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Thesis:

Impact of evolving 3G specifications on WCDMA base transceiver station protocol testing

Carried out at IP Mobility Networks division of Nokia Networks

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Agenda

- Introduction
- Objectives and methods
- UTRAN overview
- Evolving Iub interface protocols
- WCDMA BTS testing
- Testing vs. evolving specifications
- Conclusions

Introduction

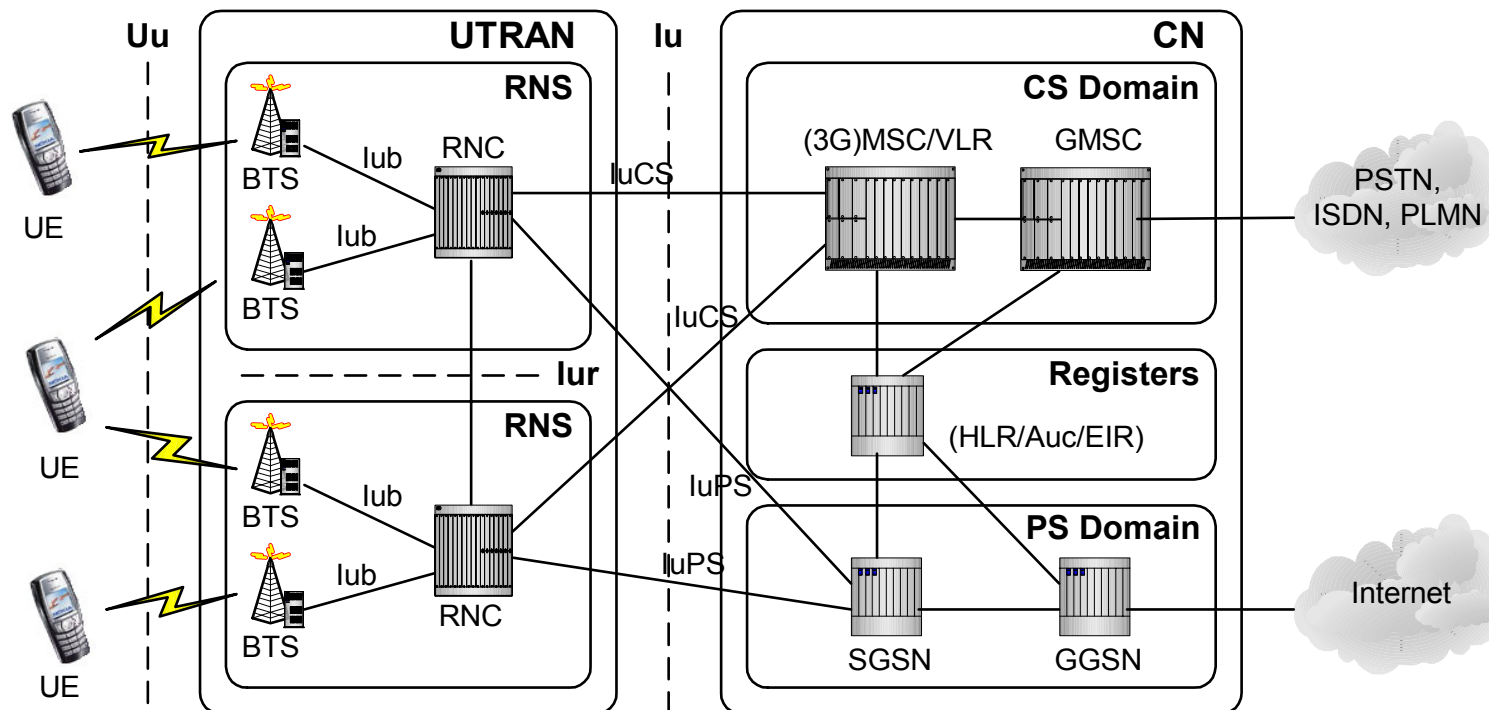
- The 3G standardization is carried out by the 3rd Generation Partnership Project (3GPP)
- Current 3G networks are based on 3GPP Release 99 (R99) specifications
- New specification releases, Release 4 (Rel-4) and Release 5 (Rel-5), introduce new features to the networks
- How is the UMTS Terrestrial Radio Access Network (UTRAN) affected by these changes?
- What are the implications in the Wideband Code Division Multiple Access (WCDMA) Base Transceiver Station (BTS) protocol testing point of view?

Objectives and methods

- The following objectives were set for the thesis:
 - to describe the WCDMA BTS as a part of the UTRAN
 - to examine the Iub interface protocol environment according to 3GPP R99, Rel-4 and Rel-5 specifications
 - to describe the testing environment of the WCDMA BTS
 - to suggest reasonable measures to deal with the changes in protocol testing environment caused by the new releases
- Methods:
 - Literature study
 - Practical involvement in BTS testing
 - Estimations based on earlier activities at Nokia Networks

UTRAN overview (1/2)

- UTRAN located between the User Equipment (UE) and Core Network (CN)
- UTRAN functionality handled by two types of network elements, Base Transceiver Stations (BTS) and Radio Network Controllers (RNC)
- UTRAN interfaces (Uu, Iu, Iub and Iur) standardized by the 3GPP



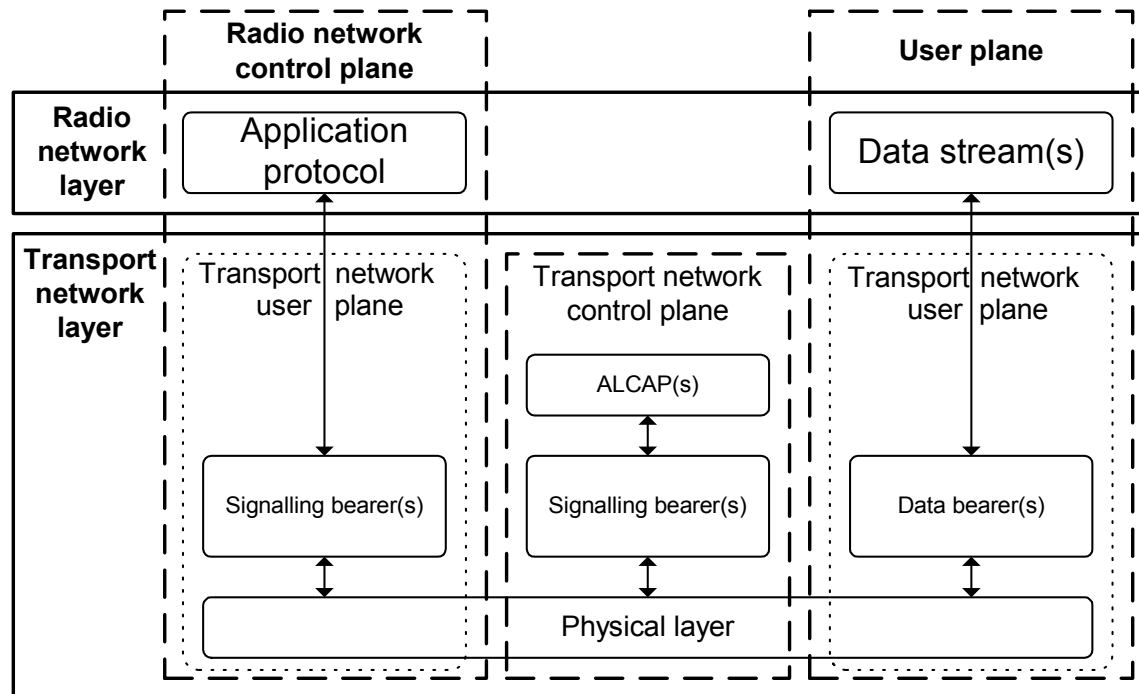
UTRAN overview (2/2)

- UTRAN is responsible for managing the transport between the UE and CN
- RNC handles the UTRAN controlling issues, such as traffic switching and Radio Resource Management (RRM)
- BTS (3GPP term Node B) implements the physical WCDMA radio access towards the UE and, on the other hand, the physical transmission towards the RNC
- Iub is the name for the interface between a BTS and RNC

Evolving Iub interface protocols (1/6)

- Iub is the interface between a BTS and RNC in a UTRAN
- The UTRAN general protocol model is applied for Iub
- The idea of the model is to keep the UTRAN specific protocols of the radio network layer independent of the underlying transport network layer

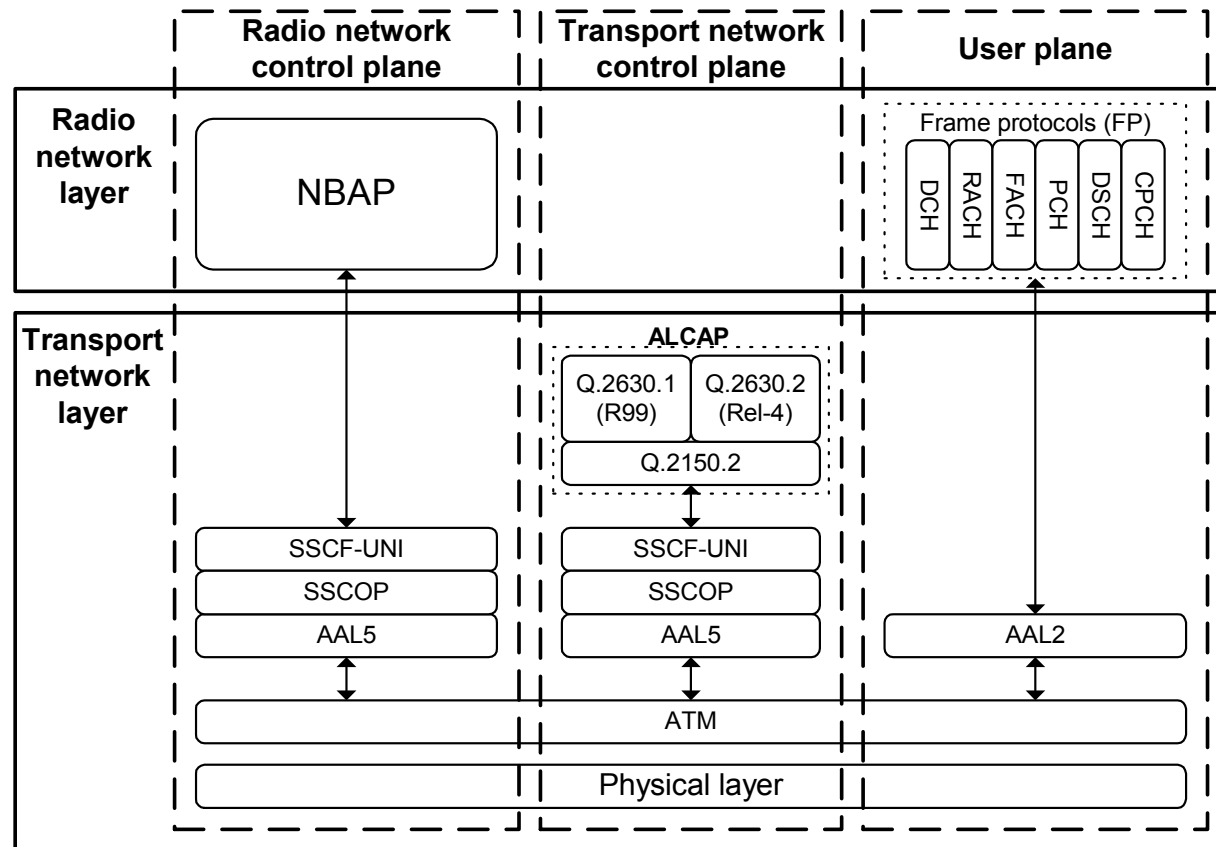
UTRAN general protocol model:



Evolving Iub interface protocols (2/6)

- The changes to UTRAN, and Iub, between R99 and Rel-4 very minor
- R99 and Rel-4 Iub use ATM in the transport network layer

R99 and Rel-4
Iub protocols:



Evolving Iub interface protocols (3/6)

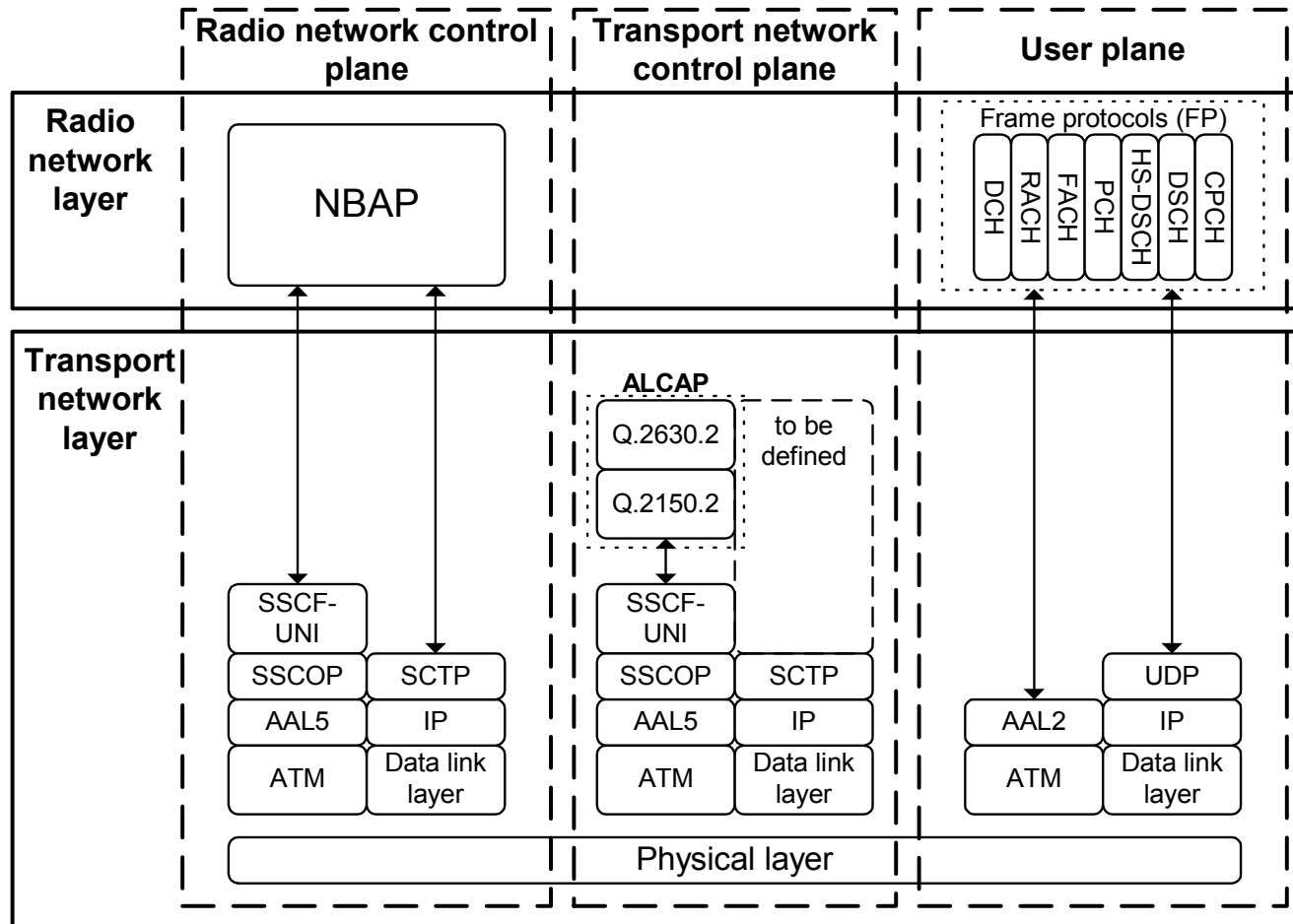
- Description of the R99 and Rel-4 Iub protocols:
 - ATM over SDH/PDH used as the basis for all the Iub protocols
 - SAAL-UNI (AAL5, SSCOP, SSCF-UNI) used as the signalling bearer for the control planes
 - AAL2 used as the user plane data bearer
 - Node B Application Protocol (NBAP) used for UTRAN related signalling between RNC and BTS
 - Frame Protocols (FP) used for user data transfer
 - ALCAP protocols for establishing and releasing user plane connections

Evolving Iub interface protocols (4/6)

- Changes to Iub when moving from R99 to Rel-4:
 - AAL2 signalling protocol changed from Q.2630.1 to Q.2630.2
 - Enables the modification of transport layer characteristics of established user plane connections
 - Minor changes or additions to NBAP functions and protocols
 - Related to e.g. GPS (positioning) functionality
- Changes to Nokia Iub/BTS implementation:
 - Nokia proprietary R99 NBAP changed to 3GPP Rel-4 NBAP
 - The support for Downlink Shared Channel (DSCH) and Common Packet Channel (CPCH) FPs added

Evolving Iub interface protocols (5/6)

- Rel-5 brings IP to the transport network layer:



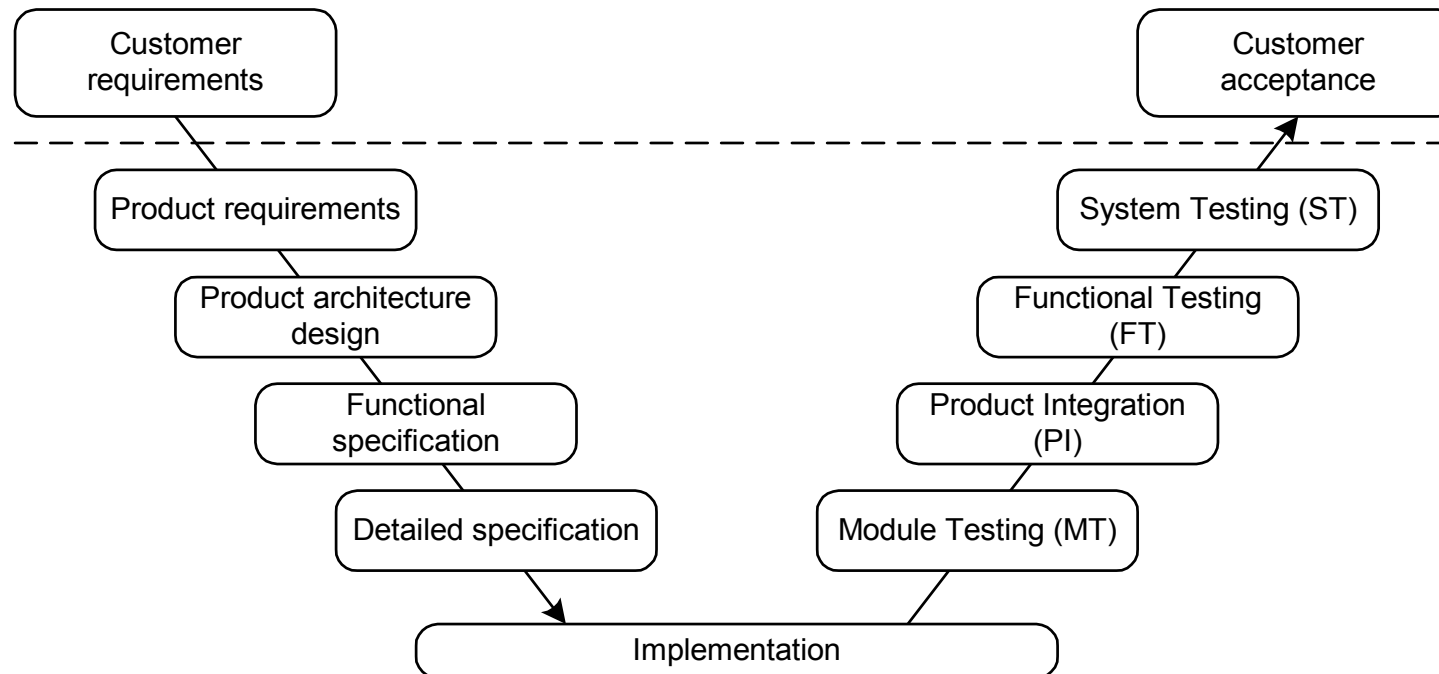
Evolving Iub interface protocols (6/6)

Changes to Iub when moving from Rel-4 to Rel-5:

- ATM transport may optionally be replaced by IP based transport
 - Rationale: wide deployment and low price of IP networking technology
 - Support for IPv6 mandatory, IPv4 optional
 - User Datagram Protocol (UDP) used as the user plane data bearer
 - Stream Control Transmission Protocol (SCTP) as the signalling bearer
 - ALCAP no longer required when IP transport is employed (IP/ATM interworking still under discussion)
 - Data link layer below IP may be implemented as preferred, but PPP with HDLC framing should be supported
 - Possible data link layer implementations: PPP/AAL5/ATM, PPP/AAL2/ATM, PPP, AAL5/ATM, MPLS/ATM, Ethernet etc...
- New High Speed DSCH (HS-DSCH) FP to support the High Speed Downlink Packet Access (HSDPA) feature
- Minor changes or additions to NBAP functions and protocols
 - Related to e.g. HS-DSCH FP functionality

WCDMA BTS testing (1/4)

- The overall testing process may be characterized by the V-model
- Test phases on the right carried out according to requirements and specifications on the left



WCDMA BTS testing (2/4)

Test tools for WCDMA BTS Iub protocol testing:

- Iub analyzers and simulators
 - Analyzers mainly used between real network elements (RNC and BTS) for analyzing the flow of protocol messages
 - Simulators are able to simulate and emulate the protocol functionality of a real RNC (and CN)
 - Support UTRAN specific protocols (NBAP and FP)
 - Companies such as Nethawk, Tektronix, Agilent and Catapult provide tools for testing Iub protocols
- Standard ATM / IP test tools
 - Can be used for transport network layer testing
 - Don't support UTRAN specific protocols
 - Might be more mature and inexpensive than Iub specific test tools
- Real network elements (RNC, UE, MSC etc...)
 - Testing in "real" environment
 - Possibilities for test automation and testing of unexpected situations more limited
- Supporting test tools
 - Analysis and controlling tools for BTS internal interfaces (fault source detection)

WCDMA BTS testing (3/4)

Test automation:

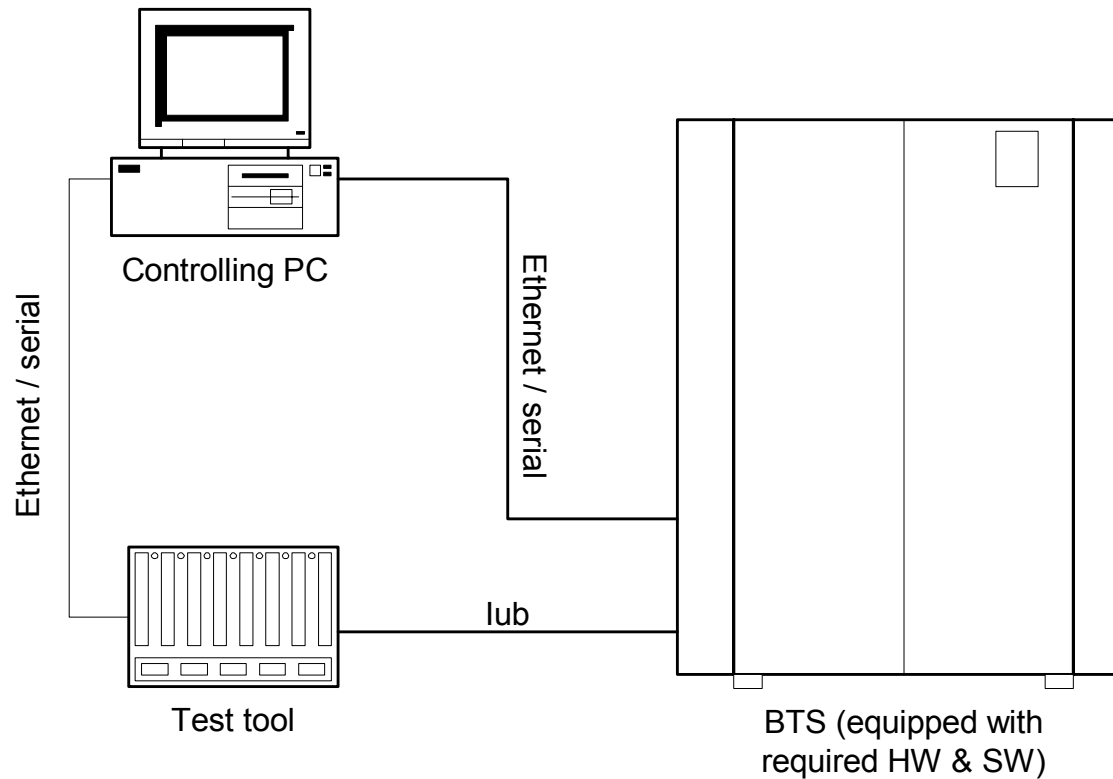
- Basic idea to make testing faster and more efficient with less resources
- Creating automated test cases requires high competence both in BTS and tester technology
- Automated testing best suited for regression testing, i.e. already implemented features tested when new SW & HW versions released
- BTS protocol testing can be automated effectively as lub protocols have well-restricted properties

Automation alternatives:

- Tree and Tabular Combined Notation (TTCN)
- Scripting and macro languages
- Labview and Agilent VEE

WCDMA BTS testing (4/4)

- Typical WCDMA BTS Iub protocol test environment:
 - includes a controlling PC and a test tool that can be automated
 - PC also used for BTS configuring and monitoring the BTS internal interfaces

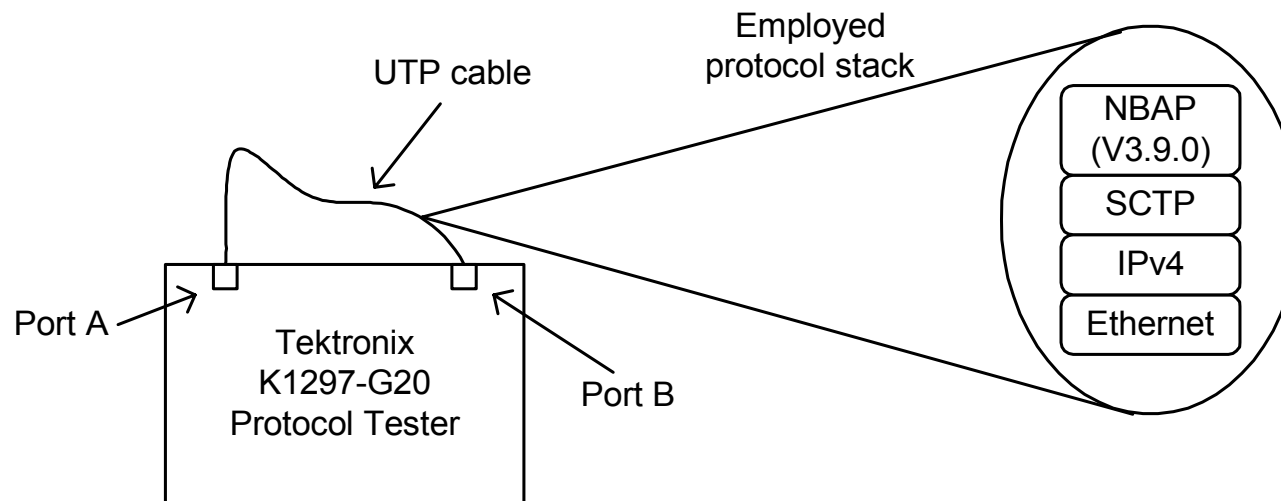


Testing vs. evolving specifications (1/3)

- Test personnel competencies
 - Theoretical and practical training about new protocols and features should be provided before implementations available -> competence related testing problems minimized
 - Use of existing personnel familiar with 3G technology plus freshly recruited IP experts
- Test system/tool development
 - Old tools require updating for the new protocols/features
 - New tools, if needed, should be acquired early enough so that cases can be developed
 - Rel-5 compliant lub not yet fully supported by the testers
 - Common protocol test tools can already be used for IP-transport testing
 - New protocols/features causing test planning attention:
 - Rel-4: ALCAP, NBAP and FP (changes in Nokia lub)
 - Rel-5: IP-transport (IPv6, SCTP, UDP, data link layer options, NBAP, FP..)
 - Majority of test cases should be automated -> emphasis on good test planning and design

Testing vs. evolving specifications (2/3)

- As a part of the thesis, Tektronix K1297-G20 Protocol Tester was evaluated and employed for an experimental simulation hosting R99 NBAP on Rel-5 compliant transport network layer (SCTP/IPv4/Ethernet)
 - The NBAP message transfer (16 messages) between a BTS and RNC, when a BTS is powered up in a network, was simulated
 - No real network elements were involved, the tester was used to send messages between two of its Ethernet ports



Testing vs. evolving specifications (3/3)

- Simulation results and conclusions:
 - NBAP messages were successfully sent and received over Rel-5 compliant transport network layer
 - Results and protocol behaviour could be monitored
 - Such simulations could be used for educative purposes, e.g. demonstrating Rel-5 protocol features to test personnel before real implementations are available
- Improvement suggestions for the simulation:
 - Addition of user plane (FP over UDP)
 - Simulating calls over IP-transport (addition of higher layer protocols such as MAC, RLC and RRC)
 - Modifying it to work with a real BTS
- Tool (Tektronix K1297-G20) evaluation results:
 - Universal protocol test tool that hosts features (SW) for Iub testing
 - Hosts powerful means for test automation, including possibility to graphically define Message Sequence Charts (MSC) for the test cases
 - Available protocols may be “freely” piled on top of each other to create own simulations

Conclusions

- The IP-transport option, presented in 3GPP Rel-5, causes the greatest impacts on BTS protocol testing
- Test personnel competencies
 - theoretical training, learning by simulations
 - in addition to the existing 3G competent personnel, IP experts could be recruited
- Test system development
 - new test tools to be acquired early enough, old tools to be upgraded
 - majority of testing should be automated i.e. emphasis on careful test planning and design
- 3GPP specifications keep on evolving – in Release 6 it is even possible that RNC functionality embedded in BTSs
 - Iub disappears? BTS would have interfaces with other BTSs and CN (Iu)?

Thank you!

Questions?