UE-A UE-B UE-C eNodeB

LTE Random Access Procedure

LTE random access procedure is used by the UEs to initiate a data transfer. The UEs also obtain uplink timing information from the initial handshake.

This sequence diagram describes the tale of three UEs (UE-A, UE-B and UE-C) that are powered on at the same time:

(1) UEs synchronize with the downlink channel by decoding the PSS and SSS signal. The UEs are synchronized to the downlink frames after completing this procedure.

(2) The three UEs initiate the random access procedure at exactly the same time. Two of them (UE-A and UE-B) happen to pick the same preamble. This results in a resulting in a collision. UE-C picks a distinct preamble so it succeeds in the random access procedure.

(3) Contention between UE-A and UE-B is resolved in UE-A'S favor. UE-A proceeds with the RRC connection.

(4) UE-C times out and retries the random access procedure.

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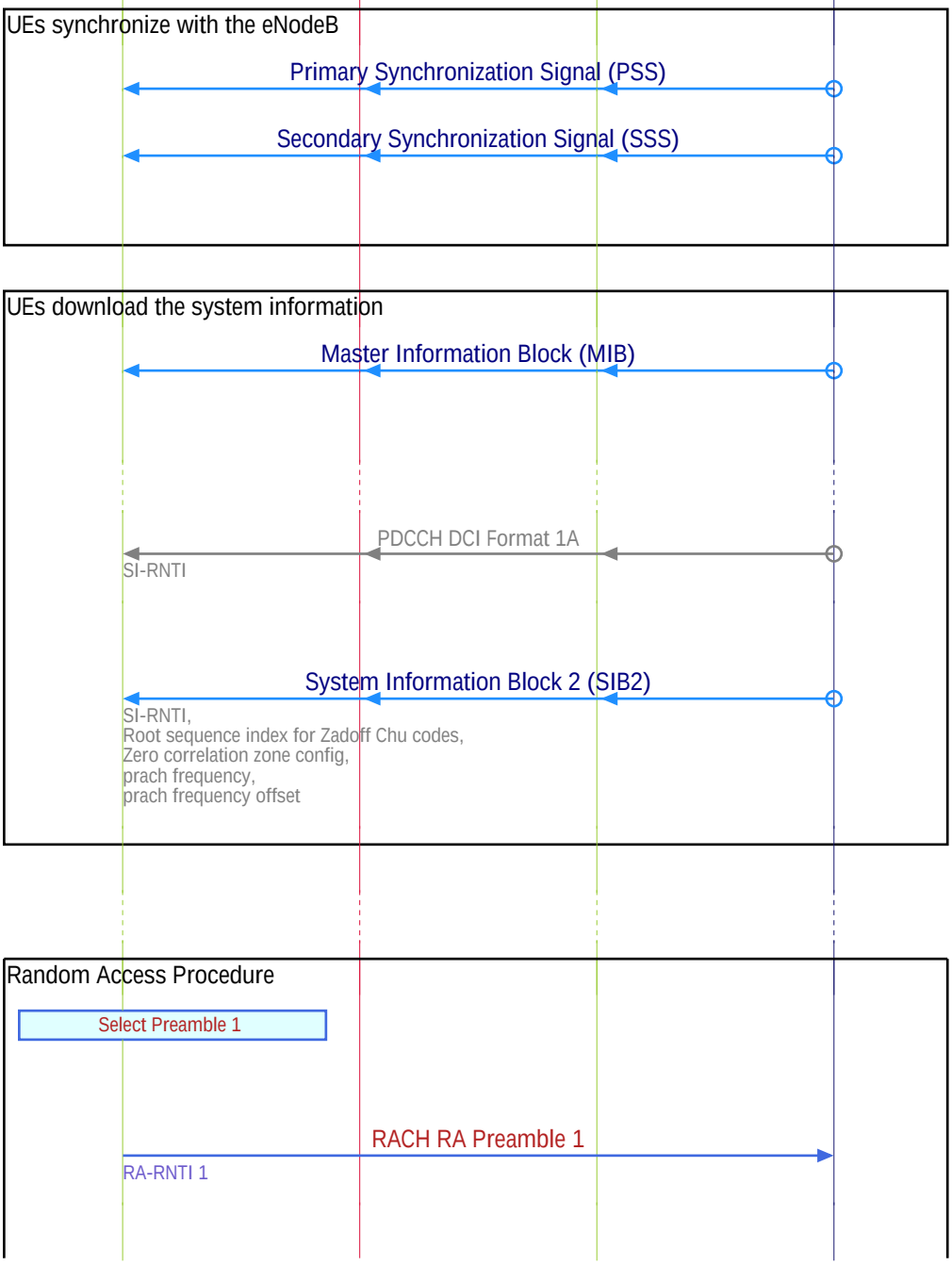


PSS is transmitted at the start and middle of every 10ms frame.

The SSS is also transmitted every 5ms. The pattern alternates every 5ms. The UE achieves downlink frame synchronization once it has decoded both SSS patterns.

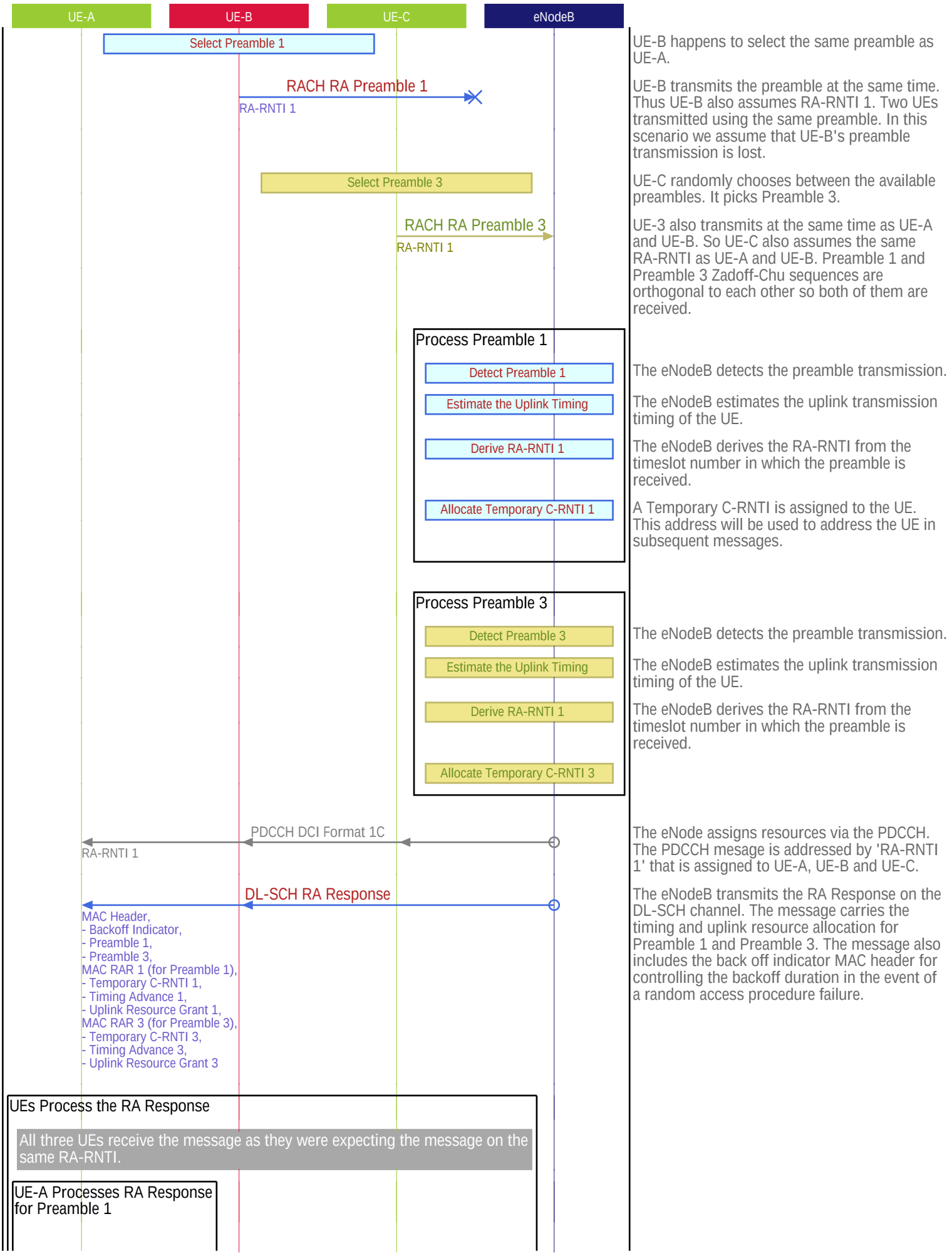
UEs download the MIB from the broadcast channel. This channel contains information about the location of the downlink and uplink carrier configuration.

The UEs tune to the PDCCH to look for DCI (Downlink Control Information) addressed with the SI-RNTI. The UL-SCH assigned by the PDCCH contains System Information Block (SIB) messages.

The UEs download the System Information Blocks from the DL-SCH. SIB2 download contains parameters needed for initial access transmission.

The UE-A randomly selects an RA preamble sequence from the set of sequences available in the cell. The preamble selection is a shift in the Zadoff-Chu code for the cell.

UE-A transmits the Preamble on an RA channel. This transmission carries no data bits. The RA-RNTI is is implicitly specified by the timing of the preamble transmission.



UE-B happens to select the same preamble as UE-A.

UE-B transmits the preamble at the same time. Thus UE-B also assumes RA-RNTI 1. Two UEs transmitted using the same preamble. In this scenario we assume that UE-B's preamble transmission is lost.

UE-C randomly chooses between the available preambles. It picks Preamble 3.

UE-3 also transmits at the same time as UE-A and UE-B. So UE-C also assumes the same RA-RNTI as UE-A and UE-B. Preamble 1 and Preamble 3 Zadoff-Chu sequences are orthogonal to each other so both of them are received.

The eNodeB detects the preamble transmission.

The eNodeB estimates the uplink transmission timing of the UE.

The eNodeB derives the RA-RNTI from the timeslot number in which the preamble is received.

A Temporary C-RNTI is assigned to the UE. This address will be used to address the UE in subsequent messages.

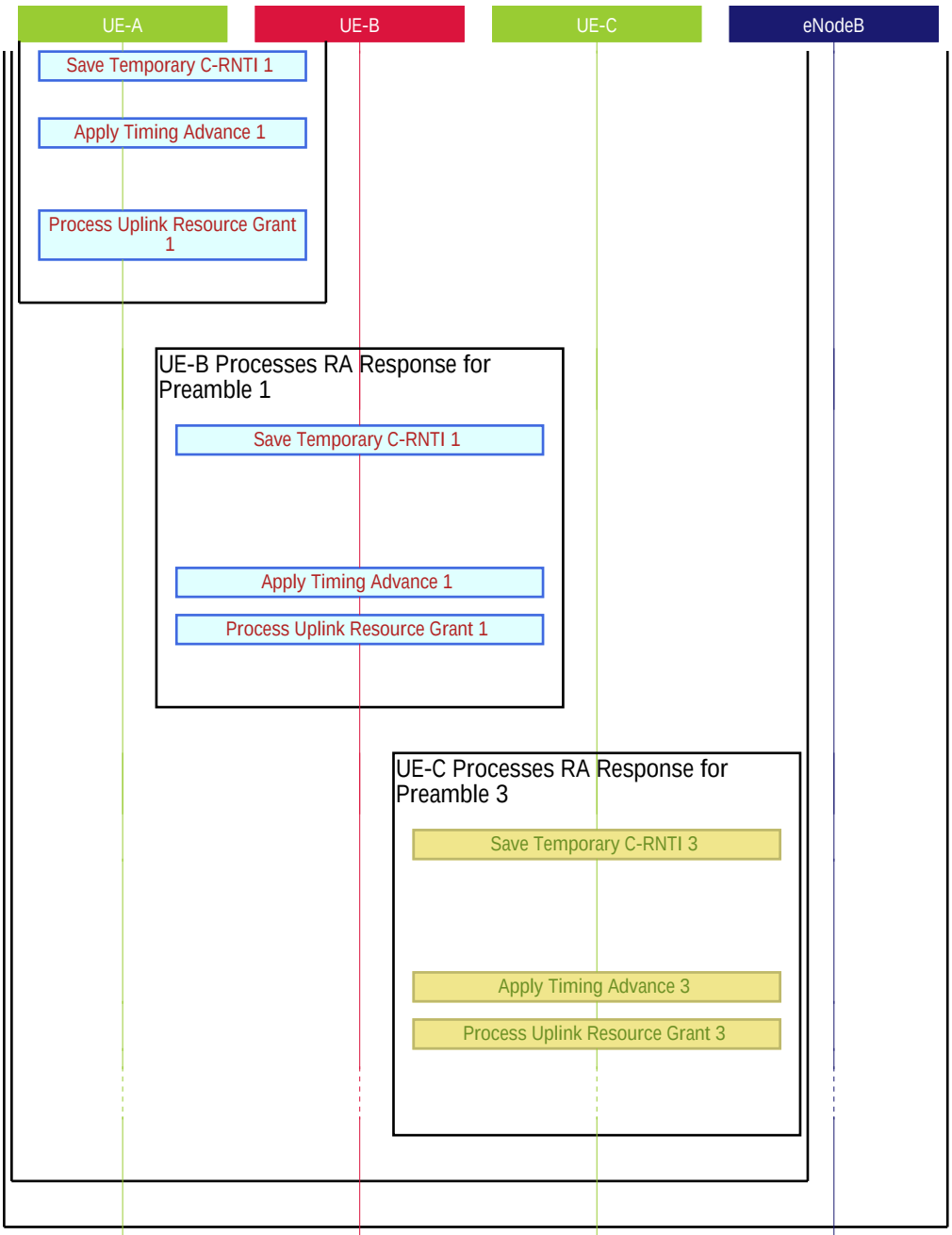
The eNodeB detects the preamble transmission.

The eNodeB estimates the uplink transmission timing of the UE.

The eNodeB derives the RA-RNTI from the timeslot number in which the preamble is received.

The eNode assigns resources via the PDCCH. The PDCCH mesage is addressed by 'RA-RNTI 1' that is assigned to UE-A, UE-B and UE-C.

The eNodeB transmits the RA Response on the DL-SCH channel. The message carries the timing and uplink resource allocation for Preamble 1 and Preamble 3. The message also includes the back off indicator MAC header for controlling the backoff duration in the event of a random access procedure failure.



UE-A saves the Temporary C-RNTI from the MAC data for Preamble 1.

After applying the correction, the UE is synchronized in the return direction and can transmits data bursts to the eNodeB.

The eNodeB assigned uplink resource information will be used to transmit the data to the eNodeB.

UE-B mistakenly believes that the RA Response is meant for it. The RA-RNTI and Preamble in the message match. UE-B has no way of knowing that the message was really meant for UE-A only.

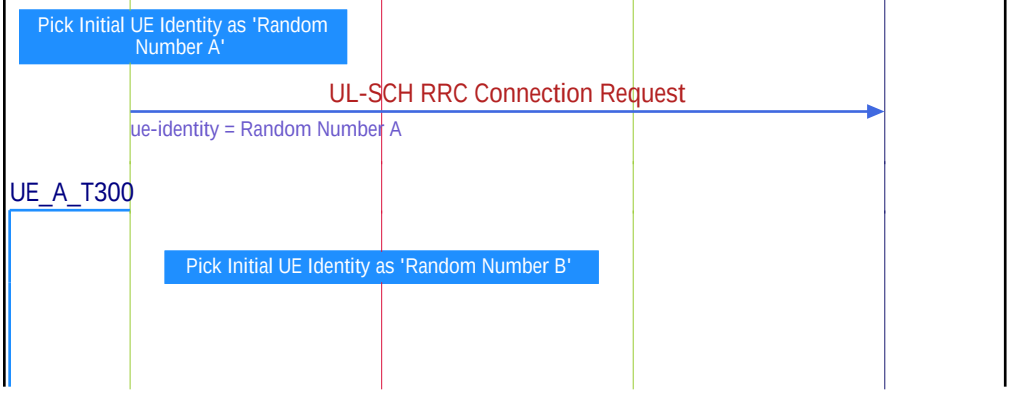
UE-B is continuing with the procedure even though had been rejected. This situation will be resolved after the contention resolution phase.

UE-C saves the Temporary C-RNTI from the MAC data for Preamble 3 and goes ahead with the random access procedure normally. The further procedure for UE-C is not shown in this flow.

Contention Resolution

The randomly selected RA preamble does not enable unique identification of the UE, and it is possible that multiple UEs attempted RA with the same RA preamble sequence on the same RA channel. The Contention Resolution phase helps uniquely identify the UE that has been selected.

In this scenario, contention resolution will resolve the random access procedure between UE-A and UE-B.

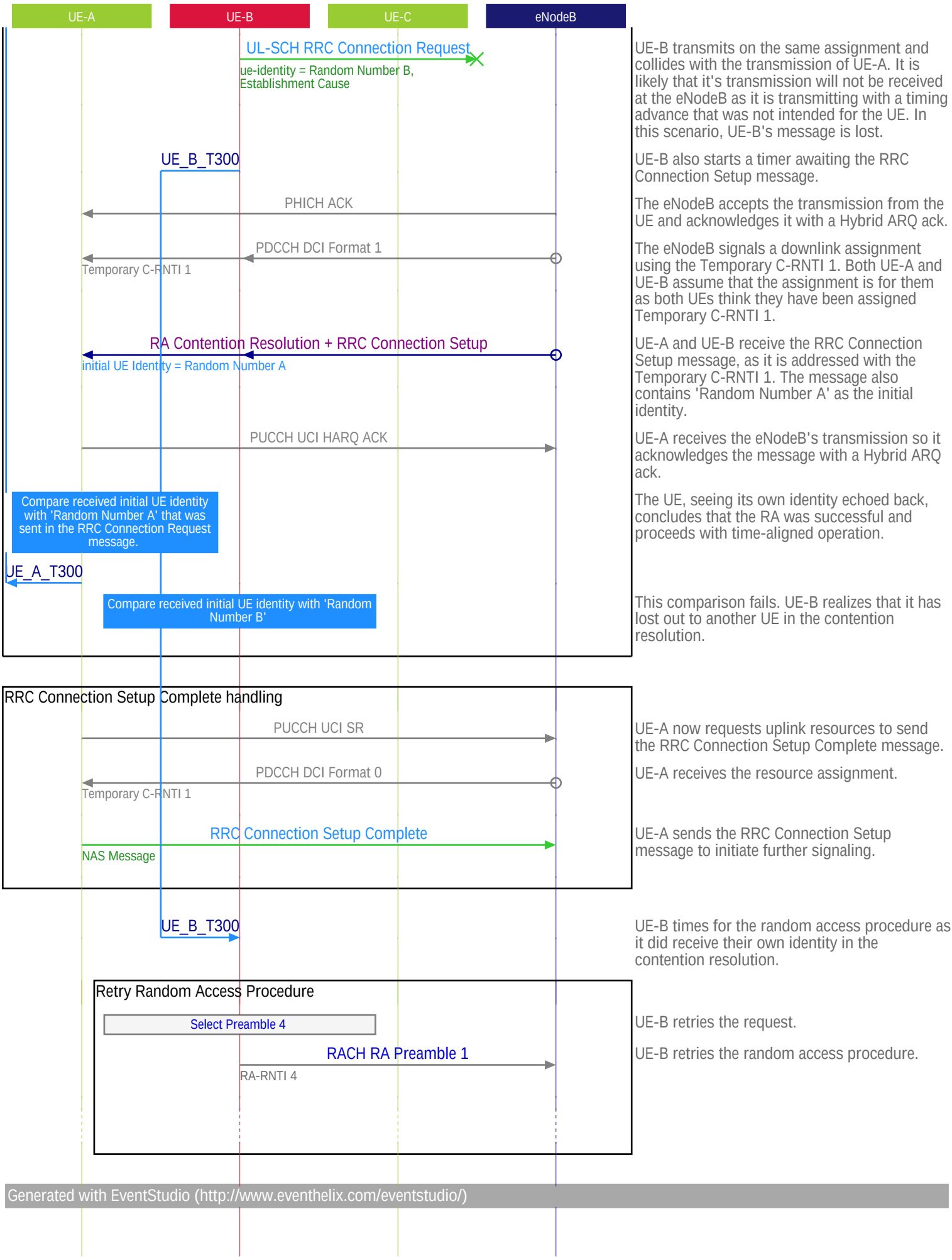


UE-A does not have a permanent identity, so it picks a random number as the UE identity.

The random UE identity is included in the RRC connection request.

UE-A starts the T300 timer, awaiting the RRC Connection Setup message.

UE-B also picks a random number as its UE identity.



UE-B transmits on the same assignment and collides with the transmission of UE-A. It is likely that it's transmission will not be received at the eNodeB as it is transmitting with a timing advance that was not intended for the UE. In this scenario, UE-B's message is lost.

UE-B also starts a timer awaiting the RRC Connection Setup message.

The eNodeB accepts the transmission from the UE and acknowledges it with a Hybrid ARQ ack.

The eNodeB signals a downlink assignment using the Temporary C-RNTI 1. Both UE-A and UE-B assume that the assignment is for them as both UEs think they have been assigned Temporary C-RNTI 1.

UE-A and UE-B receive the RRC Connection Setup message, as it is addressed with the Temporary C-RNTI 1. The message also contains 'Random Number A' as the initial identity.

UE-A receives the eNodeB's transmission so it acknowledges the message with a Hybrid ARQ ack.

The UE, seeing its own identity echoed back, concludes that the RA was successful and proceeds with time-aligned operation.

This comparison fails. UE-B realizes that it has lost out to another UE in the contention resolution.

UE-A now requests uplink resources to send the RRC Connection Setup Complete message.

UE-A receives the resource assignment.

UE-A sends the RRC Connection Setup message to initiate further signaling.

UE-B times for the random access procedure as it did receive their own identity in the contention resolution.

UE-B retries the request.

UE-B retries the random access procedure.


UE-A
UE-B
UE-C
eNodeB
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