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Introduction

• **Wireless network broad classification**
  - Access Network (connects user equipment and network using access technology)
  - Core network (Switches, Routers, Application servers, Gateways)

• **TTCN-3 is proven for radio access conformance**
  - TTCN2 for 3G UMTS and TTCN-3 for LTE, WiMax
  - Also in some of network technologies - SIP, IPv6

This presentation talks about application of TTCN-3 in development of Test system for core network of LTE-EPC network architecture.
LTE-EPC Network Architecture

Access Network
- LTE Air interface
- TTCN-3 is used / standardized already
- 3GPP Conformance test spec / cases available
- Industry proven standard test systems available

Core Network
- IP based network
- No conformance test spec / cases available
- Industry accepted preparatory test systems available
- Multiple test systems for various system testing

TTCN-3 based test solution approach recommended here!
LTE-EPC Network interface protocols

**Uu**
- NAS
- RRC
- PDCP/RLC/MAC
- Phy

**S1-C**
- NAS
- S1-AP
- SCTP
- IP
- L1/L2

**X2**
- X2-AP
- SCTP
- IP
- L1/L2

**S3/S4, S5/S8, S11, S101, Sv**
- GTP-C
- UDP
- IP
- L1/L2

**S1-U, X2-U, S3/S4, S5/S8, S10, S101, Sv (User plane)**
- GTP-U
- UDP
- IP
- L1/L2

**S6a, S7**
- DIAMETER
- SCTP
- IP
- L1/L2
Sample Requirement

- S1-C/U, X2- interface, SGI interface
- S1-AP, NAS, X2-AP, GTP-U, protocol codec
  - SCTP, UDP, IP, L2/L1 High bandwidth user plane
  - 10 Mbps, multiple sessions
- Protocol functionality test
  - NAS, S-AP, GTU-U test cases
- Network simulator for eNodeB feature demonstration
  - UE Registration, call setup, disconnect, web browsing for Video streaming
- 1 eNodeB, 2 UE
  - 2 PS calls per UE - browsing and ftp download
- Protocol functionality, limited capacity test, network simulation
Challenges

- **Codec**
  - ASN.1 / Byte aligned mixed protocol layers
    - Refer 3GPP/ETSI TTCN-3 implementation for UE as reference
  - Incremental CD / Version upgrade problem
    - TTCN-3 PDU definition to codec generation mechanism development

- **User plane performance**
  - Architecture with signaling in TTCN-3 and user plane in SA for performance

- **Common SA for multiple test applications**
  - Well defined architecture for complete requirement

- **Testing of test solution**
  - CD: codec test case with templates to test
  - Test cases without having actual SUT
    - TTCN-3 component interface simulation
    - Creating scenario from available IoT logs
  - Multiple interfaces need
    - Mixed SUT interface and SA interface to network

- **Scope, test cases**
  - Defining Test spec, configuration, test system, test suite architecture
  - Following 3GPP / ETSI representation used for UE conformance for network interfaces test scope and test suite
Applications

- **Protocol testing**
  - Layer, stack, functionality, conformance, integration testing

- **System Testing**
  - System features, capacity, load, performance, IoT/Pre-IOT testing

- **System simulation**
  - Technology demonstration, Proof of concept system integration

- **Complex automated test environment**

- **Test component for end to end complex network test setups**
  - E.g. LTE-3G network interworking testing, providing LTE network as one of test component
Applications - protocol / functions / conformance test

Test objectives

- ASPs, functionalities, error scenarios, protocol layer conformance test
- Regression test
- Version variant, Release variant, unit testing
- Any test or verification purpose where software interface testing e.g. device with software interface

S1-AP is sample reference solution applicable for any software components
- e.g. NAS, S1-AP, X2-AP, GTP-C/U, DIAMETER protocol component

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Applications - protocol stack test

Test objectives

- Integrated stack services, stack performance/capacity, binding verification, pre integration test
- Version, Release variant testing
- Regression, software debugging

Stack mentioned is S1-C stack as sample reference solution applicable for any stack.
Applications - System simulation/IoT / System test

![Diagram of network components](image)

**Test objectives**

- Simulator for end to end system, performance, lab testing
- Field scenario reproduction in lab environment
- Technology / solution demonstration for business, technical forum/conference
- Conformance / pre IoT test
- Limited capacity / performance test if TC ported on high end hardware (e.g. ATCA)

3G eNB as a reference. Test approach applicable for any technology, system, sub system
- e.g. LTE/EPC HeNB GW, 2G, 3G SS7 STP, SIP Proxy networks etc.
Applications - Complex automated test environment

Test objectives

- Integrated stack services, performance, binding verification, pre integration test
- Host (PC) or target (hardware) based test solution
- Version, Release variant, regression, IoT/Pre-IoT testing
- Integrated protocol, function, regression, system test environment
- Or any test or verification purpose where black box testing is necessary

UE control and user plane L3/L4 stack

PDCP/RLC/MAC

L1

UE Application

Test automation control

eNB System (SUT)

High end hardware based transport e.g. ATCA chassis

EPC

TTCN-3 test framework
eNB software component
3rd party component or system
Automation test tool

eNodeB as a reference. Test approach applicable for any technology, system, sub system
- e.g. LTE/EPC HeNB GW, SS7 STP, SIP Proxy etc.
Applications - re usable components

- **TTCN-3 Protocol definitions**
  - PDU definitions, templates, configuration parameters (PICS/PIXIT)

- **Codecs**
  - Protocol codecs - NAS, S1-AP, GTP-C/U, DIAMETER

- **SA**
  - Routing, scheduling, configuration mechanism

- **TE component**
  - MTC / PTC / Interface definitions

- **Automated test environment**
  - If integrated to automated environment to TTCN-3 framework
Advantages

• **Focus on test purpose and technology**
  - Rather than user interface, logging, platform, interface, preparatory architecture, design

• **Faster test system development**
  - Adaptor, codec, logging, test execution control step by step

• **Across the development/test life cycle**
  - Same test system with re usable components throughout test life cycle

• **Standard driven**
  - Architecture, syntax, industry proven tools, expertise support, Web for reference

• **Across domain**
  - Not just limited to telecom expertise/sub systems could be re used for adjacent technologies (e.g. Automobile, IMS etc.)
Conclusion

• TTCN-3 is a standard/industry supported testing technology for ‘all’ testing needs
  ▪ Could be applied for Wireless network testing in addition to proven UE testing

• Efficient way of test system development
  ▪ Test system features could be enhanced without change in architecture (e.g. automation, logging)
  ▪ Commercial test tools supports default TM, TL, DC and some of standard CD formats (ASN.1, XML etc.) to speed up
  ▪ Platform migration (between OS, or PC to hardware) impact is localized
  ▪ Re usage of test components possible (default advantage of TTCN-3)

• Beyond technology testing
  ▪ Embedded device, storage system / application, high availability software middleware could be added to TTCN-3 application list (addition to Automobile, Telecom etc.)
## Acronyms

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<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>LTE</td>
<td>Long Term Evaluation</td>
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<tr>
<td>EPC</td>
<td>Evolved Packet Core</td>
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<tr>
<td>UE</td>
<td>User Equipment</td>
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<tr>
<td>eNodeB</td>
<td>Evolved NodeB (also eNB)</td>
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<tr>
<td>SUT</td>
<td>System Under Test</td>
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<tr>
<td>SA</td>
<td>SUT Adaptor</td>
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<td>PA</td>
<td>Platform Adaptor</td>
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<td>TTCN-3</td>
<td>Testing and Test Control Notation</td>
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<td>TM</td>
<td>Test Management</td>
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<td>TL</td>
<td>Test Logging</td>
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<td>CH</td>
<td>Component Handling</td>
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<tr>
<td>TE</td>
<td>TTCN-3 Executable</td>
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<tr>
<td>CD</td>
<td>Coding / Decoding</td>
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<td>TC</td>
<td>Test Component</td>
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<td>GTP-C/U</td>
<td>GPRS Tunneling Protocol - Control/User plane</td>
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<tr>
<td>SCTP</td>
<td>Stream Control Transmission Protocol</td>
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<td>MME</td>
<td>Mobility Management Entity</td>
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<td>S1-AP</td>
<td>S1 Application Protocol</td>
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<td>X2-AP</td>
<td>X2 Application Protocol</td>
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<tr>
<td>NAS</td>
<td>Non Access Stratum</td>
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<td>SGW</td>
<td>Serving Gateway</td>
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<td>PGW</td>
<td>PDN Gateway</td>
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<tr>
<td>OS</td>
<td>Operating System</td>
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<tr>
<td>RLC</td>
<td>Radio Link Control Protocol</td>
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<td>MAC</td>
<td>Medium Access Control protocol</td>
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<td>PDCP</td>
<td>Packet Data Convergence Protocol</td>
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<tr>
<td>RRC</td>
<td>Radio Resource Control Protocol</td>
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<tr>
<td>DIAMETER</td>
<td>next generation Authentication, Authorization, and Accounting (AAA) protocol</td>
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<tr>
<td>PDN</td>
<td>Packet Data Network</td>
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<tr>
<td>HSS</td>
<td>Home Subscriber Server</td>
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<td>PCRF</td>
<td>Policy Control and Charging Rules Function</td>
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<td>UDP</td>
<td>User Datagram Protocol</td>
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<td>PICS</td>
<td>Protocol Implementation Conformance Statement and</td>
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<td>ATCA</td>
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<td>eHRPD</td>
<td>Enhanced High Rate Packet Data</td>
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<td>Mobile Switching Center</td>
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<td>SGSN</td>
<td>Serving GPRS Support Node</td>
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<td>SIP</td>
<td>Session Initiation Protocol</td>
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## References

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<td>ETSI ES 201 873-5:</td>
<td>Methods for Testing and Specification (MTS); The Testing and Test Control Notation version 3; Part 5: TTCN-3 Runtime Interface (TRI)*.</td>
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