionality can be divided into three phases as follows:

1) Relay connectivity initialization.

2) Maintaining relay connectivity.

3) Ending relay connectivity.

Any relay connection is established as a joint effort of the hub and the node, termed as an Isolated node, seeking the relay connection. In the connectivity initialization phase, the Isolated node starts to broadcast Isolated Node Notifications, thus advertising it is experiencing connection problems with the hub. At the same time, the hub has identified that a certain node has failed to transmit a frame during its allocated time slot for n^{th} consecutive Inter-Beacon Interval (IBI). Then, the hub tries to poll the node by signalling for a downlink data. If the node does not acknowledge the downlink data request, the hub concludes the node is experiencing a connection problem or it is isolated.

Next, the hub broadcasts an Isolated Node Notification Listen command to the network, thus signalling the other nodes to start listening until further notice from the hub, for Isolated Node Notifications from the Isolated node starting from the C/M period of the next Inter-Beacon Interval. Candidate relay nodes can forward the notification frame they have received from the Isolated node to the hub, which nominates a node for the relay connection among the candidate ones. Furthermore, the hub performs slot reassignments in the network to accommodate the time slots required for transmitting a relay beacon frame (R-Beacon) from the relay to the isolated node and for transmitting data from the isolated node to the hub via the relay.

While getting the relay access to the SmartBAN through the relay, the isolated node continues to listen for a Data Channel Beacon (D-Beacon) from the hub, and if it receives one, it starts counting for up to three consecutive D-Beacons, and then it terminates the relay access after completing any already started tasks.

The relay disconnection can be initiated by the isolated node, the relay, or by the hub by sending a disconnection command. In case it is initiated by the isolated node or by the hub, approval from other entities shall not be required, whereas a disconnection request initiated by the relay shall be approved either by the isolated node or by the hub.

The present document is structured as follows:

- At first, the additional management frames and information units required for the relay functionality are defined.
- Second, the present document details the operational procedures for the relay functionality.
- Finally, Annex A includes two normative flowcharts defining the relay functionality.

Introduction

Modern medical and health monitoring equipment is moving towards the trend of wireless connectivity between the data collection or control centre and the medical devices or sensors. Therefore, a standardized communication interface and protocol between the actors are required. This network of actors performing some medical monitoring or functions is called a Smart Body Area Network (SmartBAN).

A SmartBAN is a simple, low complexity, low energy communication network that allows wireless connectivity between the devices and a hub. The distinct features of the SmartBAN are ease of access, minimal listening, reliable data transfer, and provision of additional control messages (in the form of C-Beacons) for the low-duty cycling nodes while maintaining a simple and flexible protocol. SmartBAN also provides a multi-use channel access mechanism for emergency and other high-priority access and improved channel utilization.

The basic access specifications for Medium Access Control (MAC) are defined in ETSI TS 103 325 [1] and for the physical layer (PHY) in ETSI TS 103 326 [2]. The present document extends ETSI TS 103 325 [1] by defining technical specifications for relay functionality enabling a two-hop communication within a SmartBAN.

Additional information can be found in the following documents:

- ETSI EN 300 328-1 [i.1] defines requirements for equipment operating in the 2,4 GHz ISM band;
- IEEE™ 802.15.6-2012 [i.2] defines an alternative standard for Wireless Body Area Networks;
- IEEE™ 802.15.4-2011 [i.3] defines a standard for Wireless Personal Area Networks; and
- ETSI TS 103 806 [i.4] defines hub to hub communication for SmartBAN MAC defined in ETSI TS 103 325 [1].

1 Scope

The present document extends the low complexity Medium Access Control (MAC) for SmartBAN defined in ETSI TS 103 325 [1] with relay functionality. The main scope of the present document is to define specifications for relay node functionality enabling a two-hop communication within a SmartBAN.

2 References

2.1 Normative references

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The following referenced documents are necessary for the application of the present document.

[1] ETSI TS 103 325 (V1.2.1): "Smart Body Area Network (SmartBAN); Low Complexity Medium Access Control (MAC) for SmartBAN".

[2] ETSI TS 103 326 (V1.2.1): "Smart Body Area Network (SmartBAN); Enhanced Ultra-Low Power Physical Layer".

2.2 Informative references

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI EN 300 328-1 (V1.3.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Wideband Transmission systems; Data transmission equipment operating in the 2,4 GHz ISM band and using spread spectrum modulation techniques; Part 1: Technical characteristics and test conditions".

[i.2] IEEE™ 802.15.6-2012: "IEEE Standard for Local and metropolitan area networks - Part 15.6: Wireless Body Area Networks".

[i.3] IEEE™ 802.15.4-2011: "IEEE Standard for Local and metropolitan area networks - Part 15:4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specification for Low-Rate Wireless Personal Area Networks".

[i.4] ETSI TS 103 806: "Smart Body Area Network (SmartBAN); Hub to Hub Communication for SmartBAN Medium Access Control (MAC)".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

active period: period within the superframe period that is ready for frame reception and transmission

active state: internal power management state that is ready for the frame reception and transmission

allocation: one or more time intervals that a node or a hub obtains using an access method for initiating one or more frame transactions

beacon: frame transmitted by a hub to facilitate network management, such as the coordination of medium access and power management of the nodes in the SmartBAN, and to facilitate clock synchronization therein

beacon period: duration when a beacon is transmitted

connection: relation between a node and a hub in a Body Area Network (BAN), substantiated by an identification assigned to the node by the hub and by access arrangement between them

device: entity conforming to the SmartBAN medium access control and physical interface to the wireless medium

downlink: communication link for transfer of management and data traffic from a hub to a node, or in the context of hub to hub communication, from target hub to initiating hub

frame: uninterrupted sequence of octets delivered by the Medium Access Control (MAC) sublayer to the Physical (PHY) layer, or vice versa, within a node or a hub

hub: entity that possesses a node's functionality and coordinates the medium access and power management of the nodes in the SmartBAN

hub to hub mode: optional enhanced operation mode where hubs of neighbouring SmartBANs may form a connection, obtain allocation(s), and transmit and receive management and data traffic between them

inactive period: period in time following an active transmission sequence during which the equipment other than the hub does not transmit or receive

medical device: any instrument, apparatus, appliance, software, material or other article, whether used alone or in combination, together with any accessories, including the software intended by its manufacturer to be used specifically for diagnostic and/or therapeutic purposes and necessary for its proper application, intended by the manufacturer to be used for human beings for the purpose of:

- diagnosis, prevention, monitoring, treatment or alleviation of disease;
- diagnosis, monitoring, treatment, alleviation of or compensation for an injury or handicap;
- investigation, replacement or modification of the anatomy or of a physiological process;
- control of conception;

and which does not achieve its principal intended action in or on the human body by pharmacological, immunological or metabolic means but which may be assisted in its function by such means

multi-use channel access mode: mode of operation where the slot structure during the scheduled and control and management periods is accessible by multiple different priorities based on a temporal order

node: entity conforming to the SmartBAN medium access control and physical interface to the wireless medium

operating frequency: frequency at which the equipment can be operated

priority channel access: highest priority access during multi-use channel access

relay: node entity that is temporarily assigned by the hub the functionality to relay frames received from the node to the hub or vice versa

relay mode: optional enhanced operation mode where a node entity is temporarily assigned by the hub the functionality to relay frames received from another node to the hub and vice versa

re-use channel access: lowest priority access during multi-use channel access enables re-use of scheduled but not utilized slots

scheduled access: one or more scheduled reoccurring time intervals that a node and a hub obtains using scheduled access for initiating frame transactions

NOTE: A scheduled allocation is an uplink or downlink allocation suitable for servicing high or low duty cycle periodic or quasi-periodic traffic on a committed schedule.

star network: logical network partition comprising a hub and zero or more nodes whose medium access and power management are coordinated by the hub

uplink: communication link for transfer of management and data traffic from a node to a hub, or in the context of hub to hub communication, from initiating hub to target hub

3.2 Symbols

For the purposes of the present document, the following symbols apply:

×	Mathematical multiplication of the term immediately preceding the symbol and the term immediately following the symbol
CP_{max}	Maximum Contention Probability
CP_{min}	Minimum Contention Probability
GHz	Gigahertz
L_D	Number of time slots in Inter-Beacon Interval
L_F	Length of MAC Frame Body (bits)
MHz	Megahertz
N_{CM}	Number of time slots in Control and Management Period
N_S	Number of time slots in Schedule Period
T_C	Interval between control channel beacons
T_D	Duration of Inter-Beacon Interval
T_{MUA}	Total duration of sensing period in Multi-use Channel Access
T_S	Duration of a time slot

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ACK	Acknowledgement
BAN	Body Area Network
C-Beacon	Control Channel Beacon
CCH	Control Channel
C-Frame	Control Frame
D-Beacon	Data Channel Beacon
DCH	Data Channel
D-Frame	Data Frame
DL	DownLink
IBI	Inter-Beacon Interval
I-Listen	Isolated Node Notification Listen
IM	Information Module
I-Notif	Isolated Node Notification
I-Sack	Isolated Node Slot Reassignment Acknowledgement
ISM	Industrial, Scientific and Medical
IU	Information Units
MAC	Medium Access Control

N-Sreq	Node Status Request
PHY	Physical Layer
R-Beacon	Relay Beacon
R-Conn	Relay Connection
R-Dreq	Relay Disconnection Request
R-Nom	Relay Nomination
R-Status	Proposed Relay Link Status
Rx	Receive
S-Listen	Stop Isolated Node Listening
S-Ras	Slot Reassignment
WBAN	Wireless Body Area Network

4 General MAC Framework

4.0 Different device types

This clause provides the basic MAC framework for the nodes and hubs.

Two different device types can participate in SmartBAN: a medical sensor device (node) and a coordinator device (hub). A hub is a device that acts as a SmartBAN coordinator. A node is any device that acts as an information source or an information sink. A relay is a node entity temporarily assigned by the hub the functionality to relay frames received from the node to the hub or vice versa. One hub and at least one node constitute a SmartBAN.

A SmartBAN shall be organized into a star topology consisting of at least one node communicating directly with the hub.

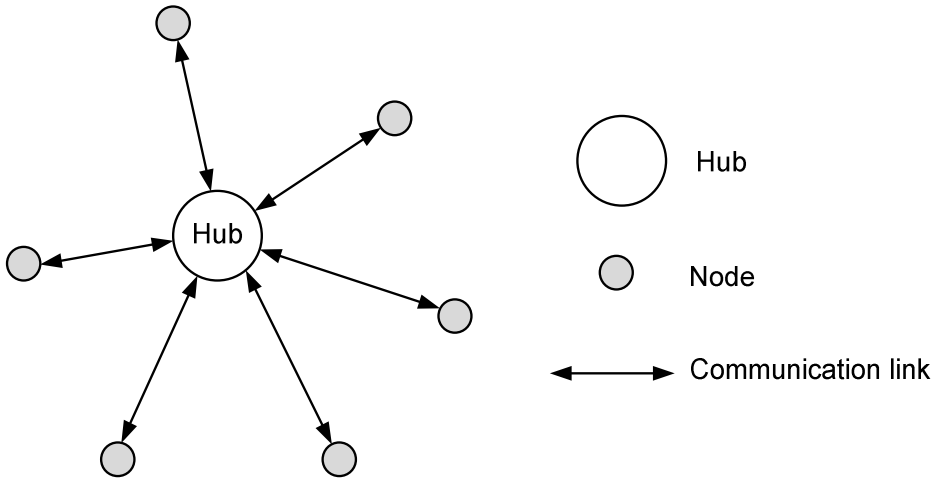

Figure 1: SmartBAN Topology

The hub and nodes shall communicate using communication media known as channels. A SmartBAN shall use two different channel entities to enable communication between the hub and nodes. The channel entities are assigned the following names:

- Data Channel (DCH).
- Control Channel (CCH).

Each SmartBAN shall utilize one Control Channel (CCH) and one Data Channel (DCH) at any one time.

4.1 Frequency Spectrum

Defined in ETSI TS 103 325 [1].

4.2 Channel Format

Defined in ETSI TS 103 325 [1].

4.3 User Priorities

Defined in ETSI TS 103 325 [1].

4.4 Node IDs

Defined in ETSI TS 103 325 [1].

4.5 Information Units

Information Units (IUs) encapsulate the required information for specific operations. IUs shall be defined as follows:

- IUs for Management, Control, and Data frame types:
  - Defined in ETSI TS 103 325 [1].
- IUs for General purpose frame type:
  - Operations requiring IUs shall use the appropriate Element ID listed in Table 1. An IU shall be formatted as in Figure 2.

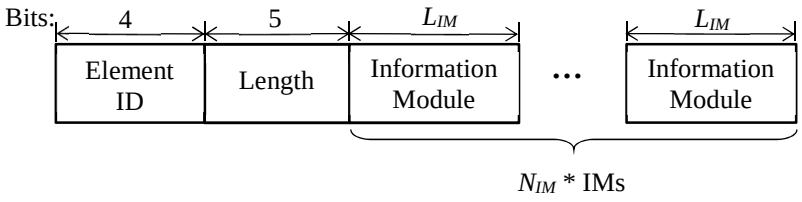

Figure 2: Structure of an Information Unit for General Purpose Frame Type

Table 1: Element ID for relay connectivity and hub to hub communication operations

Element ID	Operation	Notation	Description
0000	Isolated Node Notification	I-Notif	The way an isolated node notifies the WBAN about its new status
0001	Node Status Request	N-Sreq	Explains the node status requirement when a certain node does not transmit in its scheduled slots
0010	Isolated Node Notification Listen	I-Listen	Explains the command details given to the nodes to start listening to Isolated Node Notifications
0011	Relay Nomination	R-Nom	Explains the details about the R-Beacon transmission period
0100	Proposed Relay Link Status	R-Status	Explains if the proposed relay link is successful/unsuccessful
0101	Stop Isolated Node Listening	S-Listen	Explains the command details given to the nodes to stop listening to Isolated Node Notifications
0110	Relay Connection	R-Conn	Describes the details of the relay connection
0111	Isolated Node Slot Reassignment ACK	I-SAck	Acknowledgement by the Isolated node for the new slot allocations
1000	Relay Disconnection Request	R-Dreq	Explains the requirement for a relay disconnection
1001	Relay Beacon	R-Beacon	Explains the beacon frame transmitted from a Relay to an isolated node
1010	Hub to Hub Connection Request	H-Creq	Specifies connection request command from a hub to request connection with a neighbouring hub
1011-1111	Reserved		Reserved

5 Frame Formats

5.1 MAC General Frame Format

Defined in ETSI TS 103 325 [1].

5.2 Management Frames

5.2.0 Management Frames for Relay Communication

In addition to the management frames defined in ETSI TS 103 325 [1], the following management frames are applied in the context of the present document.

5.2.1 Isolated Node Notification (I-Notif)

The Isolated Node Notification frame shall be formatted as an Information Unit as described in clause 4.5. The Information Unit shall consist of at least 1 Information Module with elements listed in Table 2.

Table 2: Information Module Field for Isolated Node Notification Information Unit

Type	Number of bits	Subfields	Number of bits
Isolated Node Notification	≥ 8	Isolated Node ID	8

5.2.2 Node Status Request (N-Sreq)

The Node Status Request frame shall be formatted as an Information Unit as described in clause 4.5. The Information Unit shall consist of at least 1 Information Module with elements listed in Table 3.

Table 3: Information Module Field for Node Status Request Information Unit

Type	Number of bits	Subfields	Number of bits
Node Status Request	0	null	0

5.2.3 Isolated Node Notification Listen (I-Listen)

The Isolated Node Notifications Listen frame shall be formatted as an Information Unit as described in clause 4.5. The Information Unit shall consist of at least 1 Information Module with elements listed in Table 4.

Table 4: Information Module Field for Isolated Node Notification Listen Information Unit

Type	Number of bits	Subfields	Number of bits
Isolated Node Notification Listen	≥ 24	Node ID	8
		Listen Start Timing	8
		Listen End Timing	8

5.2.4 Relay Nomination (R-Nom)

The Relay Nomination frame shall be formatted as an Information Unit as described in clause 4.5. The Information Unit shall consist of at least 1 Information Module with elements listed in Table 5.

Table 5: Information Module Field for Relay Nomination Information Unit

Type	Number of bits	Subfields	Number of bits
Relay Nomination	≥ 16	Isolated Node ID	8
		R-Beacon Start Timing	8

5.2.5 Proposed Relay Link Status (R-Status)

The Proposed Relay Link Status frame shall be formatted as an Information Unit as described in clause 4.5. The Information Unit shall consist of at least 1 Information Module with elements listed in Table 6.

Table 6: Information Module Field for Link Status Information Unit

Type	Number of bits	Subfields	Number of bits
Proposed Relay Link Status	≥ 8	Relay Link Status	1
		Reserved	7

The Relay Link Status subfield describes the status of the proposed relay connection. The bits layout of the Information Module is indicated in Table 7. If bit b1 is set to 1, the connection is successful; otherwise, the connection is unsuccessful.

Table 7: Information Bits Layout in a Proposed Relay Link Status Frame

b8	b7	b6	b5	b4	b3	b2	b1
x	x	x	x	x	x	x	Relay Link Status

5.2.6 Stop Isolated Node Listening (S-Listen)

The Stop Isolated Node Listening frame shall be formatted as an Information Unit as described in clause 4.5. The Information Unit shall consist of at least 1 Information Module with elements listed in Table 8.

Table 8: Information Module Field for Stop Isolated Node Listening Information Unit

Type	Number of bits	Subfields	Number of bits
Stop Isolated Node Listening	≥ 16	Node ID	8
		Stop Listening Timing	8

5.2.7 Relay Connection (R-Conn)

The Relay Connection frame shall be formatted as an Information Unit as described in clause 4.5. The Information Unit shall consist of at least 1 Information Module with elements listed in Table 9.

Table 9: Information Module Field for Relay Connection Information Unit

Type	Number of bits	Subfields	Number of bits
Relay Connection	≥ 16	Isolated Node ID	8
		Relay Start timing	8

5.2.8 Isolated Node Slot Reassignment ACK (I-Sack)

The Isolated Node Slot Reassignment frame shall be formatted as an Information Unit as described in clause 4.5. The Information Unit shall consist of at least 1 Information Module with elements listed in Table 10.

Table 10: Information Module Field for Isolated Node Slot Reassignment ACK Information Unit

Type	Number of bits	Subfields	Number of bits
Isolated Node Slot Reassignment ACK	8	Slot Reassignment	1
		Reserved	7

The Slot Reassignment subfield indicates the type of acknowledgement for the slot reassignment made. The bits layout of the Information Module is indicated in Table 11. If bit b1 is set to 1, slot reassignment is successful; otherwise, the slot reassignment is unsuccessful.

Table 11: Information Bits Layout in an Isolated Node Slot Reassignment ACK Frame

b8	b7	b6	b5	b4	b3	b2	b1
x	x	x	x	x	x	x	Slot Reassignment

5.2.9 Relay Disconnection Request (R-Dreq)

The Relay Disconnection Request frame shall be formatted as an Information Unit as described in clause 4.5. The Information Unit shall consist of at least 1 Information Module with elements listed in Table 12.

Table 12: Information Module Field for Relay Disconnection Request Information Unit

Type	Number of bits	Subfields	Number of bits
Relay Disconnection Request	8	Reason	8

The Reason subfield of the Information Module describes the reason for the relay disconnection request. The bit values of the field shall be set according to Table 13.

Table 13: Bit values for the Reason subfield

Bit Value	Reason for a relay disconnection
00000000	Isolated node wants to switch to normal connectivity
00000001	Stop operation
00000010	Insufficient resources
00000011	Unknown
00000100 - 11111111	Reserved

5.2.10 Relay Beacon (R-Beacon)

Relay Beacon is a D-Beacon received by the relay from the hub and further transmitted by the relay to the isolated node. R-Beacon shall be formatted as D-Beacon described in clause 6.2.2 of ETSI TS 103 325 [1].

To signal that the R-Beacon is sent by the relay to the isolated node, the following two steps shall be performed:

1) The Recipient ID field in the MAC Header shall be set as the Node ID of the isolated node.

2) The Sender ID field in the MAC Header shall be set as the Node ID of the relay.

5.3 Control Frames (C-Frame)

Defined in ETSI TS 103 325 [1].

5.4 Data Frames (D-Frame)

Defined in ETSI TS 103 325 [1].

6 Relay Communication

6.1 Relay Connectivity Initialization

Any relay connection shall be initiated with the joint effort of the hub and the node seeking the relay connection. Each one performs certain procedures, as illustrated in Figure 4 and Figure 5. The Isolated node commences broadcasting Isolated Node Notifications, and the hub performs the following steps:

1) The hub identifies that a certain node fails to transmit a frame during its allocated time slot for the n^{th} consecutive Inter-Beacon Interval (IBI).

2) The hub, on the D-Beacon, signals to the node for a downlink data.

3) The node, if it is not experiencing any problem, acknowledges the command while transmitting its uplink data during its allocated time slot and listens for the downlink data during the C/M Period. Then, the hub can either transmit a Node Status Request frame in the C/M Period or ignore the remaining steps of the status request procedure.

4) If the hub does not receive an acknowledgement from the node for the downlink data signal, it repeats the procedure as many times as necessary in the following D-Beacons. If the hub still does not receive an acknowledgement from the node, it concludes that the node is experiencing a connection problem or it is isolated.

5) During the C/M period of the next Inter-Beacon Interval, the hub broadcasts an Isolated Node Notification Listen command to the network. Once the nodes receive the command, they start listening, until further notice from the hub, for Isolated Node Notifications from the Isolated node starting from the C/M period of the next Inter-Beacon Interval.

6) If the hub receives the Isolated Node Notification frame, the reconnection process is made directly with the Isolated node. This implies the Isolated node can receive the D-Beacon frame and gets synchronized easily. Otherwise, candidate relay nodes can forward the notification frame to the hub in the C/M period, and they do not expect any acknowledgement for it from the hub. To minimize the effect on the SmartBAN's performance (to save resources), nodes can forward the message only once during the current IBI, and otherwise discard the message.

7) The hub receives all relayed Isolated Node Notifications during the current IBI, and it performs the following steps:

   a) Among the candidate nodes, it nominates a node for the relay connection. This is implemented by indicating to the nominated node on the D-Beacon a downlink data and a slot reassignment. The indicated Slot Reassignment frame contains slot allocation details for the R-Beacon period. The R-Beacon period will be used for the relay-to-isolated node beacon information transmissions. The timing for the slot allocation is indicated on the D-Beacon.

   b) The hub transmits the Relay Nomination frame in the C/M period as a downlink data and the Slot Reassignment frame to the relay. If the hub is unable to deliver the frames in the current Inter-Beacon Interval, it shall attempt again in the next Inter-Beacon Interval by using the above-mentioned procedure.

8) The nominated node acknowledges the nomination and slot reassignments using the Command Ack bit when it transmits a frame during its own time slots.

9) On the R-Beacon period, the relay transmits the R-Beacon to the isolated node so that it gets synchronized to the SmartBAN. By setting the ACK field of the Frame Control of the R-Beacon, the relay indicates and hence expects for an immediate acknowledgement from the Isolated node. The immediate ACK for the R-Beacon by the isolated node helps to make sure a successful link is created between the relay and the isolated node. Once the R-Beacon is acknowledged, the isolated node stops transmitting Isolated Node Notifications to the network and waits for further details from the relay.

10) During the same Inter-Beacon Interval, the relay informs the hub about the successful/unsuccessful establishment of a relay link to the isolated node by sending the Proposed Relay Link Status frame in the C/M period.

11) After receiving the Proposed Relay Link Status frame, the hub broadcasts a Stop Isolated Node Listening command to all nodes to stop receiving and relaying Isolated Node Notifications from the target isolated node. In the next D-Beacon, the hub indicates slot reassignments for the other nodes in the network which need slot reassignments to enable the relay connectivity. The slot reassignment can be done in more than one Inter-Beacon Interval if not successful in the first attempt.

12) After the slot reassignment for the other nodes is successful, the hub signals for a downlink data (Relay Connection frame) to the relay and slot reassignments for the relay and isolated node. The Relay Connection and Slot Reassignment frames are transmitted during the C/M period and acknowledged by the relay in the next Inter-Beacon Interval while transmitting data on its time slots.

13) On the R-Beacon of the same Inter-Beacon Interval, the relay indicates a slot reassignment for the isolated node. Then, the Slot Reassignment frame is transmitted during the C/M Period.

14) The isolated node acknowledges the slot reassignment by sending the Isolated Node Slot Reassignment ACK frame during the next Inter-Beacon Interval C/M period, and the relay delivers the Isolated Node Slot Reassignment ACK to the hub during the same C/M period or during the next one if not successful.

A sample Inter-Beacon Interval structure of a relay-enabled SmartBAN showing the new time slot allocations for the R-Beacon period, isolated node, and for the relay is shown in Figure 3. The hub allocates time slots for the R-Beacon period, isolated node, and for the relay according to the order shown in Figure 3.

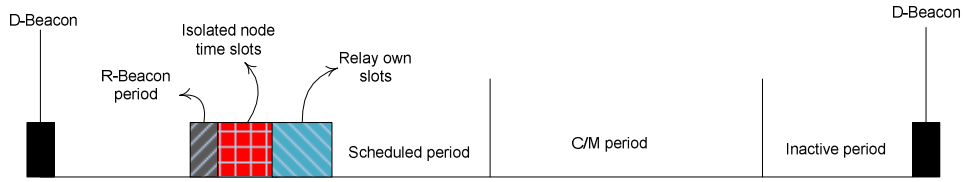

Figure 3: Inter-Beacon Interval Structure in a Relay-Enabled SmartBAN Illustrating Time Slot Allocations for R-Beacon, Isolated Node, and Relay

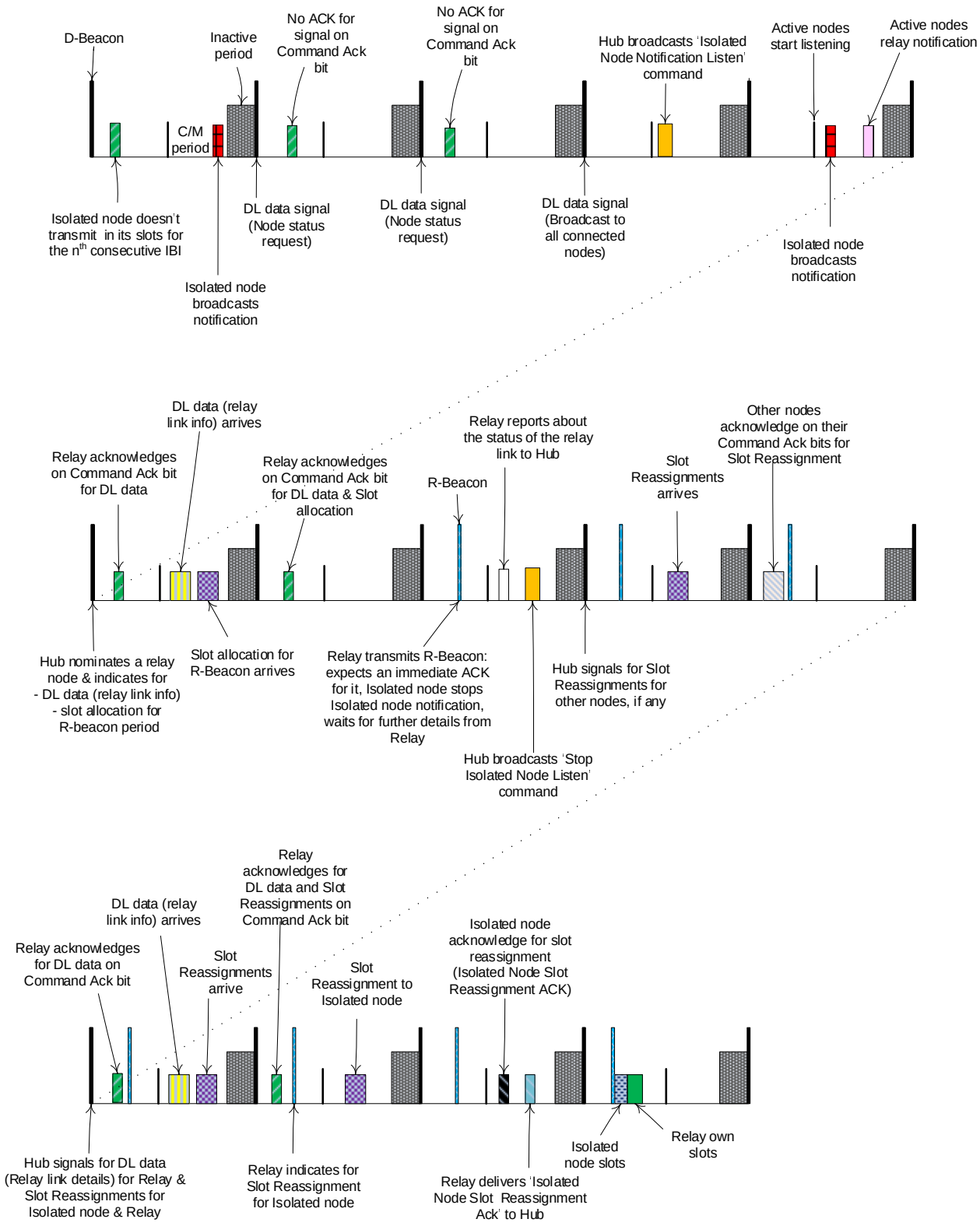

Figure 4: Relay Connectivity Establishment Procedure

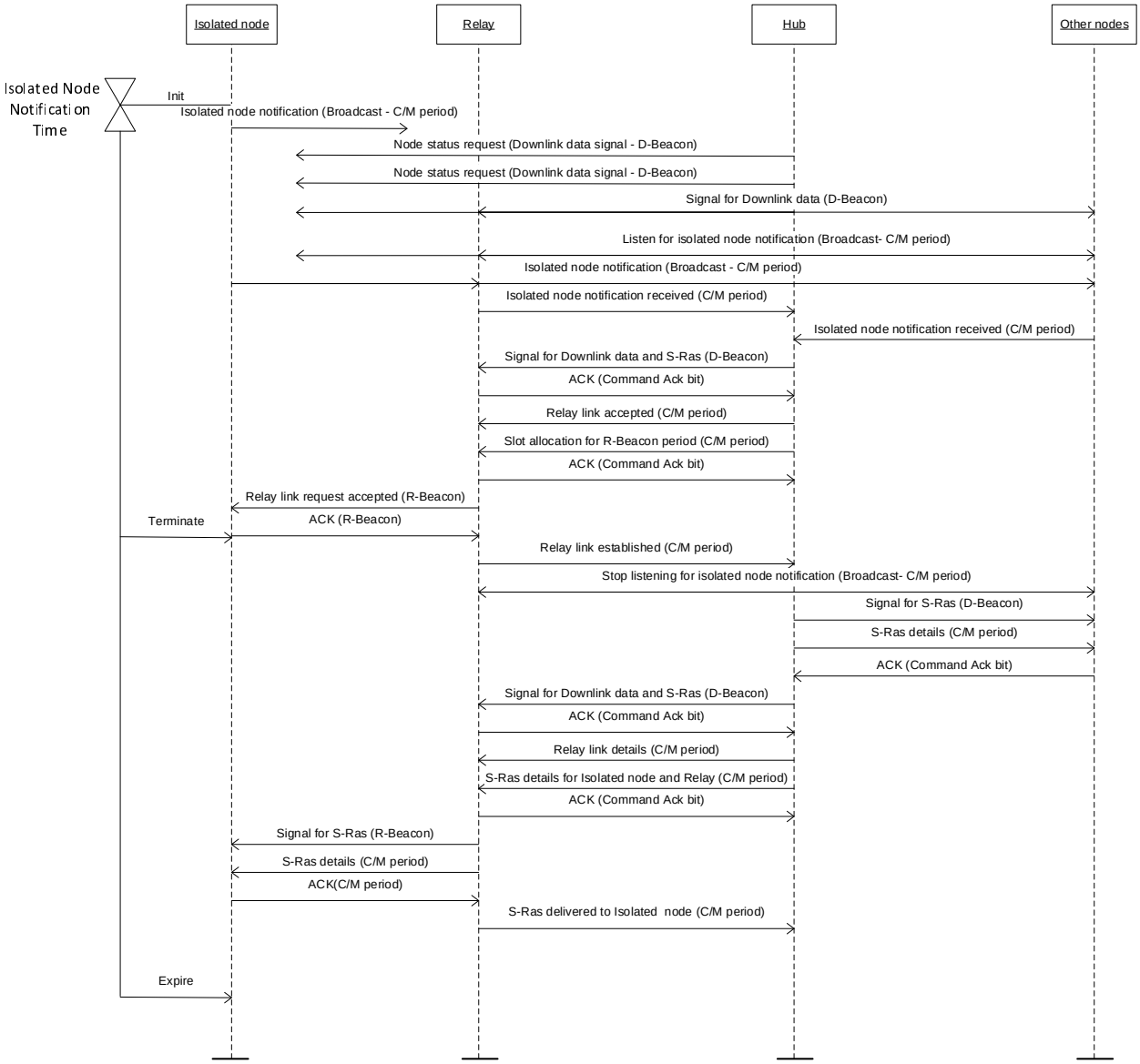

Figure 5: Relay Connectivity Initialization Message Sequence Chart

6.2 Maintaining Relay Connectivity

The Isolated node receives R-Beacons during the R-Beacon period and gets updates about the network resources, upcoming downlink data, slot reassignments, etc.

The slots allocated for the Isolated node are divided into two equal groups. In the first group of slots, the isolated node transmits its data to the relay; and the relay uses the second group of slots to deliver the isolated node data to the hub. The isolated node can also send data and control and management frames during the C/M period by using the same procedure.

Then, the relay transmits its own data only during its own slots or during the C/M period.

While getting the relay access to the SmartBAN through the relay, the isolated node continues to listen for a D-Beacon from the hub, and if it receives one, it starts counting for up to three consecutive D-Beacons, and then it terminates the relay access after completing any already started tasks.

6.3 Ending Relay Connectivity

The relay disconnection can be initiated by the isolated node, the relay, or by the hub.

The isolated node initiates the disconnection request by sending a disconnection frame with a null payload frame. The 'Disconnection Request' frame and the corresponding 'Disconnection Response' frame shall be the same as those defined in clauses 6.2.6 and 6.2.7 of ETSI TS 103 325 [1].

The relay can invoke the disconnection by sending a disconnection command to both the isolated node and the hub. The relay connection can be disconnected if one of them approves the disconnection request. For this purpose, the relay sends 'Disconnection Request' and 'Relay Disconnection Request' command frames to the isolated node and to the hub, respectively. The 'Disconnection Response' frame formats for both are defined in the SmartBAN standard. In doing so, the hub removes allocated time slots for the R-Beacon period and for the Isolated node.

The hub can initiate a disconnection request by sending a 'Relay Disconnection Request' frame to the relay.

Annex A (normative): Relay Connectivity Establishment

Figures A.1 and A.2 describe the relay connectivity establishment by the isolated node and by the hub, respectively.

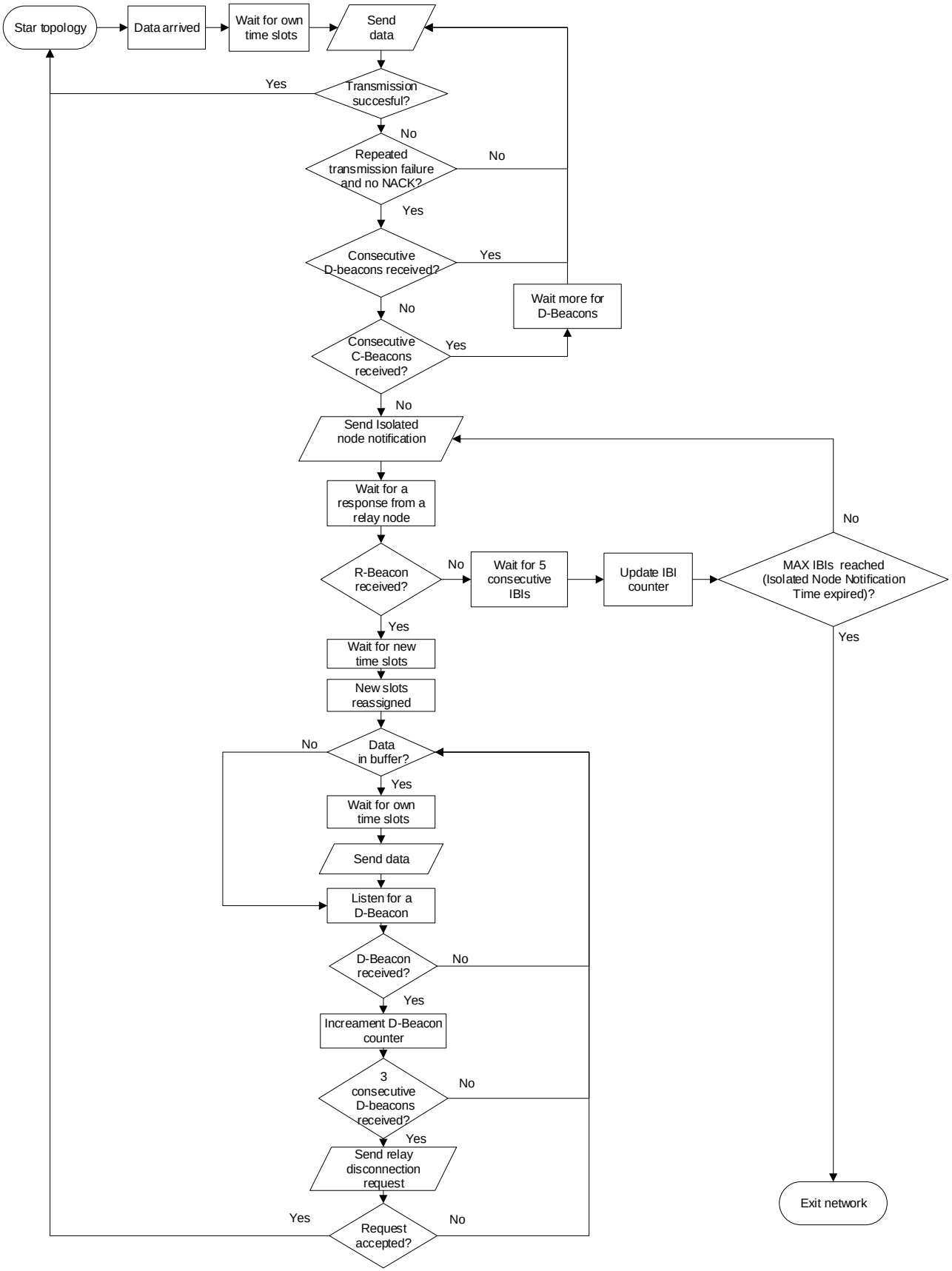

Figure A.1: Flowchart of Relay Connectivity Establishment by the Isolated Node

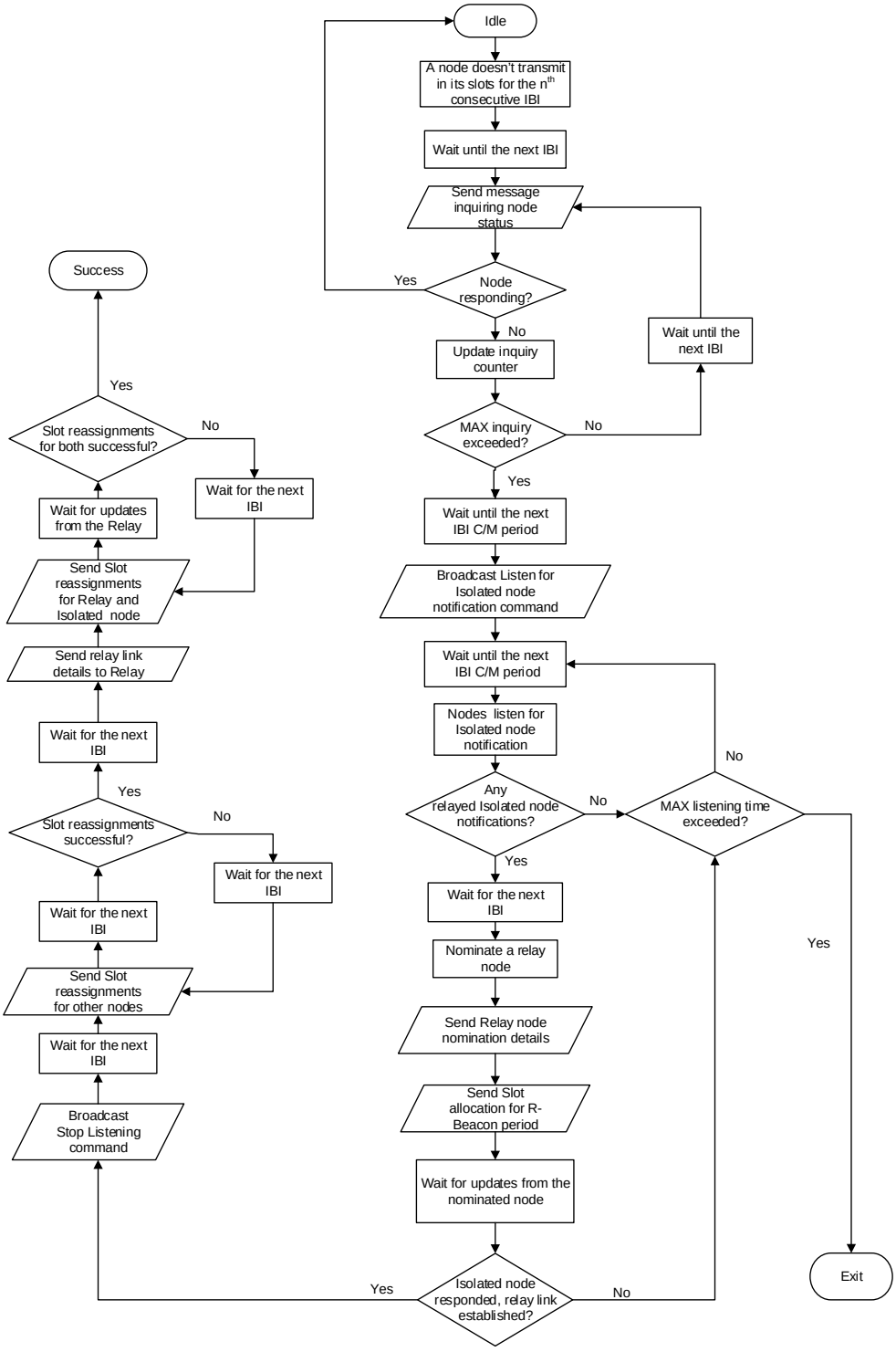

Figure A.2: Flowchart of Relay Connectivity Establishment by the Hub

History

Document history		
V1.1.1	January 2024	Publication