Protocol Stack o f 4G-LTE Terminal

Mahongjun

Course Objectives:

- Know Protocol Stack of LTE-Uu Radio Interface
- Know the main Physical/RRC/NAS Layer procedure
- Know protocol conformance testing of 4G-LTE Terminal:

  necessity, relevant organization, important Test Specifications, approval process

Agenda

- LTE Protocol Stack
- Physical/RRC/NAS Layer Procedure of 4G-LTE Terminal
- Protocol conformance testing of 4G-LTE Terminal

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- LTE Protocol Stack
- Physical/RRC/NAS Layer Procedure of 4G-LTE Terminal
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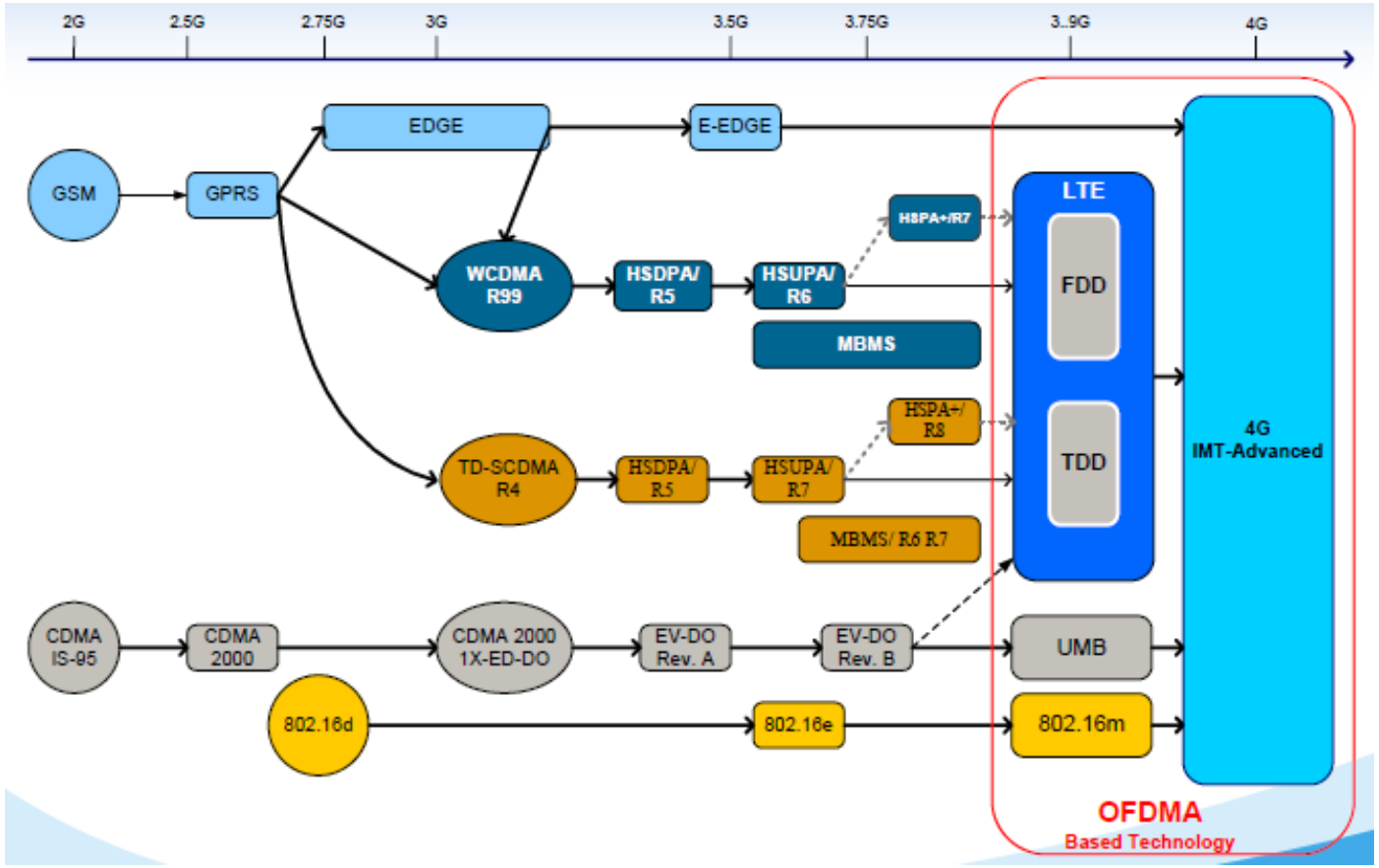
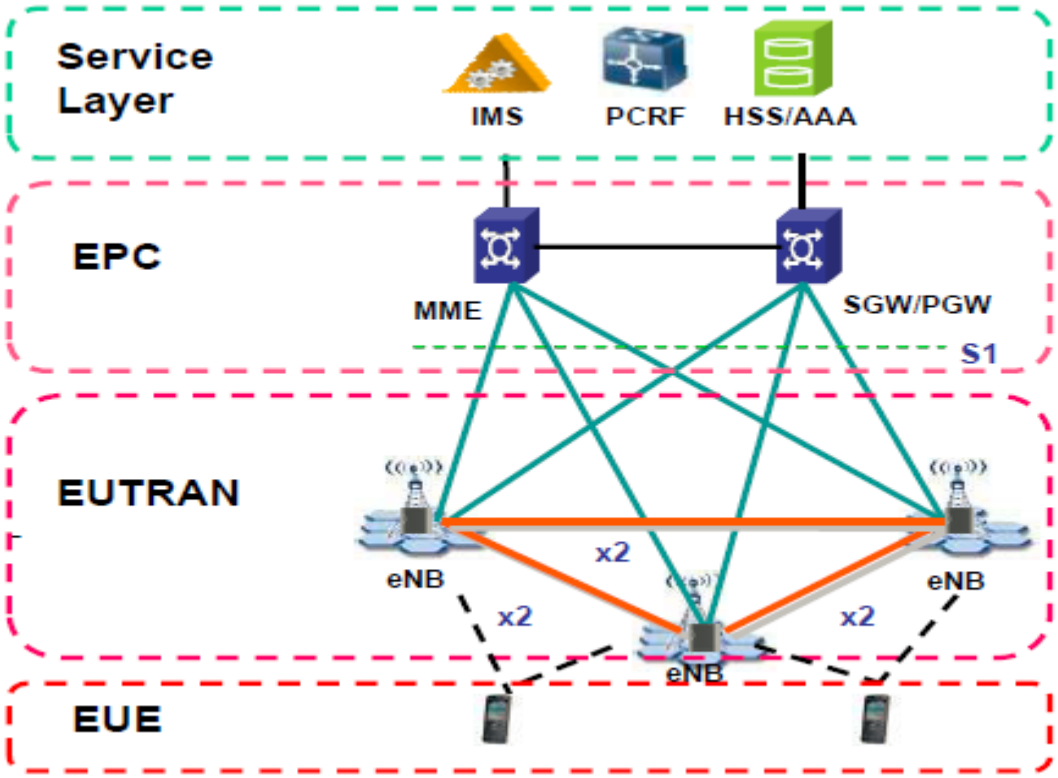
Motivation for LTE Advanced



LTE Network Architecture



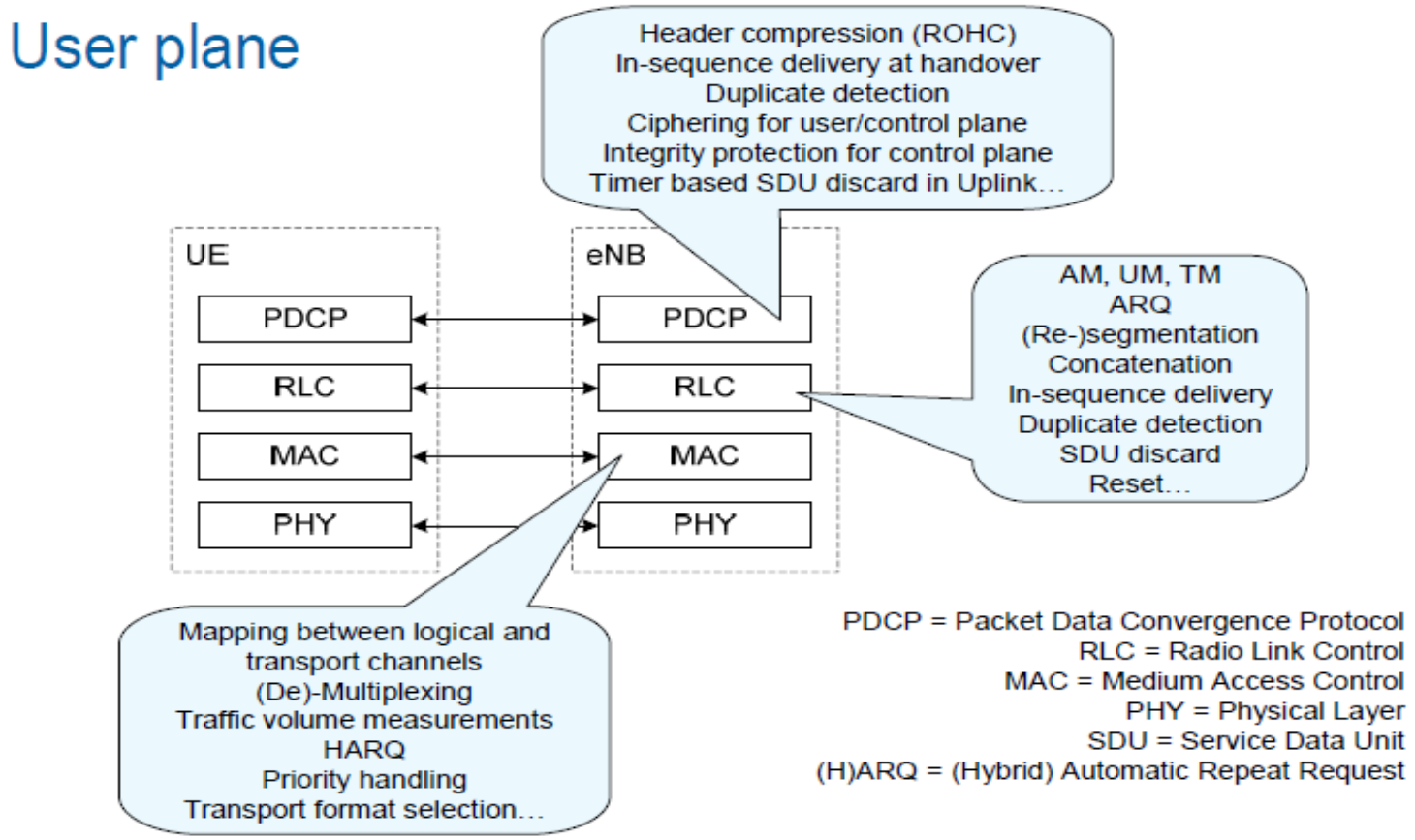
eNB:Evolved NdoeB

MME:Mobility Management Entity

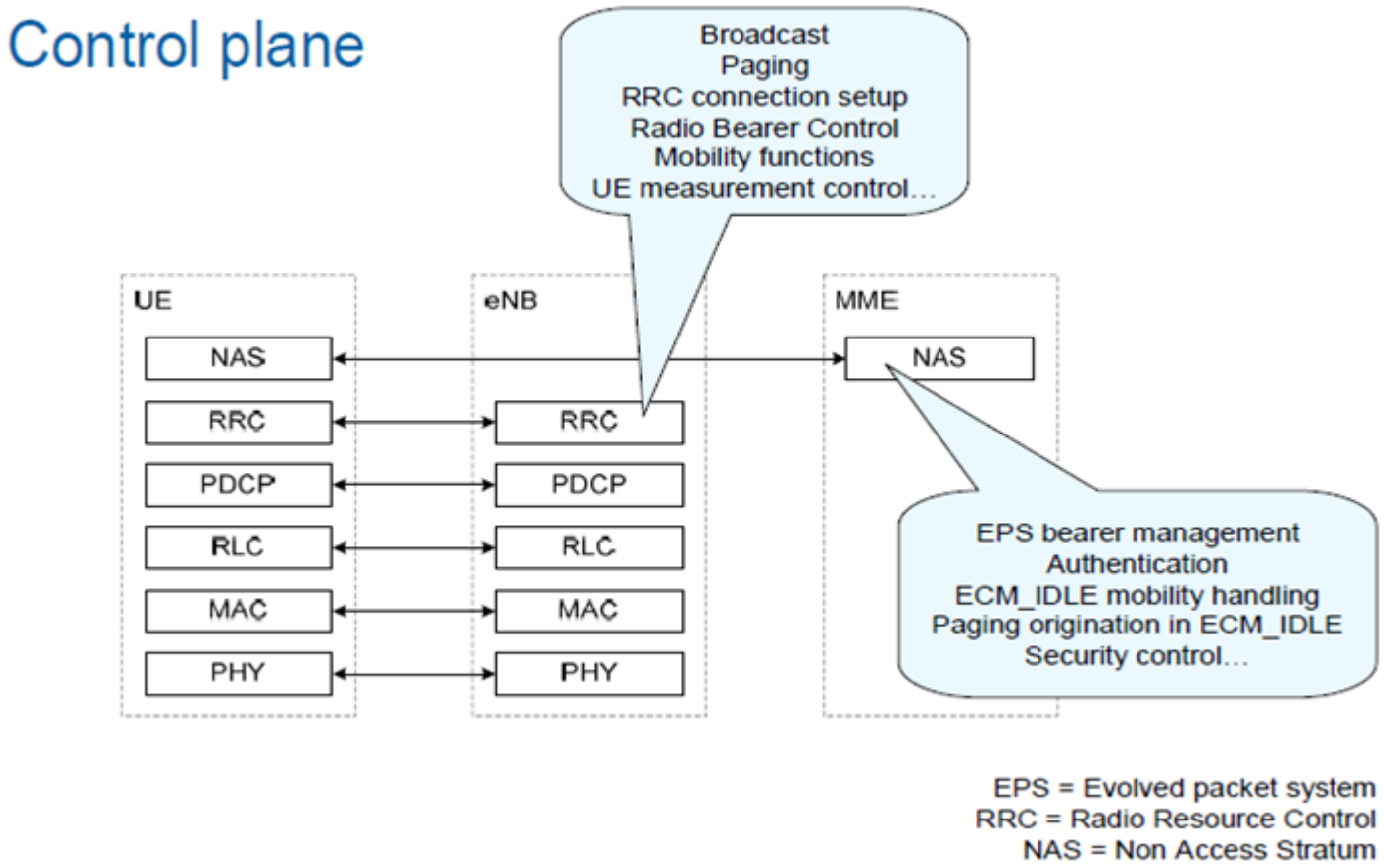
SGW:Serving Gateway

PGW:Packet Gateway

Protocol Stack – LTE-Uu radio interface



Protocol Stack – LTE-Uu radio interface

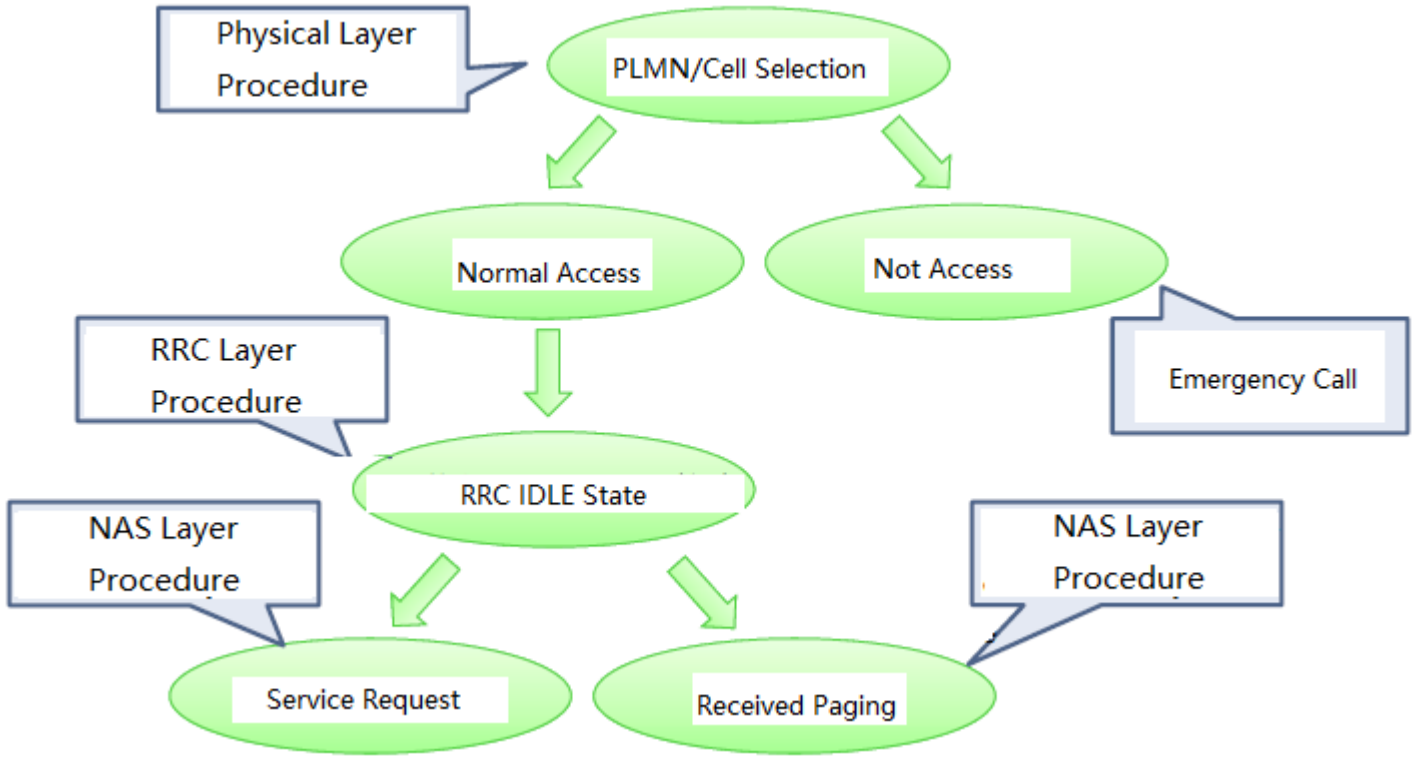


EPS = Evolved packet system
RRC = Radio Resource Control
NAS = Non Access Stratum

Agenda

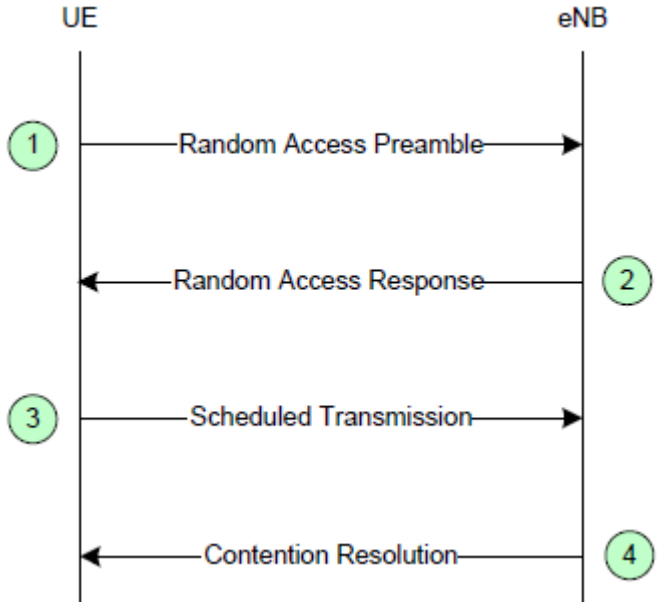
- LTE Protocol Stack
- Physical/RRC/NAS Layer Procedure of 4G-LTE Terminal
- Protocol conformance testing of 4G-LTE Terminal

Signalling Procedure Summary – Multi_Layer Co-operation



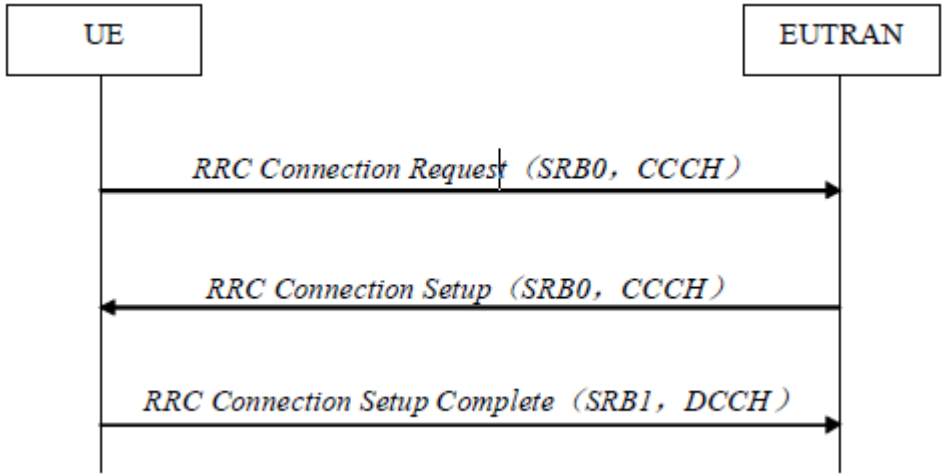
Physical Layer Procedure

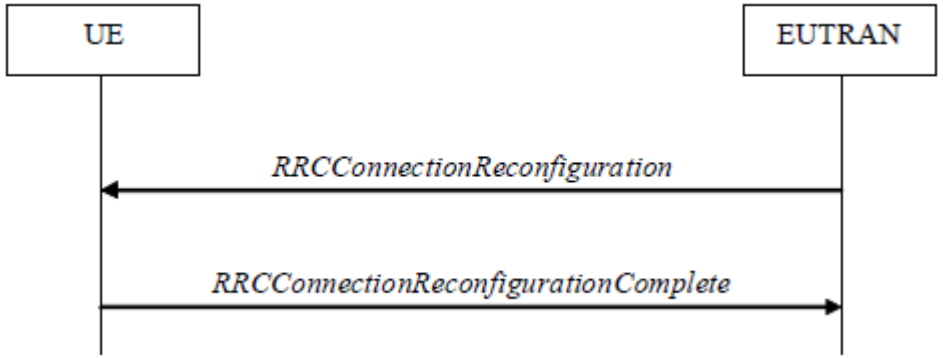
- Random Access;
- PLMN selection / Inter-RAT PLMN selection;
- Cell selection and reselection / Inter-RAT cell selection and reselection;
- Closed Subscriber Group cells;



RRC Layer Procedure

- RRC connection establishment;
- RRC connection release;
- RRC connection reconfiguration;
- Measurement configuration control and reporting;
- RRC others - Radio link failure;
- RRC others - Redirection to E-UTRAN;



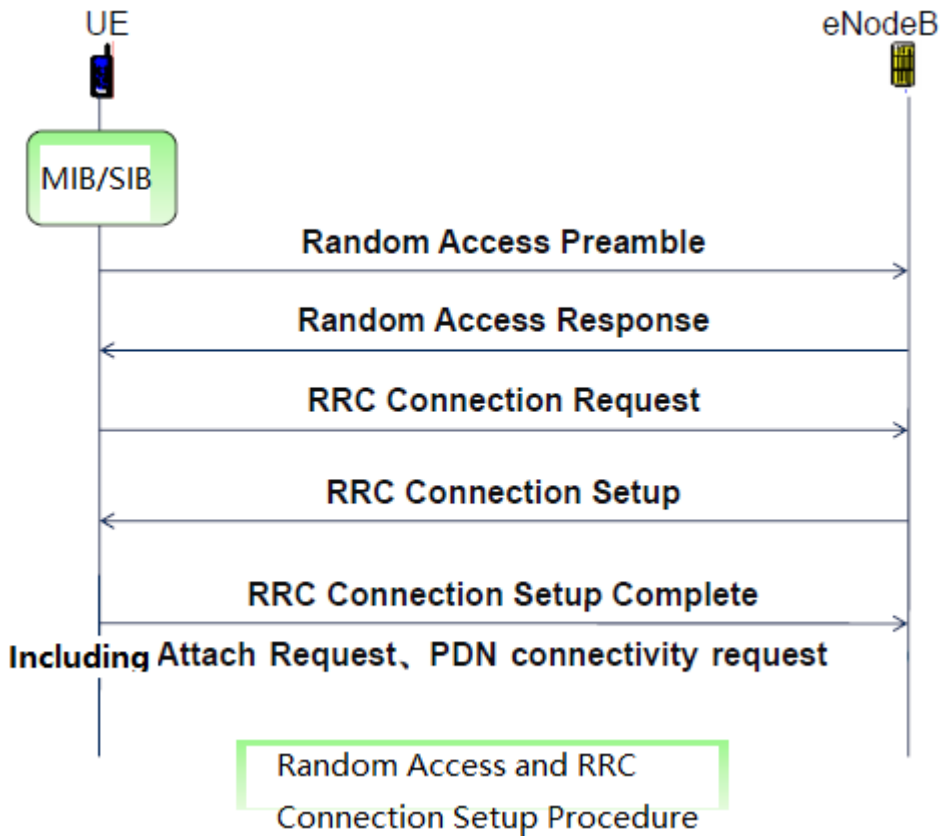


NAS Layer Procedure - EPS mobility management

- Authentication procedure;
- Security mode control procedure;
- Identification procedure;
- Attach procedure;
- Detach procedure;
- Tracking area updating procedure;
- Service request procedure;
- Paging procedure;

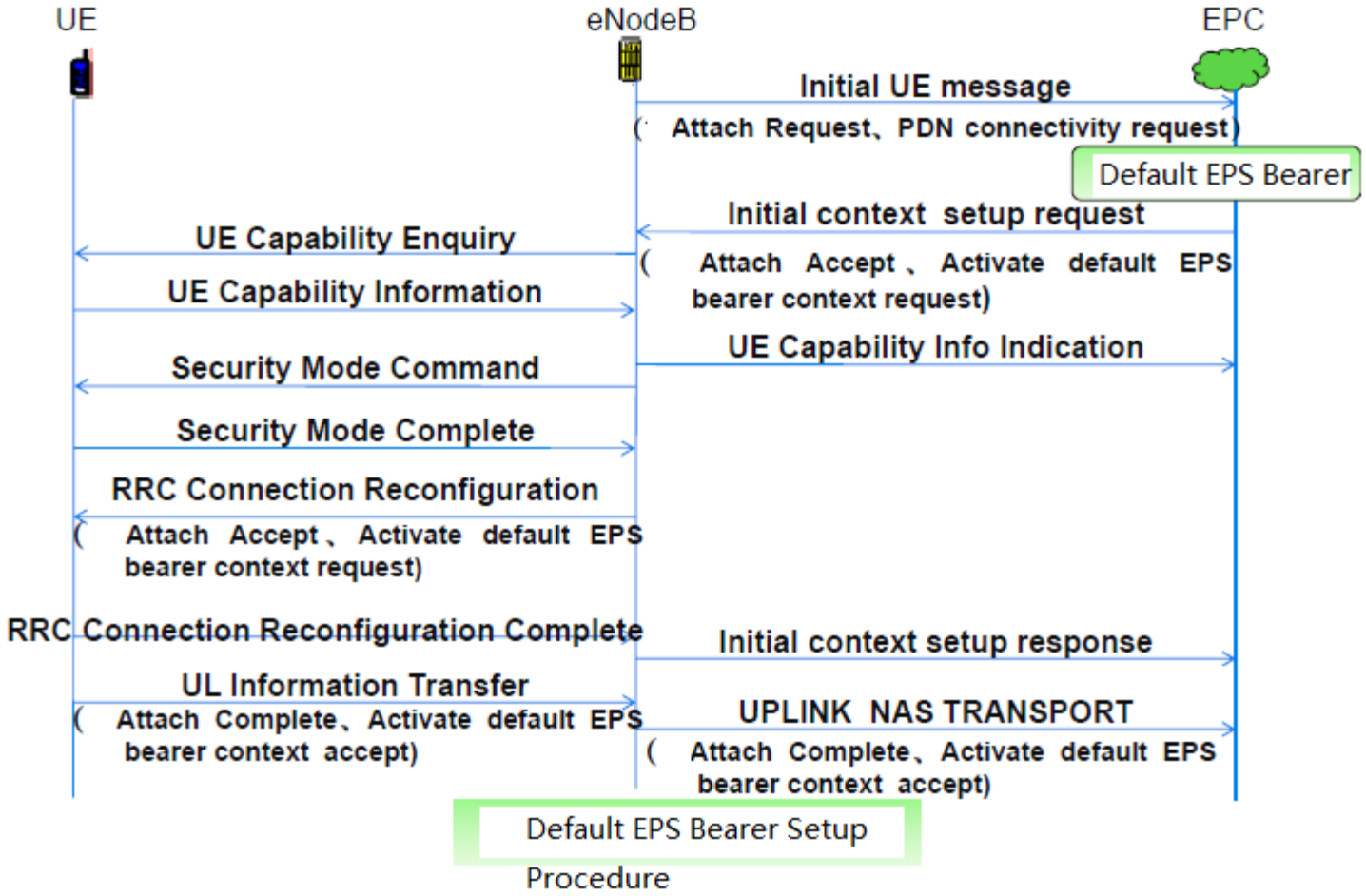
NAS Layer Procedure - EPS mobility management

➢Attach Procedure



NAS Layer Procedure - EPS mobility management

➢Attach Procedure

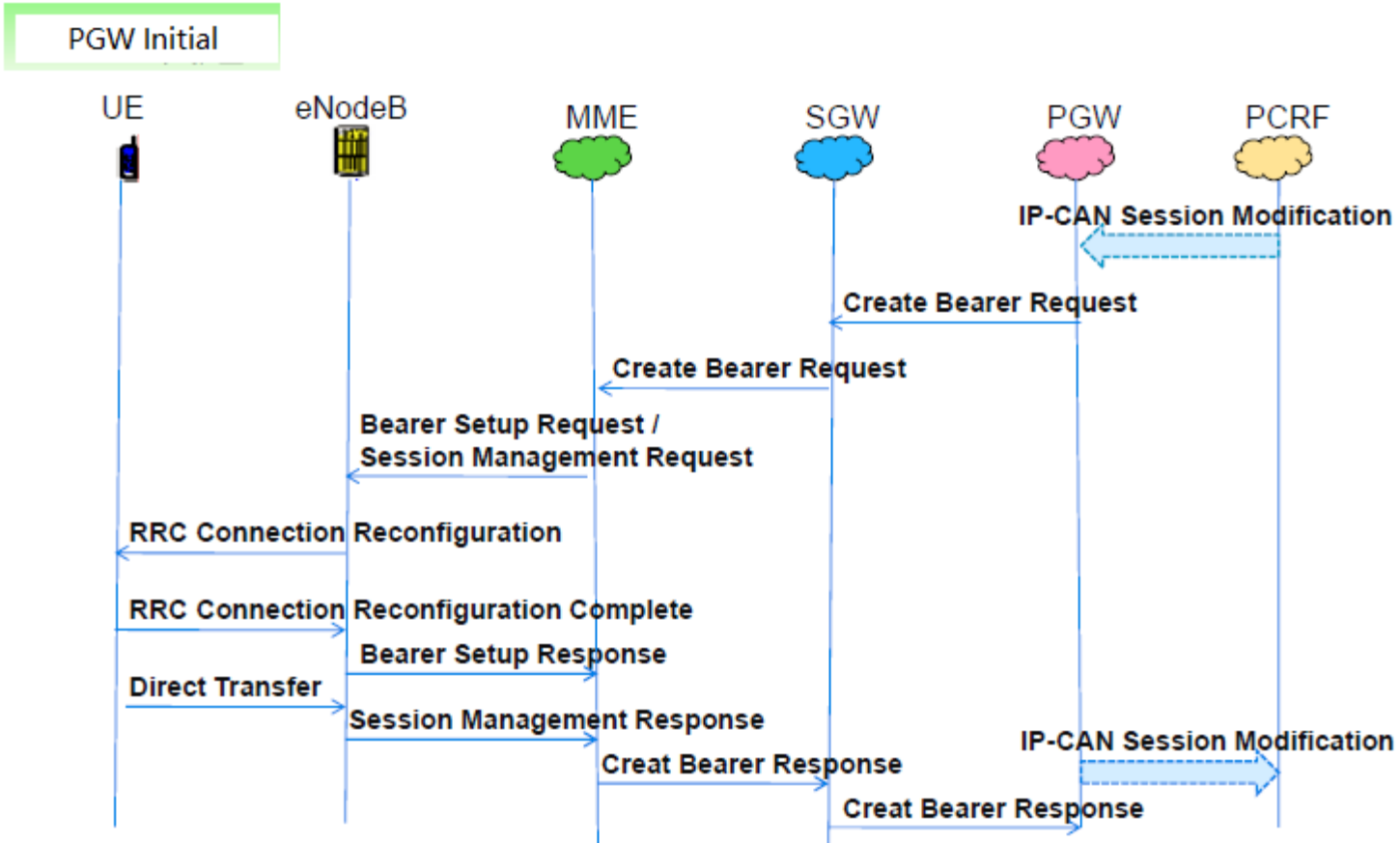


NAS Layer Procedure - EPS session management

- Dedicated EPS bearer context activation;
- EPS bearer context modification;
- EPS bearer context deactivation;
- UE requested PDN connectivity;
- UE requested PDN disconnect;
- UE requested bearer resource allocation;
- UE requested bearer resource modification;

NAS Layer Procedure - EPS session management

- Dedicated EPS bearer context activation;



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- LTE Protocol Stack
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Conformance Testing – Why Need?

Conformance Testing – Why Need?

- Before adding new mobile devices to their portfolio, network operators will typically subject them to a rigorous programme of acceptance testing - to assure themselves that the devices are interoperable with, and will work well on, their own networks and those of their roaming partners.
- The assurance of interoperability also builds confidence that the certified device should meet end-users' expectations for service access and interaction.

Benefits of Certification for Operators

- Identifies mobile devices that meet operator's needs;
- Allows operators to focus their own test resources in areas that add value to their own customers and provide differentiation in their own market. Operators do not need to duplicate Certification tests;
- Internal testing costs for operators who actively test can be reduced by as much as 80%;

Benefits of Certification for Operators

- Greatly simplifies acceptance testing and approval process for devices to be sold directly by operators;
- Helps operators select devices to recommend for sale through indirect sales channels;
- Offers a level of assurance about the performance of Open Market devices;

Benefits of Certification for Manufacturers

- Helps manufacturers expand their addressable market by identifying that their device is relevant to multiple operators (or distributors) in multiple export markets;
- Provides confidence in, and comparability of, test results through the harmonisation of testing;
- Creates economies of scale and a competitive market in the supply of test tools and services;
- Reduces cumulative testing costs when supplying a device to multiple operator partners;

Benefits of Certification for Manufacturers

- Defines the boundary between the testing responsibilities of manufacturers and operators;
- Advertises a Manufacture's newly certified products automatically to GCF/PTCRB's entire operator membership – Operator members can access and review the product's test results;
- Supports the commercialization and shortens time-to market for important new technologies by achieving industry consensus on the most appropriate, effective testing;

Conformance Testing - relevant organization

- 3GPP

  -Core Specifications and Test Specifications;

- ETSI

  -TTCN Scripts and Abstract Test Suite (ATS) Implementation and Release;

- GCF/PTCRB

  -Define certification test programs for approving device inter-Operability with networks.

  -Approve the validation of test cases from Test Vendors for use in the certification programs

Conformance Testing - relevant organization

➢GCF - Europe

-The GCF was founded in 1999, in response to change in the regulatory environment in Europe, to give operators confidence in the interworking of new mobile devices at a time of rapid technological development and market growth;

-With GCF's ‘tested once, use anywhere‘ maxim,manufacturers can significantly reduce the requirement for operator acceptance testing if presenting GCF certified devices.

http://www.globalcertificationforum.org/about.html

Conformance Testing - relevant organization

➢PTCRB – North Amecran

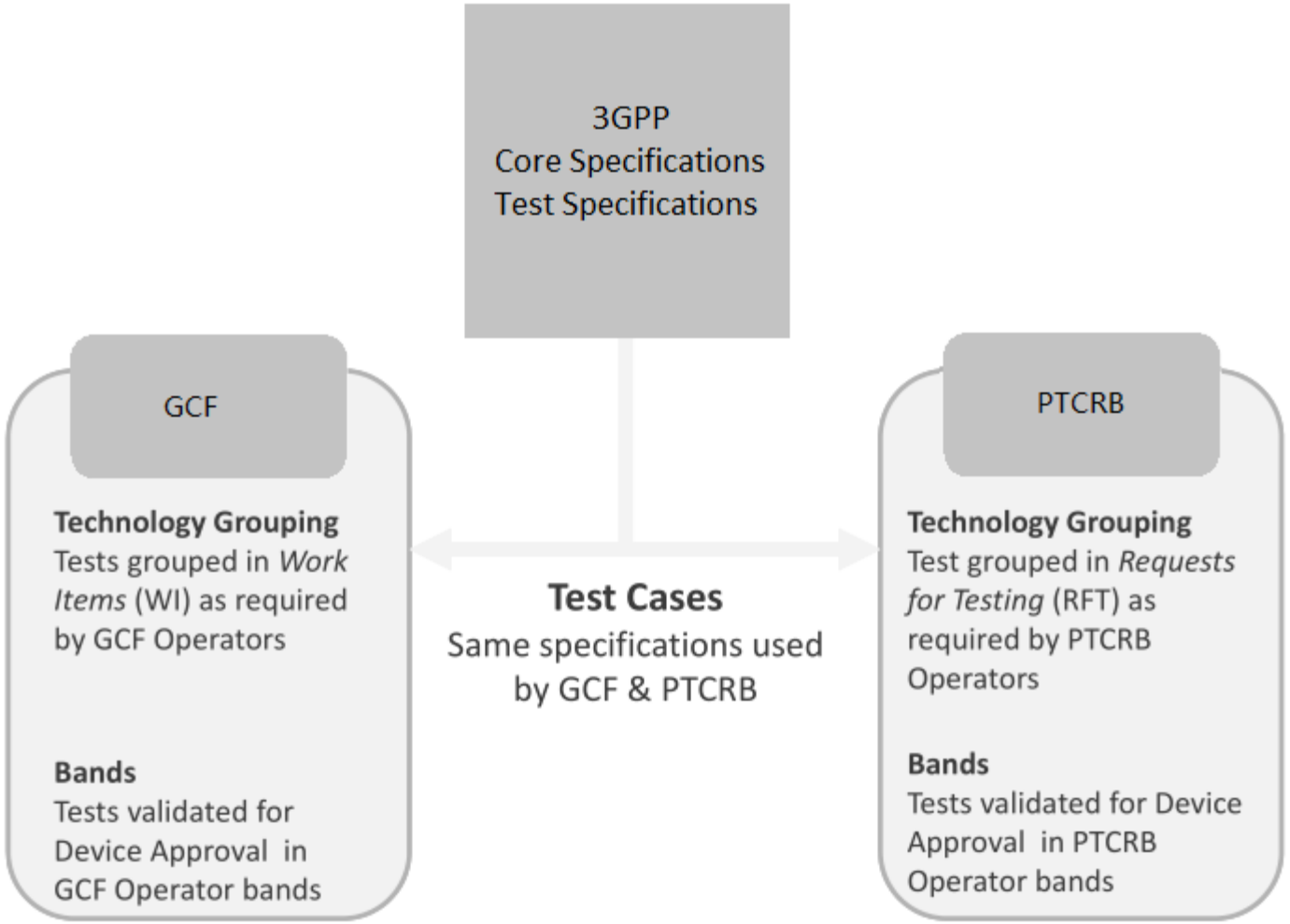
-The PTCRB was established in 1997 as the wireless device certification forum by North American Mobile Network Operators (MNO);

-The purpose of the PTCRB is to provide the framework within which cellular GERAN (GSM), UTRA (UMTS) and EUTRA (LTE) mobile devices and modules obtain certification for use on PTCRB Operator networks;

-Obtaining PTCRB Certification on a mobile device ensures compliance with 3GPP network Standards within the PTCRB Operators‘ networks. Consequently, PTCRB Operators may block Devices from their network if they are not PTCRB certified.

http://www.ptcrb.com/

Conformance Testing - relevant organization



LTE Protocol Conformance Testing

Key Test Specifications:

➢TS 36.523-1 - Protocol conformance specification

-the overall test structure;

-the test configurations;

-the conformance requirement and reference to the core specifications;

-the test purposes;

-a brief description of the test procedure, the specific test requirements and short message exchange table.

LTE Protocol Conformance Testing

Key Test Specifications:

➢TS 36.523-2 - Implementation Conformance Statement (ICS) proforma specification

-provides the Implementation Conformance Statement (ICS) proforma for UE, in compliance with the relevant EPS (E-UTRA/EPC) requirements;

-specifies a recommended applicability statement for the test cases included in TS 36.523-1. These applicability statements are based on the features implemented in the UE.

LTE Protocol Conformance Testing

Key Test Specifications:

➢TS 36.523-3 - Test Suites

-contains a detailed and executable description of the test cases written in a standard testing language, TTCN, as defined in ISO/IEC 9646

➢TS 36.508 - Common test environments for User Equipment (UE) conformance testing

-contains definitions of reference conditions and test signals, default parameters, reference radio bearer configurations used in radio bearer interoperability testing, common radio bearer configurations for other test purposes, common requirements for test equipment and generic set-up procedures for use in conformance tests for the UE.

LTE Protocol Conformance Testing

LTE Layer 1 Testing Aspects Verify Physical Layer Procedures:

- Verify timing requirements;
- Random Access procedure;
- Scheduling process;
- Performance of coder/decoder in UE;
- Relevant for testing HARQ retransmission protocols, power control, adaptive modulation/coding,
- …

LTE Protocol Conformance Testing

LTE AS/NAS Layer Testing Aspects Verify RRC/NAS Procedures:

- Establishment, reconfiguration, release of RRC Connection;
- Throughput verification;
- Mobility scenarios;
- Interworking with other technologies;
- Failure cases;
- …

LTE Protocol Conformance Testing

Example Test Case 9.2.1.2.1(Combined attach procedure / Success / EPS and non-EPS services)

- Test Purpose (TP);
- Conformance requirements;
- Pre-test conditions: System Simulator / UE / Preamble;
- Test procedure sequence;
- Specific message contents;

LTE Protocol Conformance Testing

Example Test Case 9.2.1.2.1(Combined attach procedure / Success / EPS and non-EPS services)

➢Test Purpose (TP);

- 9.2.1.2.1 Combined attach procedure / Success / EPS and non-EPS services
- 9.2.1.2.1.1 Test Purpose (TP)
- (1)

```
with { UE in state EMM-DEREGISTERED and is switched off }
ensure that {
  when { UE is powered up or switched on}
   then { UE sends ATTACH REQUEST message with EPS attach type IE 'combined EPS/IMSI attach' }
}
```

- (2)

```
with { UE in state EMM-REGISTERED-INITIATED}
ensure that {
  when { UE receives ATTACH ACCEPT message with EPS attach result 'combined EPS/IMSI attach' }
   then { UE sends ATTACH COMPLETE message and enters EMM state EMM-REGISTERED and MM state MM-
IDLE }
}
```

LTE Protocol Conformance Testing

Example Test Case 9.2.1.2.1(Combined attach procedure / Success / EPS and non-EPS services)

➢Conformance requirements

- 9.2.1.2.1.2 Conformance requirements

References: The conformance requirements covered in the present TC are specified in: 3GPP TS 24.301 clauses 5.5.1.3.1, 5.5.1.3.4.1 and 5.5.1.3.4.2.

[TS24.301 clause5.5.1.3.1]

The combined EPS attach procedure is used by a UE in CS/PS mode 1 or CS/PS mode 2 of operation to attach for both EPS and non-EPS services.

The combined EPS attach procedure is also used by a UE in CS/PS mode 1 or CS/PS mode 2 of operation to attach for EPS services if it is already attached for non-EPS services.

When the UE initiates a combined EPS attach procedure, the UE shall indicate "combined EPS/IMSI attach" in the EPS attach type IE.

The combined EPS attach procedure follows the attach procedure for EPS described in subclause 5.5.1.2.

[TS24.301 clause5.5.1.3.2]

If the UE is in EMM state EMM-DEREGISTERED, the UE initiates the combined attach procedure by sending an ATTACH REQUEST message to the network, starting timer T3410 and entering state EMM-REGISTERED-INITIATED (see example in figure 5.5.1.2.2.1).

The UE shall include the TMSI status IE if no valid TMSI is available. Furthermore, if the UE has stored a valid location area identification, the UE shall include it in the Old location area identification IE in the ATTACH REQUEST message.

LTE Protocol Conformance Testing

Example Test Case 9.2.1.2.1(Combined attach procedure / Success / EPS and non-EPS services)

➢Pre-test conditions: System Simulator / UE / Preamble

- 9.2.1.2.1.3 Test description
- 9.2.1.2.1.3.1 Pre-test conditions
- System Simulator:
  - cell A, cell B and cell C are configured according to Table 6.3.2.2-1 in [18]:
    - cell A belongs to TAI-1 (home PLMN);
    - cell B belongs to TAI-2 (home PLMN, another TAC);
    - cell C belongs to TAI-3 (home PLMN, another TAC).
    - The different cells may not be simultaneously activated (at most 2 cells are active simultaneously).
    - System information combination 3 as defined in TS 36.508[18] clause 4.4.3.1 is used in E-UTRA cells;
- UE:
  - the UE is configured to initiate combined EPS/IMSI attach;
  - the UE is previously registered on E-UTRAN, and when on E-UTRAN, the UE is last authenticated and registered on cell A using default message contents according to TS 36.508 [18].
- Preamble:
  - the UE is in state Switched OFF (state 1) according to TS 36.508 [18].

LTE Protocol Conformance Testing

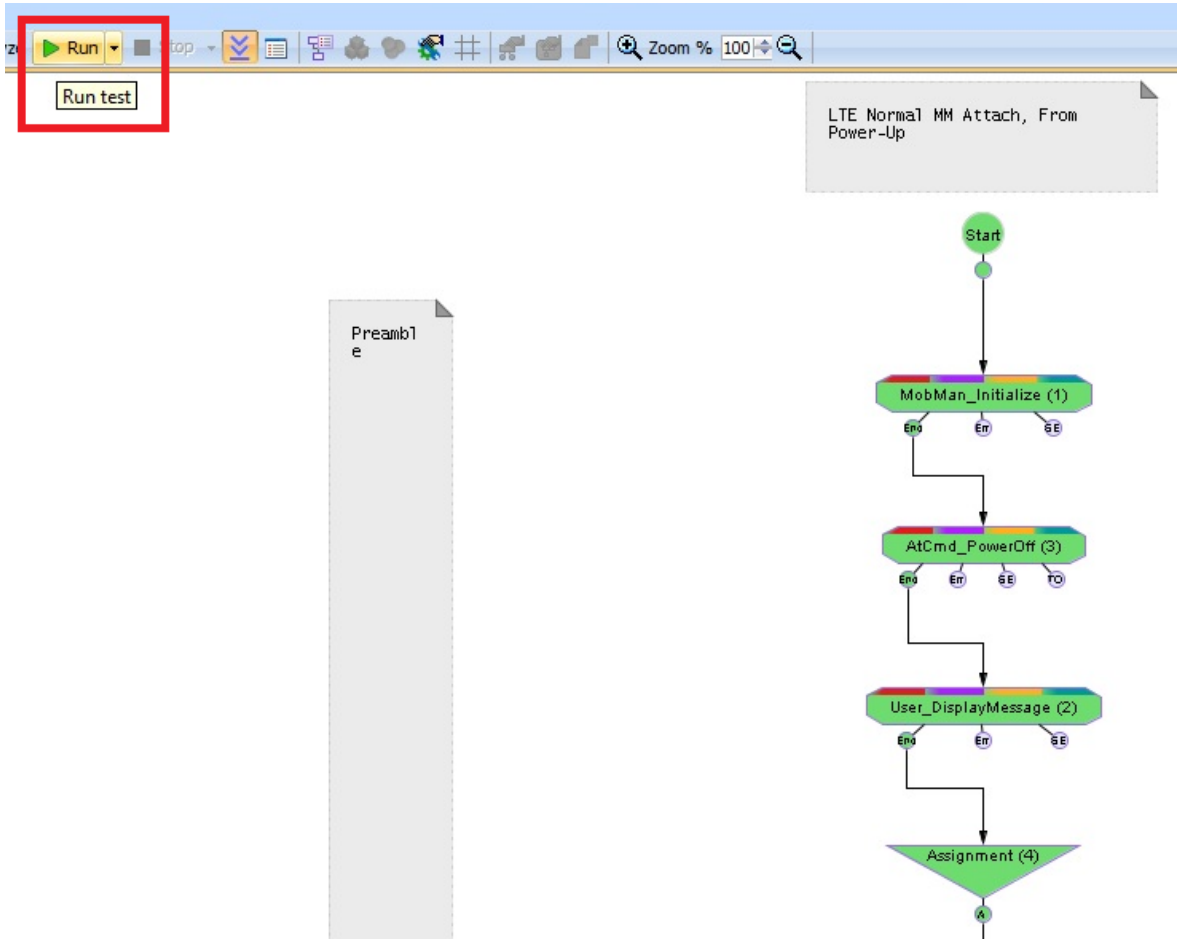
Example Test Case 9.2.1.2.1(Combined attach procedure / Success / EPS and non-EPS services)

➢Test System

LTE Protocol Conformance Testing

Example Test Case 9.2.1.2.1(Combined attach procedure / Success / EPS and non-EPS services)

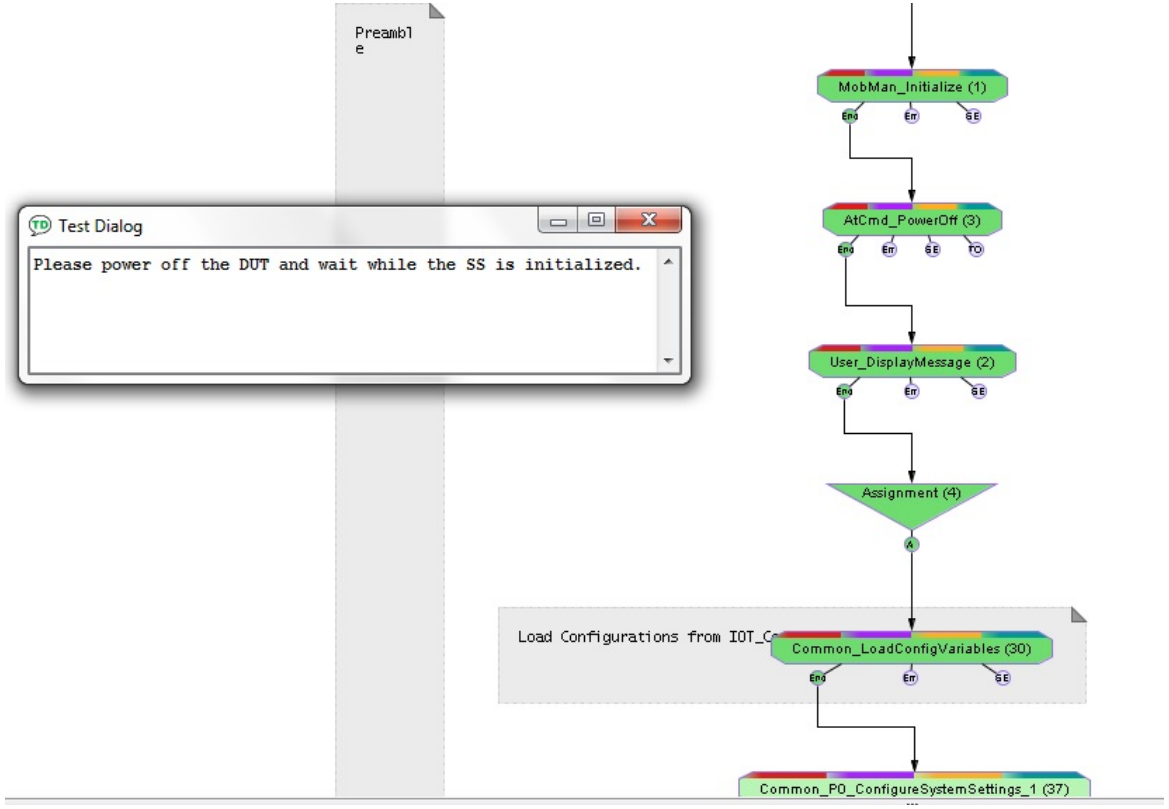
➢Test methods



LTE Protocol Conformance Testing

Example Test Case 9.2.1.2.1(Combined attach procedure / Success / EPS and non-EPS services)

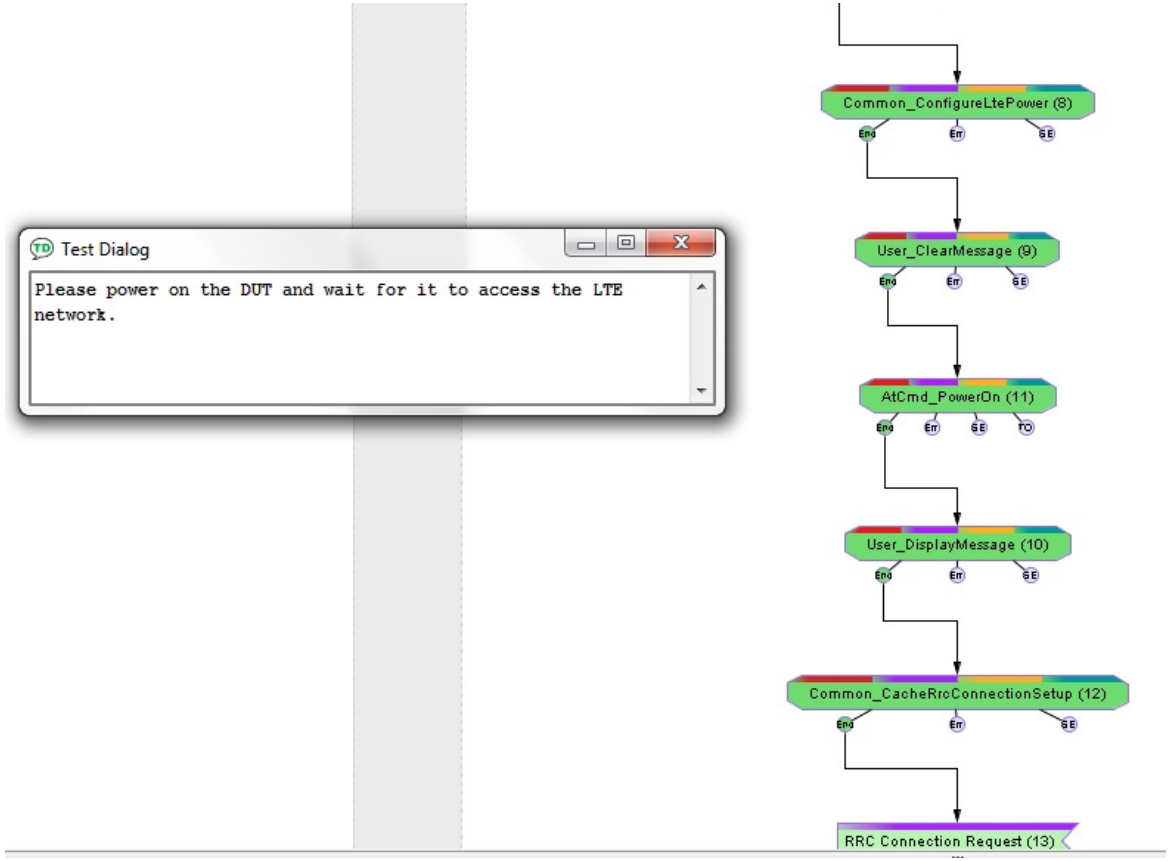
➢Test methods



LTE Protocol Conformance Testing

Example Test Case 9.2.1.2.1(Combined attach procedure / Success / EPS and non-EPS services)

➢Test methods



LTE Protocol Conformance Testing

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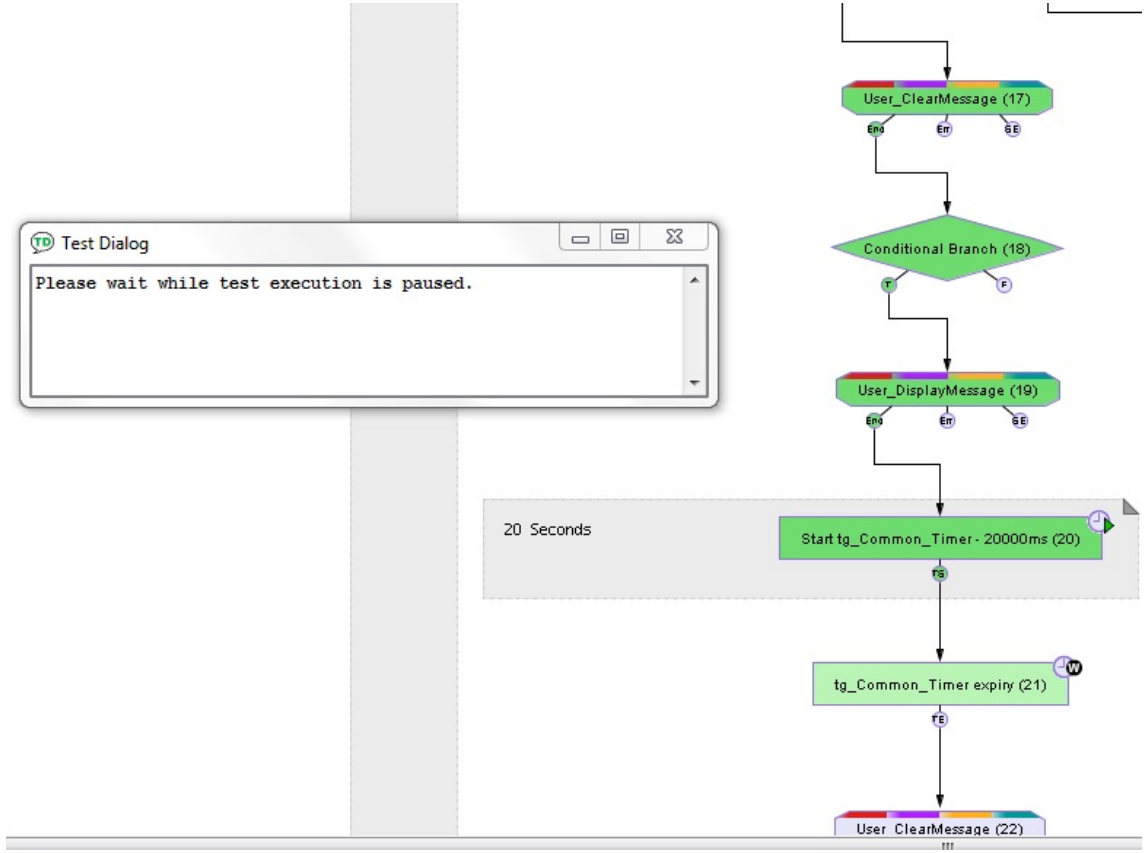

LTE Protocol Conformance Testing

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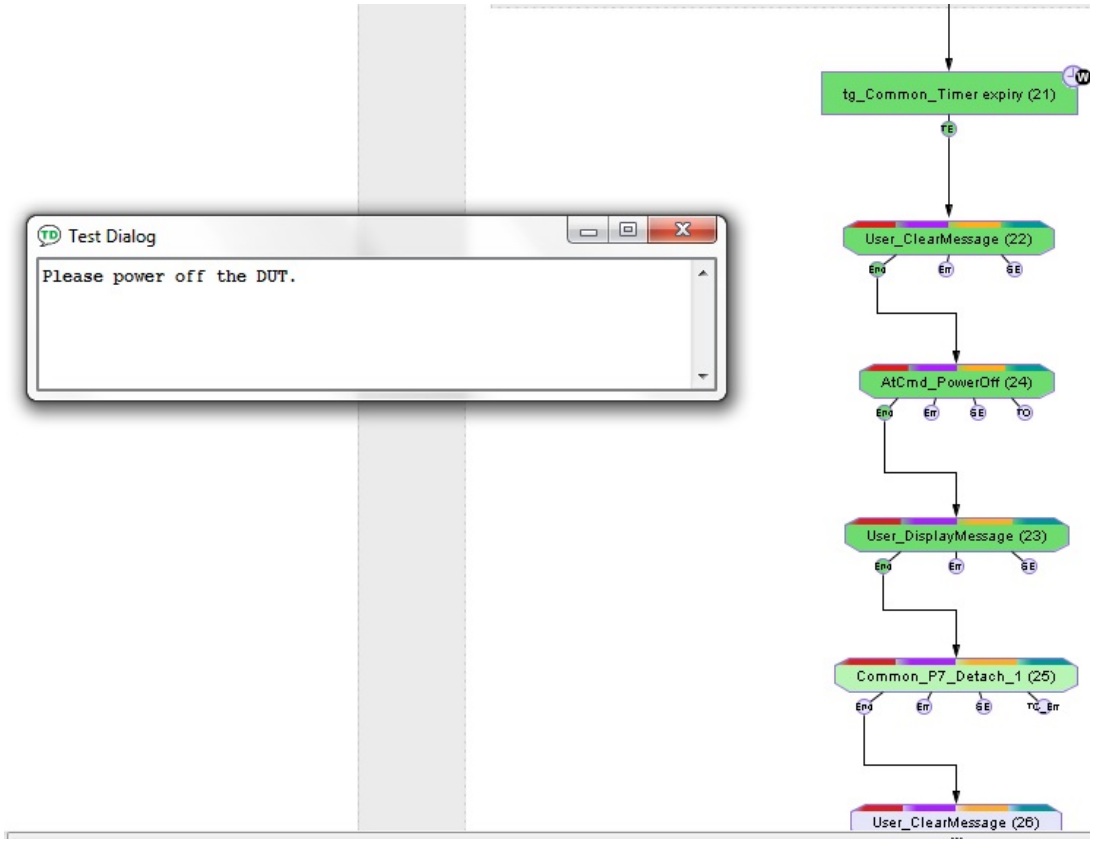

LTE Protocol Conformance Testing

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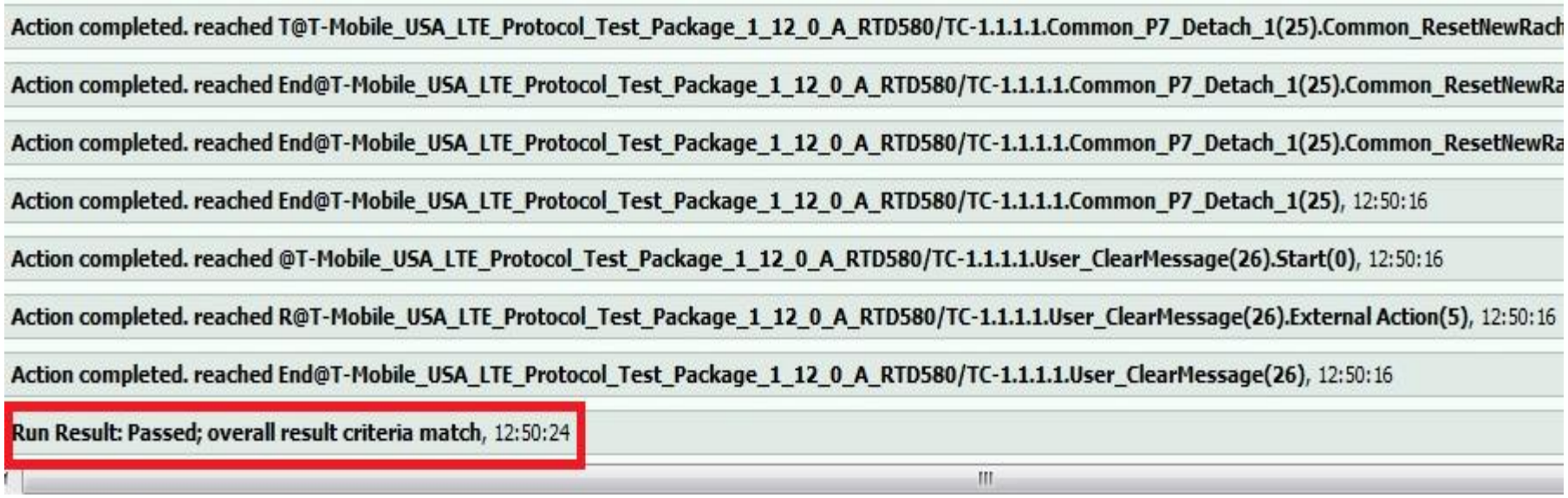

LTE Protocol Conformance Testing

Example Test Case 9.2.1.2.1(Combined attach procedure / Success / EPS and non-EPS services)

➢Test procedure sequence

9.2.1.2.1.3.2 Test procedure sequence

Table 9.2.1.2.1.3.2-1: Main Behaviour

St	Procedure	Message Sequence		TP	Verdict
		U - S	Message		
1	The SS configures: - Cell A as the "Serving cell". - Cell B as a "Non-Suitable cell". - Cell C as a "Non-Suitable Off cell". cell	-	-	-	-
-	The following messages are to be observed on Cell A unless explicitly stated otherwise.	-	-	-	-
2	The UE is powered up or switched on.			-	-
3	Check: Does the UE send an ATTACH REQUEST message with a PDN CONNECTIVITY REQUEST message to request PDN connectivity to the default PDN. EPS attach type = "combined EPS/IMSI attach"?	-->	ATTACH REQUEST	1	P
4	The SS starts an authentication procedure.	<--	AUTHENTICATION REQUEST	-	-
5	The UE responds properly to the authentication procedure.	-->	AUTHENTICATION RESPONSE	-	-
6	The SS starts a NAS security mode command procedure to perform NAS integrity protection.	<--	SECURITY MODE COMMAND	-	-
7	The UE responds properly to the NAS security mode command procedure.	-->	SECURITY MODE COMPLETE	-	-
-	EXCEPTION: Steps 7Aa1 to 7Aa2 describe behaviour that depends on UE configuration; the "lower case letter" identifies a step sequence that take place if the UE has ESM information which needs to be transferred.	-	-	-	-
7A a1	IF the UE sets the ESM information transfer flag in the last PDN CONNECTIVITY REQUEST message THEN the SS transmits an ESM INFORMATION REQUEST message to initiate exchange of protocol configuration options and/or APN.	<--	ESM INFORMATION REQUEST	-	-
7A a2	The UE transmits an ESM INFORMATION RESPONSE message to transfer protocol configuration options and/or APN.	-->	ESM INFORMATION RESPONSE	-	-
8	The SS sends ATTACH ACCEPT message with the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message.	<--	ATTACH ACCEPT	-	-
9	Check: Does the UE send ATTACH COMPLETE message with the ACTIVATE	-->	ATTACH COMPLETE	2	P

LTE Protocol Conformance Testing

Example Test Case 9.2.1.2.1(Combined attach procedure / Success / EPS and non-EPS services)

➢Test procedure sequence

9.2.1.2.1.3.3 Specific message contents

Table 9.2.1.2.1.3.3-1: Message ATTACH REQUEST (step 3, Table 9.2.1.2.1.3.2-1)

Derivation path: 36.508 table 4.7.2-4			
Information Element	**Value/Remark**	**Comment**	**Condition**
EPS attach type	'0010'B	"combined EPS/IMSI attach"	
Old GUTI or IMSI	GUTI-1		
Last visited registered TAI	TAI-1		
Old location area identification	LAI-1		
TMSI status	Not Present		

CTTL-Terminal Lab

➢A leading 3rd-Part test organization with ISO17025 accreditation, GCF/PTCRB/CTIA/Orange/Vodafone/TMO authorization.

➢Covering GSM/WCDMA/CDMA/TD-SCDMA/LTE/WiFi/Bluetooth/NFC technologies.

➢Headquarter in Beijing, with three branch labs:

Shenzhen site / Shanghai site / Chongqing site

CTTL-Terminal Lab

Authorizations















questions:

Why Need Conformance Testing？

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Photo：

Thank You

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