26.1 RRC CONNECTION ESTABLISHMENT

- RRC connection establishment is used to make the transition from RRC Idle mode to RRC Connected mode. UE must make the transition to RRC Connected mode before transferring any application data, or completing any signalling procedures
- The RRC connection establishment procedure is always initiated by the UE but can be triggered by either the UE or the network. For example, the UE triggers RRC connection establishment if the end-user starts an application to browse the internet, or to send an email. Similarly, the UE triggers RRC connection establishment if the UE moves into a new Tracking Area and has to complete the Tracking Area Update signalling procedure. The network triggers the RRC connection establishment procedure by sending a Paging message. This could be used to allow the delivery of an incoming SMS or notification of an incoming voice call
- RRC connection establishment for LTE is relatively simple compared to UMTS. The UMTS procedure requires NBAP and ALCAP signalling across the Iub interface between the Node B and RNC. These signalling protocols are used to setup a radio link and new transport connection. The flat network architecture for LTE removes the requirement for these signalling procedures
- In the case of LTE, the initial Non-Access Stratum (NAS) message is transferred as part of the RRC connection establishment procedure. In the case of UMTS, the initial NAS message is transferred after the RRC connection establishment procedure. The approach used by LTE helps to reduce connection establishment delay
- RRC connection establishment configures Signalling Radio Bearer (SRB) 1 and allows subsequent signalling to use the Dedicated Control Channel (DCCH) rather than the Common Control Channel (CCCH) used by SRB 0
- The signalling for RRC connection establishment is shown in Figure 234. The entire procedure is completed using only RRC signalling. A 3-way handshake is used to move the UE into RRC connected mode

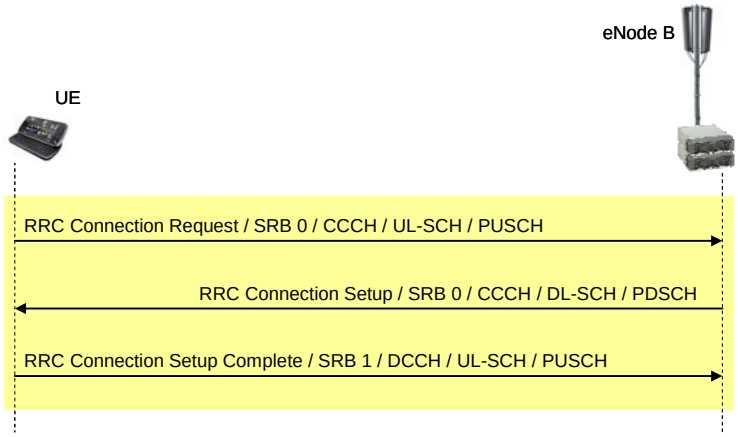

Figure 234 – Signalling for RRC connection establishment

- The RRC Connection Request message is sent as part of the Random Access procedure. It corresponds to the initial Layer 3 message shown in Figure 202 (section 24.1). It is transferred using SRB 0 on the Common Control Channel (CCCH) because neither SRB 1 nor a Dedicated Control Channel (DCCH) have been setup at this point. The uplink Resource Block allocation for the RRC Connection Request message is signalled within the Random Access Response message
- The content of the RRC Connection Request message is shown in Table 283. It includes a UE identity and an establishment cause. There is no scope for the UE to report any measurements within the RRC Connection Request message. The UMTS version of the RRC Connection Request message allows the UE to report CPICH measurements which can subsequently be used for open loop power control calculations

Information Elements	
UE Identity	CHOICE
	S-TMSI
	Random Value
Establishment Cause	CHOICE
	Emergency
	High Priority Access
	Mobile Terminating Access
	Mobile Originating Signalling
	Mobile Originating Data
	Delay Tolerant Access (3GPP release 10)

Table 283 – Content of RRC Connection Request message

- The UE identity is signalled using the SAE Temporary Mobile Subscriber Identity (S-TMSI) if the UE is registered with the Tracking Area to which the current cell belongs. Otherwise, the UE selects a random number in the range from 0 to 2^{40} - 1 to represent the UE identity. The S-TMSI is described in section 33.2
- The establishment cause within the RRC Connection Request message is determined by the Non-Access Stratum (NAS) procedure for which the connection is being established. The relationship between establishment cause and NAS procedure is specified by 3GPP TS 24.301. This relationship is presented in Table 284

NAS Procedure		RRC Establishment Cause
Attach		Mobile Originating Signalling Delay Tolerant Access Emergency
Detach		Mobile Originating Signalling
Tracking Area Update		Mobile Originating Signalling Delay Tolerant Access Emergency
Service Request	User plane radio resources request	Mobile Originating Data Delay Tolerant Access Emergency
	Uplink signalling resources request	Mobile Originating Data Delay Tolerant Access
	Paging response for PS core network domain	Mobile Terminating Access
	PDN connectivity request with cause ‘emergency’	Emergency
Extended Service Request	Mobile originating CS fallback	Mobile Originating Data Delay Tolerant Access
	Mobile terminating CS fallback	Mobile Terminating Access
	Mobile originating CS fallback emergency call	Emergency
	Packet services via S1	Mobile Terminating Access Delay Tolerant Access Emergency

Table 284 – Relationship between higher layer establishment cause and RRC establishment cause

- In the case of the Attach procedure:
  - the ‘Mobile Originating Signalling’ cause value is used by default
  - the ‘Delay Tolerant Access’ cause value is used if the UE has been configured for ‘low priority NAS signalling’. This RRC establishment cause was introduced within the release 10 version of the 3GPP specifications. The concept of ‘low priority NAS signalling’ is intended to provide a mechanism for congestion control, i.e. low priority signalling is dropped prior to higher priority signalling during periods of congestion. The ‘NAS Signalling Priority Tag’ within the USIM defines whether or not the device has been configured for low priority NAS signalling. This priority can also be used to impact charging, i.e. devices using low priority signalling could be charged less. Machine to machine type communications could use low priority signalling if their traffic is primarily background and best effort
  - the ‘Emergency’ cause value is used if the EPS Attach Type within the Attach Request message is set to ‘EPS Emergency Attach’. The ‘Emergency’ cause value can also be used if the higher layers within the UE indicate the requirement to establish emergency bearer services, even when the EPS Attach Type is not set to ‘EPS Emergency Attach’
- In the case of the Detach procedure, the ‘Mobile Originating Signalling’ cause value is used
- In the case of the Tracking Area Update procedure:
  - the ‘Mobile Originating Signalling’ cause value is used by default
  - the ‘Delay Tolerant Access’ cause value is used if the UE has been configured for ‘low priority NAS signalling’
  - the ‘Emergency’ cause value is used if the UE already has a Packet Data Network (PDN) connection established for emergency bearer services, or if the UE is establishing a PDN connection for emergency bearer services
- In the case of the Service Request procedure:
  - the ‘Mobile Originating Signalling’ cause value is used by default when the Service Request is used to request either user plane radio resources or uplink signalling resources
  - the ‘Delay Tolerant Access’ cause value is used when the Service Request is used to request either user plane radio resources or uplink signalling resources, and the UE has been configured for ‘low priority NAS signalling’

- the ‘Mobile Terminating Access’ cause value is used when the Service Request is a response to paging where the core network domain indicator is set to Packet Switched (PS)
- the ‘Emergency’ cause value is used if the Service Request is being used to request user plane radio resources for emergency bearer services, or if the Service Request is triggered by a PDN connectivity request with an emergency cause value

★ In the case of the Extended Service Request procedure:

- the ‘Mobile Originating Data’ cause value is used by default if the Extended Service Request is used for mobile originating CS fallback
- the ‘Delay Tolerant Access’ cause value is used for mobile originating CS fallback and packet services via the S1 when the UE has been configured for ‘low priority NAS signalling’
- the ‘Mobile Terminating Access’ cause value is used by default if the Extended Service Request is used for packet services via S1. It is also used when the Extended Service Request is used for mobile terminating CS fallback
- the ‘Emergency’ cause value is used if the Extended Service Request is being used for a mobile originating CS fallback emergency call. It is also used if the Extended Service Request is being used for packet services via S1 when requesting radio resources for emergency bearer services

★ In all cases, the RRC establishment cause is set to ‘High Priority Access’ if the UE uses Access Class (AC) 11 to 15 within its home PLMN

★ The UE starts the T300 timer after transmitting the RRC Connection Request message. The value of T300 is broadcast within SIB 2. UMTS uses T300 in combination with N300 to manage retransmissions of the RRC Connection Request message. LTE does not have an N300 parameter and the RRC layer sends the RRC Connection Request message only once per establishment procedure. HARQ retransmissions from the MAC layer can be used to improve the reliability of transferring the RRC Connection Request and RRC Connection Setup messages. LTE uses the T300 timer to define how long the UE waits for a response to the RRC Connection Request message. The establishment procedure fails if T300 expires before receiving an RRC Connection Setup message. The procedure also fails if the UE completes a cell re-selection prior to receiving the RRC Connection Setup message

★ Random access contention can occur after sending the RRC Connection Request message. Section 24.1 explains that contention occurs when multiple UE select the same subframe and preamble sequence for PRACH transmission. Contention requires the UE to repeat transmission of the PRACH preamble and the subsequent RRC Connection Request message. This increases the delay associated with connection establishment but does not cause the overall procedure to fail unless the maximum number of preamble transmissions has been reached

★ Assuming that random access contention does not occur, the UE proceeds to wait for an RRC Connection Setup message from the eNode B. The UE has successfully completed the random access procedure so has been allocated a C-RNTI (signalled within the random access response message). The UE monitors the PDCCH for a downlink allocation addressed to its C-RNTI. The PDCCH specifies the set of PDSCH Resource Blocks used to transfer the RRC Connection Setup message. The RRC Connection Setup message is transferred using SRB 0 on the CCCH

★ The RRC Connection Setup message contains configuration information for SRB 1. This allows subsequent signalling to use the DCCH logical channel. SRB 2 is always configured after security activation so the RRC Connection Setup message does not include any information regarding SRB 2. The eNode B can instruct the UE to apply a default configuration for SRB 1, or it can instruct the UE to apply a specific configuration.

★ The default configuration for SRB 1 is presented in Table 285. This default configuration has been specified by 3GPP within TS 36.331. Using the default configuration helps to reduce the signalling requirement. The default configuration for SRB 2 is also presented in Table 285 for information. SRB 2 has a lower priority than SRB 1, i.e. a value of 3 represents a lower priority than a value of 1. Both SRB 1 and 2 always use acknowledged mode RLC

			SRB 1	SRB 2
RLC Configuration	Uplink	Poll Retransmission Timer	45	45
		Poll PDU	Infinity	Infinity
		Poll Byte	Infinity	Infinity
		Max Retransmission Threshold	4	4
	Downlink	Re-ordering Timer	35	35
		Status Prohibit Timer	0	0
Logical Channel Configuration		Priority	1	3
		Prioritised Bit Rate	Infinity	Infinity
		Bucket Size Duration	N/A	N/A
		Logical Channel Group	0	0

Table 285 – Default configurations for SRB 1 and SRB 2

- The RRC Connection Setup message can also define configuration information for the PDSCH, PUCCH and PUSCH physical channels. It can also include information regarding uplink power control, CQI reporting, the Sounding Reference Signal, antenna configuration and scheduling requests
- Upon receiving an RRC Connection Setup message, the UE stops the T300 timer and makes the transition to RRC Connected mode. The UE then proceeds to complete the procedure by sending an RRC Connection Setup Complete message. The content of the RRC Connection Setup Complete message is shown in Table 286

Information Elements	
RRC Transaction Identifier (0 to 3)	
Selected PLMN Identity (1 to 6)	
Registered MME	PLMN Identity
	MMEGI
	MMEC
Dedicated NAS Information	
GUMMEI Type (3GPP release 10)	
Radio Link Failure Information Available (3GPP release 10)	
Logged Measurements Available (3GPP release 10)	
Relay Node Subframe Configuration Requested (3GPP release 10)	

Table 286 – Content of RRC Connection Setup Complete message

- The Transaction Identifier, combined with the message type, identifies the RRC procedure with the UE
- The Selected PLMN Identity defines a pointer to a PLMN listed within SIB1, i.e. UE select the PLMN to which they want to connect when a cell belongs to more than a single PLMN
- The Registered MME information is optional, and is included when available. It becomes available after a UE has registered with an MME. The MME is identified by its Globally Unique MME Identity (GUMMEI) which is a concatenation of the PLMN identity, MME Group Identity (MMEGI) and MME Code (MMEC). The MMEC identifies the MME within its group
- The UE also includes its initial Non-Access Stratum (NAS) message within the RRC Connection Setup Complete message. NAS messages are specified within 3GPP TS 24.301. As indicated within Table 284, the NAS message could be an Attach, Detach, Tracking Area Update, Service Request or Extended Service Request message
- The Globally Unique MME Identity (GUMMEI) Type information was added within the release 10 version of the specifications. This can be signalled using values of ‘native’ or ‘mapped’. The ‘native’ value indicates that the GUMMEI has been assigned by the Evolved Packet Core (EPC), whereas the ‘mapped’ value indicates that the GUMMEI has been derived from 2G/3G identifiers. This information can impact the selection of an MME for the UE
- The Radio Link Failure Information Available flag was added within the release 10 version of the specifications. This flag can be used for the mobility robustness optimisation component of Self Organising Networks (SON). Mobility robustness optimisation and radio link failure reporting is described in section 32.9
- The Logged Measurements Available flag was added within the release 10 version of the specifications. This flag can be used to indicate that information is available to be reported for the Minimisation of Drive Tests (MDT). MDT is described in section 32.15
- The Relay Node Subframe Configuration Requested information element was also added within the release 10 version of the specifications. It is used to indicate that the RRC connection establishment is for a relay node. It is also used to indicate whether or not the relay node would like a subframe configuration to be allocated, i.e. when included, it can be signalled using values of ‘required’ or ‘not required’. Relay nodes are described in section 30.7
- The eNode B extracts the NAS message from the RRC Connection Setup Complete message and forwards it to an MME using the S1 Application Protocol (S1-AP) Initial UE Message. Forwarding this message does not form part of the RRC establishment procedure but is described within this section for completeness
- The content of the S1-AP Initial UE Message is shown in Table 287. The eNode B sends this message to the appropriate MME based upon its NAS Node Selection Function (NNSF). In the case of a Service Request, the S-TMSI included within the RRC Connection Request is used to identify the appropriate MME (S-TMSI includes the MMEC). In the case of an Attach or Tracking Area Update, the eNode B uses the GUMMEI included within the RRC Connection Setup Complete message. The eNode B is free to select an MME when the UE does not have an S-TMSI nor GUMMEI
- The eNode B allocates the ‘eNode B UE S1-AP Identity’ to allow the eNode B to identify the UE within S1 signalling procedures. The MME UE S1-AP Identity (not included within the Initial UE Message) allows the MME to identify the UE within S1 signalling procedures
- The release 9 version of the specifications added the Cell Access Mode information to the S1-AP: Initial UE message. This is used to indicate whether or not the source cell is operating in hybrid mode. Hybrid mode allows the definition of a Closed Subscriber Group (CSG) but also allows any UE to gain access. UE which are registered with the CSG are provided with priority over non-registered UE

Information Elements	Presence
eNode B UE S1-AP Identity	Mandatory
NAS PDU	Mandatory
Tracking Area Identity (TAI)	Mandatory
E-UTRAN Cell Global Identity (CGI)	Mandatory
RRC Establishment Cause	Mandatory
S-TMSI	Optional
CSG Identity	Optional
Globally Unique MME Identity (GUMMEI)	Optional
Cell Access Mode (3GPP release 9)	Optional
GW Transport Layer Address (3GPP release 10)	Optional
Relay Node Indicator (3GPP release 10)	Optional

Table 287 – Content of S1 Application Protocol (S1-AP) Initial UE Message

- The release 10 version of the specifications added the Gateway (GW) Transport Layer Address to the S1-AP: Initial UE message. This can be used to define a GW transport layer address when the GW is collocated with the eNode B. This is relevant when the RRC connection is established for a relay node, or when the eNode B has a Local Gateway function for Local IP Access (LIPA)
- The release 10 version of the specifications also added the Relay Node Indicator to the S1-AP: Initial UE message. This flag is used to indicate that the message is originating from a relay node rather than a UE
- Figure 235 illustrates the signalling associated with the RRC connection establishment procedure when the eNode B rejects the RRC Connection Request. The reject message is returned to the UE using SRB 0 on the CCCH logical channel. The eNode B may reject the connection establishment request as a result of congestion

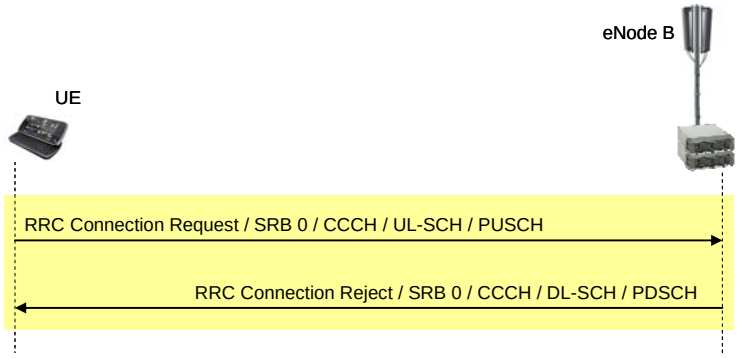

Figure 235 – Signalling for rejected RRC connection establishment

- The content of the RRC Connection Reject message is presented in Table 288. This message only includes a Wait Time. This is in contrast to the equivalent UMTS message which also includes a rejection cause, although the UMTS rejection cause can only be defined as congestion or unspecified. The UMTS message can also include redirection information to direct the UE towards another RF carrier, or Radio Access Technology (RAT)
- The Extended Wait Time was added by the release 10 version of the specifications. This is applicable when the connection is being established by a UE which has been configured for 'low priority NAS signalling', e.g. machine to machine type communications

Information Elements
Wait Time (1 to 16 seconds)
Extended Wait Time (1 to 1800 seconds) (3GPP release 10)

Table 288 – Content of RRC Connection Reject message

- Upon receiving an RRC Connection Reject message, the UE starts the T302 timer with its value set equal to the Wait Time. Access Class barring for mobile originating calls, mobile originating signalling and mobile terminating access is applied until T302 expires, i.e. the UE is not allowed to send another RRC Connection Request for those connection types, and to the same cell, until T302 expires. T302 is stopped if the UE completes cell reselection. In that case, the UE is permitted to send an RRC Connection Request to the new cell. If included, the Extended Wait Time is forwarded to the upper layers
- In contrast to UMTS, LTE requires the higher layers to initiate a new connection establishment procedure after the UE receives an RRC Connection Reject message. UMTS allows the RRC Connection Request message to be repeated from the RRC layer, based upon the value of N300
- 3GPP References: TS 36.331, TS 36.413