TEST SYSTEM ARCHITECTURES USING ADVANCED STANDARDIZED TEST LANGUAGES

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Fraunhofer FOKUS

Engineering a Connected World

CONTENTS

AXEL RENNOCH

- **Researcher at Fraunhofer FOKUS in Berlin, Germany**

- **User of standardized Modelling and Test languages**
  - LOTOS, SDL/UML
  - Tree and Tabular Combined notation (TTCN-1&2)

- **TTCN-3 user from the beginning**
  - Developer for ETSI, 3GPP and industry
  - Trainer and consultant
  - Research projects and evolution team

MOTIVATION

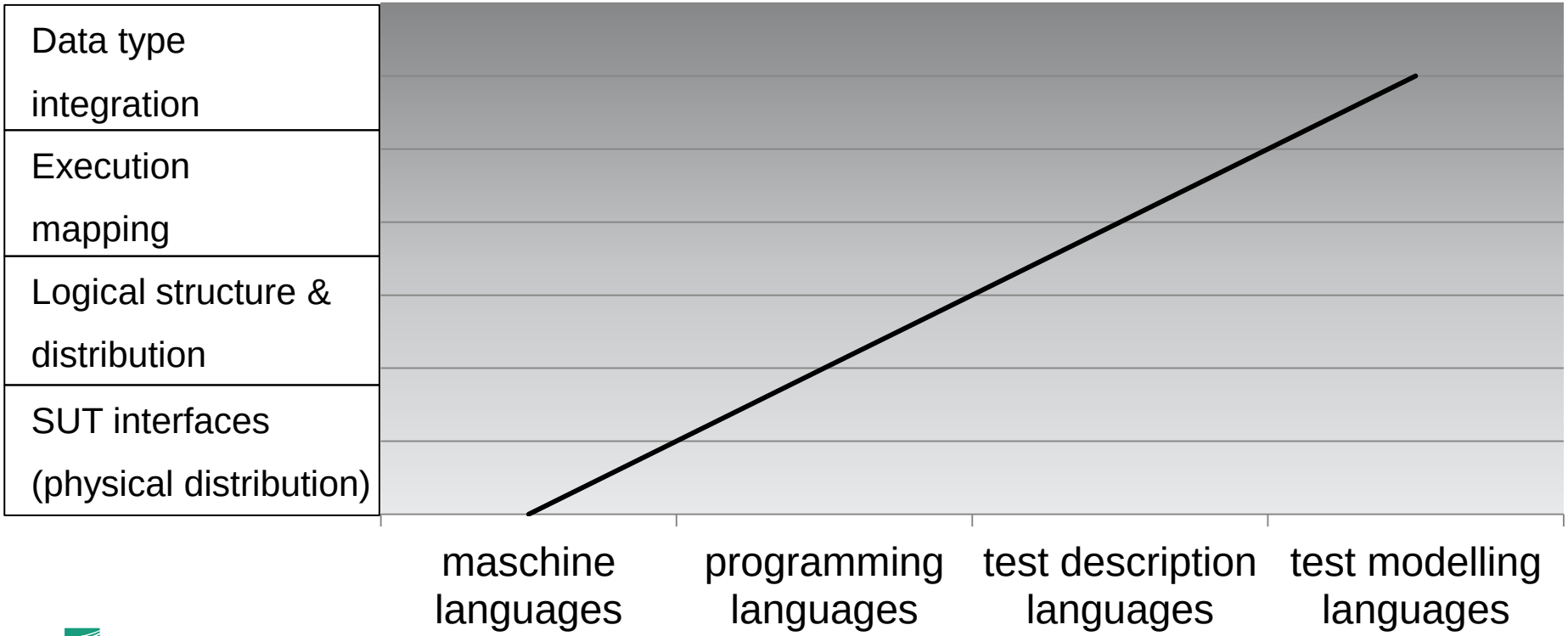
InSTA **2015**:

- Keynote by **Sigrid Eldh** on
  - **Software Test Architecture**
  - definition & aspects

InSTA **2016**:

- Continuation on **Advanced Standardized Test Languages** for
  - **Test System Architecture**
  - means & examples, user perspective

CHALLENGES FOR TEST SYSTEMS



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SOME INITIAL QUESTIONS FOR TEST DEVELOPERS

- Identify SUT access interface points
- Test objectives: functional, load, security?

- Target :
  - standardization body (more abstraction, top down) or
  - in-house test solution (address concrete tools, bottom up)

- Parallel test components (scalability?)
- Coordination & synchronization (existing frameworks?)

CONTENTS

- **Introduction**
- **Advanced standardized test languages**
  - **TTCN-3**
  - UML testing profile
  - TDL
- **Test Automation Architecture**
- **Conclusions**

WHAT IS TTCN-3?

- Testing and Test Control Notation
- Internationally standardized testing language for formally defining test scenarios. Designed purely for testing

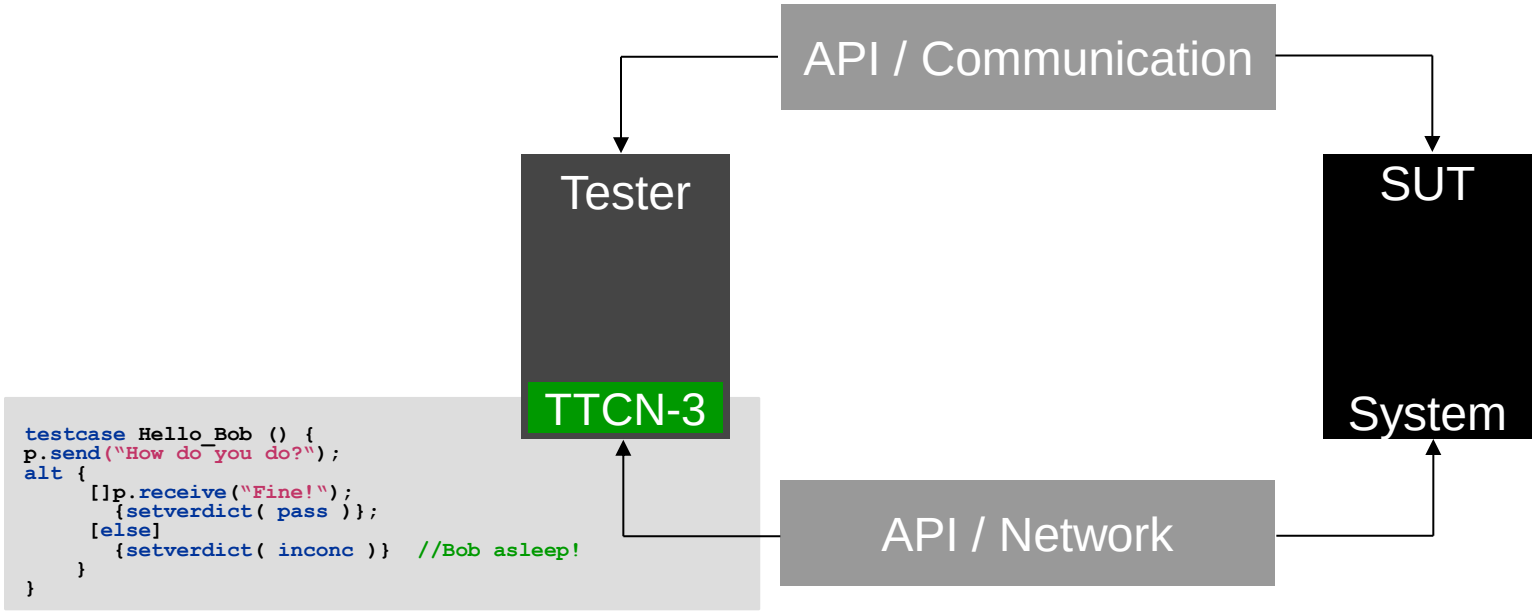
```
testcase Hello_Bob () {
p.send("How do you do?");
alt {
     []p.receive("Fine!");
          {setverdict( pass )};
     [else]
          {setverdict( inconc )}  //Bob asleep!
}
}
```

IDEA & DESIGN PRINCIPLES OF TTCN-3

- **One test technology for different tests**
  - Distributed, platform-independent testing
  - Integrated graphical test development, -documentation and –analysis
  - Adaptable, open test environment

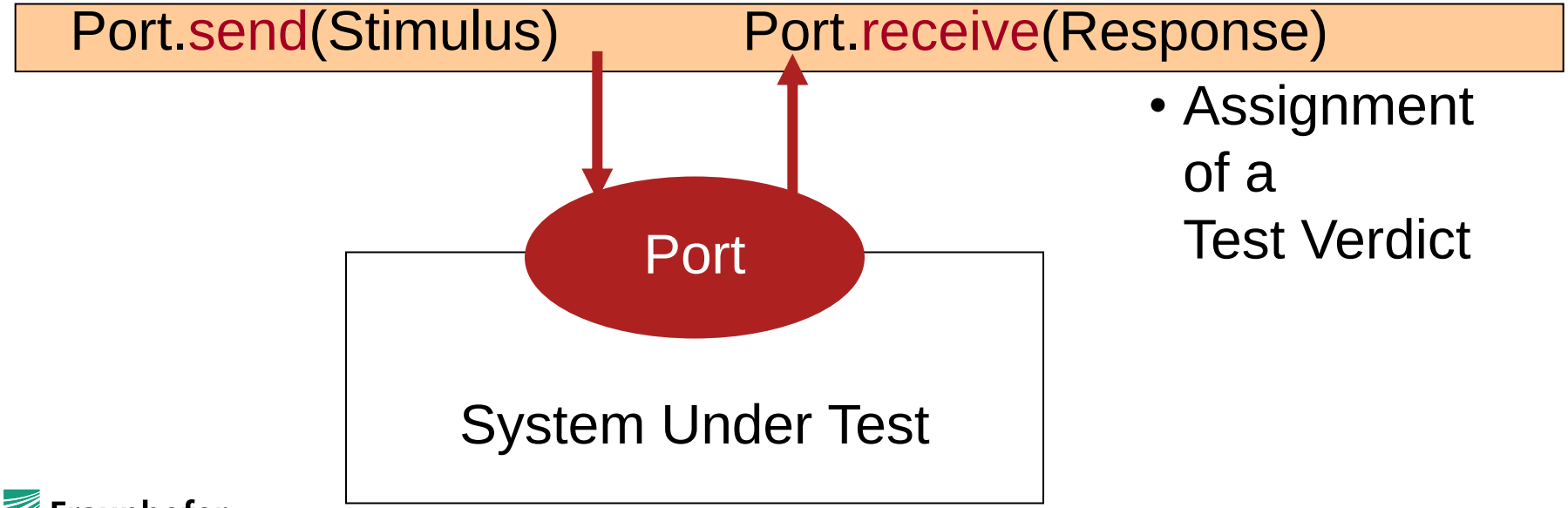
- **Areas of Testing**
  - Regression Testing
  - Conformance and Functionality Testing
  - Interoperability and Integration Testing
  - Load/ Stress Testing

TTCN-3 EXECUTION



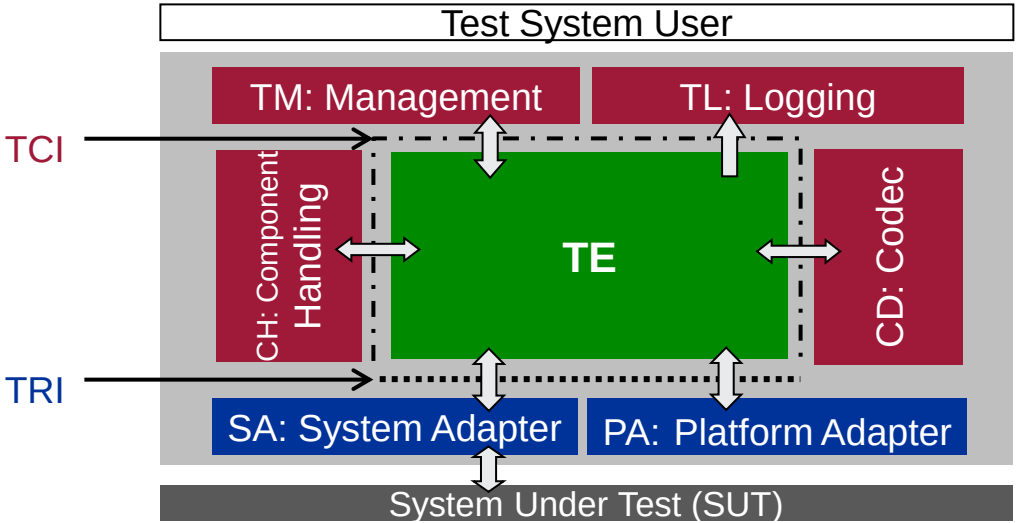
TTCN-3 IS DESIGNED FOR BLACK-BOX TESTING

TTCN-3 Test Case



- Assignment of a Test Verdict

A TTCN-3 TEST SYSTEM

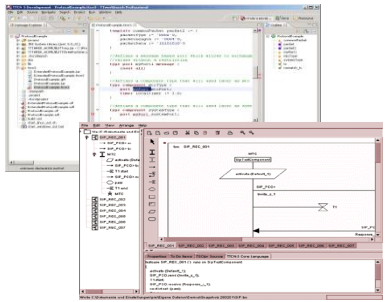


ETSI ES 201 873-1 TTCN-3 Core Language (CL)
ETSI ES 201 873-5 TTCN-3 Runtime Interface (TRI)
ETSI ES 201 873-6 TTCN-3 Control Interfaces (TCI)

TE – TTCN-3 Executable
TM – Test Management
TL – Test Logging
CD – Codec
CH – Component Handling
SA – System Adapter
PA – Platform Adapter
SUT – System Under Test

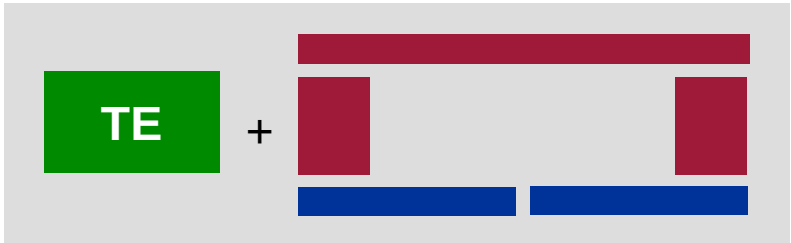
IMPLEMENTATION

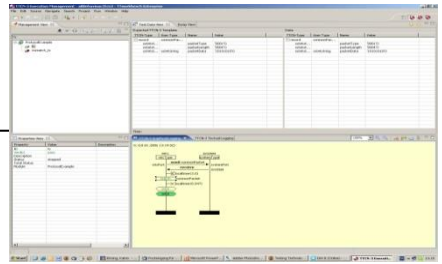
ATS



TTCN-3

Test System





SUT

Communication

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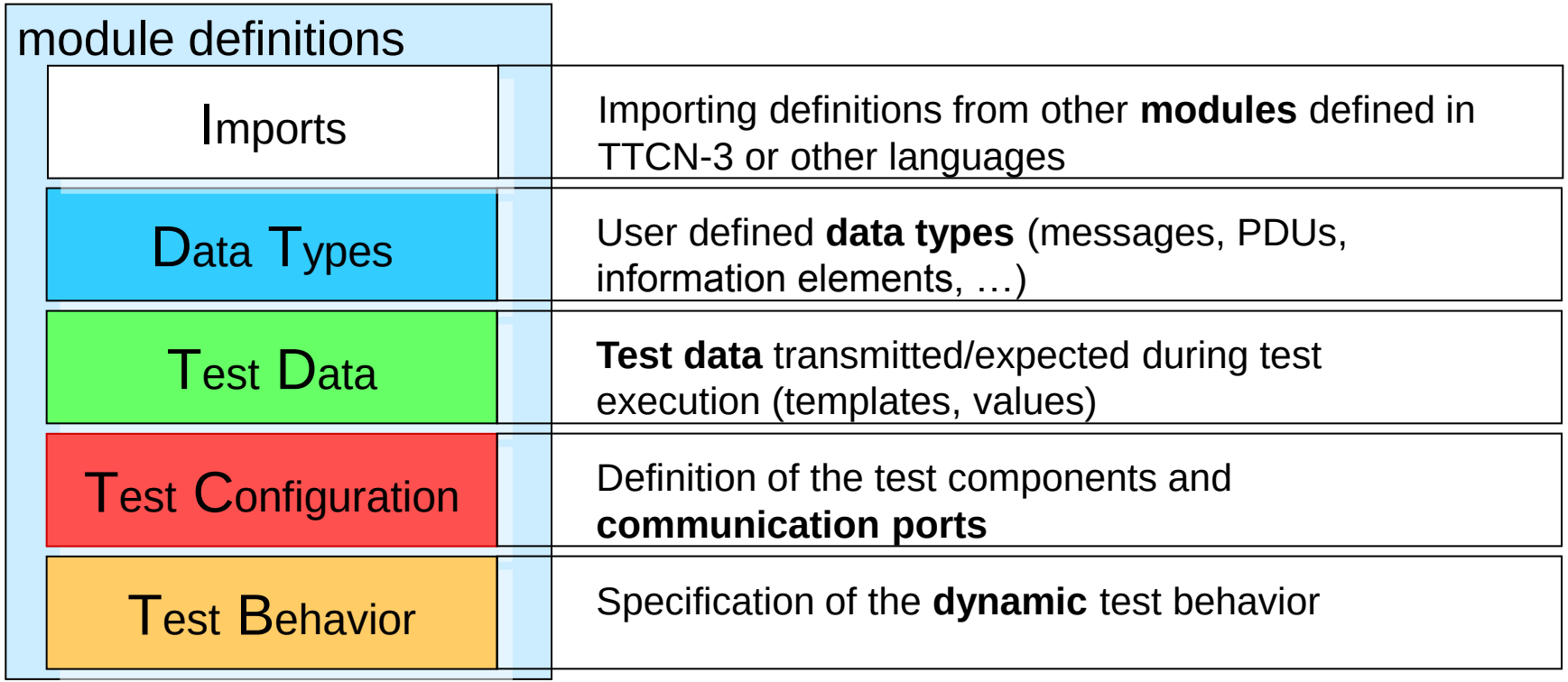
MAJOR LANGUAGE ELEMENTS OF TTCN-3 NOTATION



TTCN-3 DOMAINS: TELECOM

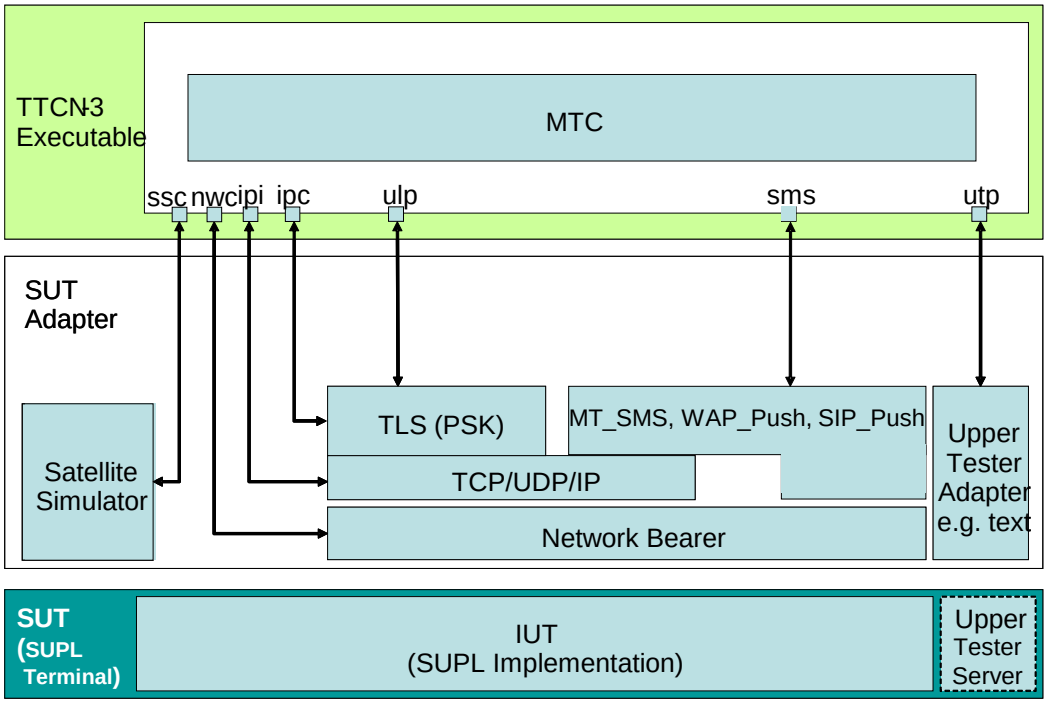
- Industrial use
  - Big companies with hundreds of TTCN-3 engineers: Ericsson, Nokia, Siemens, Motorola
  - large distribution among SME
- Standardization bodies
  - standardized test suites:
    ETSI / 3GPP (**LTE**!)/ OMA / TETRA and its members
  - IMS performance benchmark project:
    Intel, HP, BT, FOKUS and others
- Test tool manufacturer:
  - Commercial Tektronix, Catapult, Nexus, R&S, Spirent, …
- Certification program based on TTCN-3: e.g. WiMax forum

TEST SYSTEM EXAMPLE 1: OMA SUPL

Secure UserPlane Location Protocol

Single MTC controls e.g.:

- UlpPort (Lup interface)
- IpcPort (IP configuration)
- smsPort used for SMS
- UtpPort for upper tester commands
- IpiPort (IP information, e.g. release)
- NwcPort: network bearer control, e.g. handover trigger
- SscPort: satellite simulation control, e.g. scenario trigger



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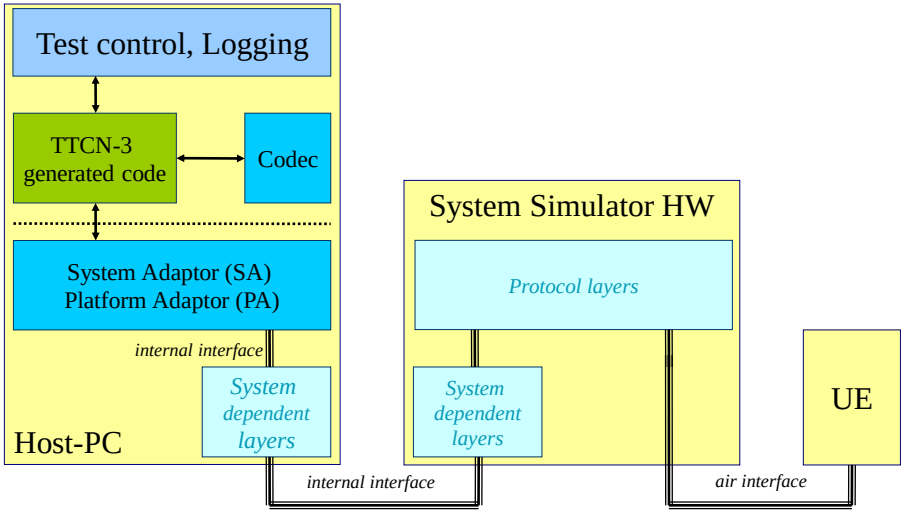
TEST SYSTEM EXAMPLE 2: 3GPP UE TESTING

- **E-UTRAN (LTE air interface):** 3GPP TS 36.523-3 V12.4.0 (2015-12)

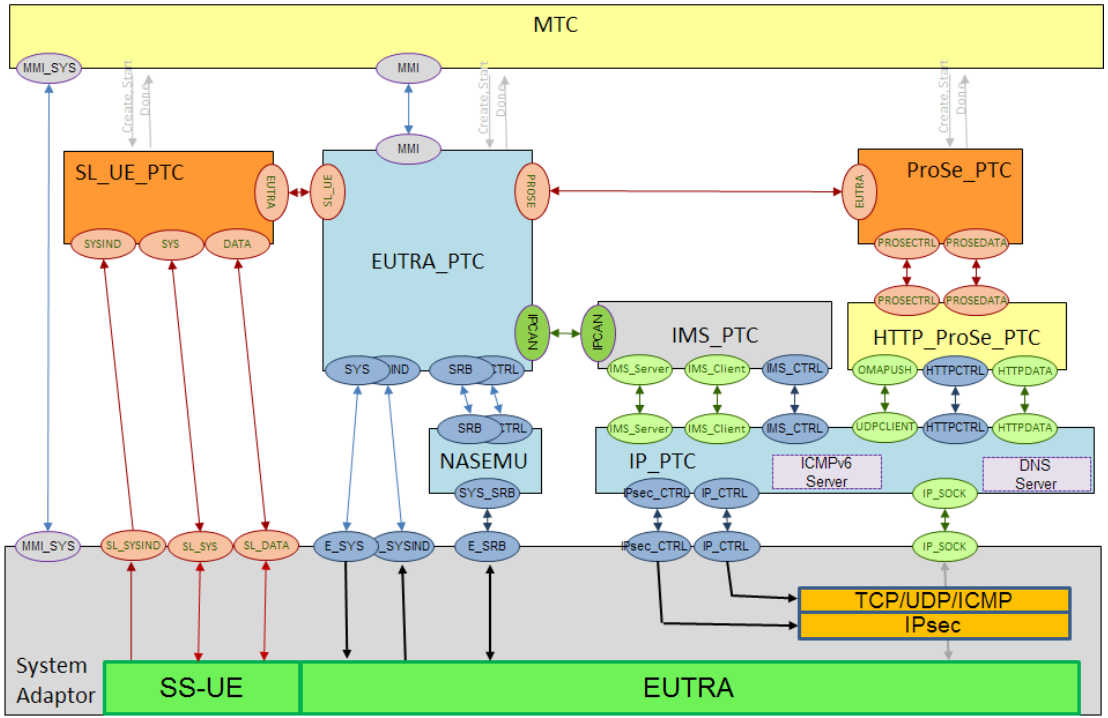
- **Each radio access technology (RAT) is hosted by a separate TTCN-3 parallel component:** E-UTRAN, UTRAN, GERAN, others.

- **PTCs are controlled by the TTCN-3 main test component (MTC) which:**
  - is independent from the RAT;
  - may host the upper tester for MMI and AT commands;



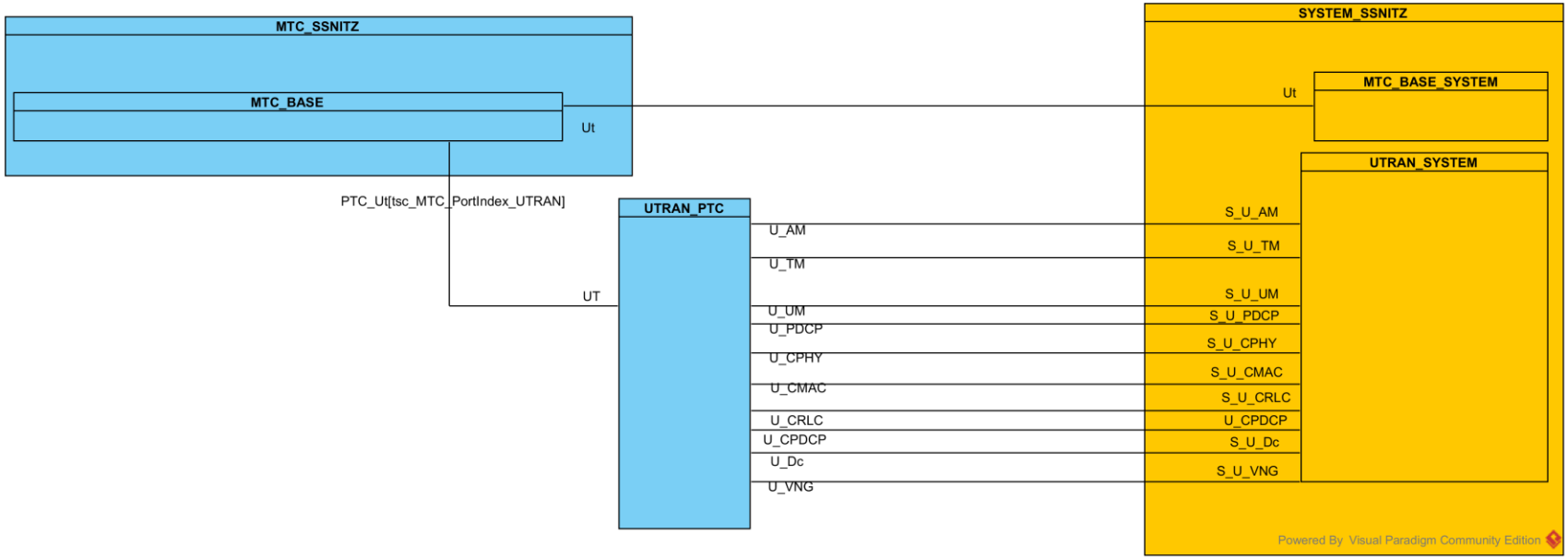
TEST SYSTEM EXAMPLE 2: 3GPP UE TESTING

- Multiple of configurations
- Several PTCs
  - Cooperating
  - Communicating



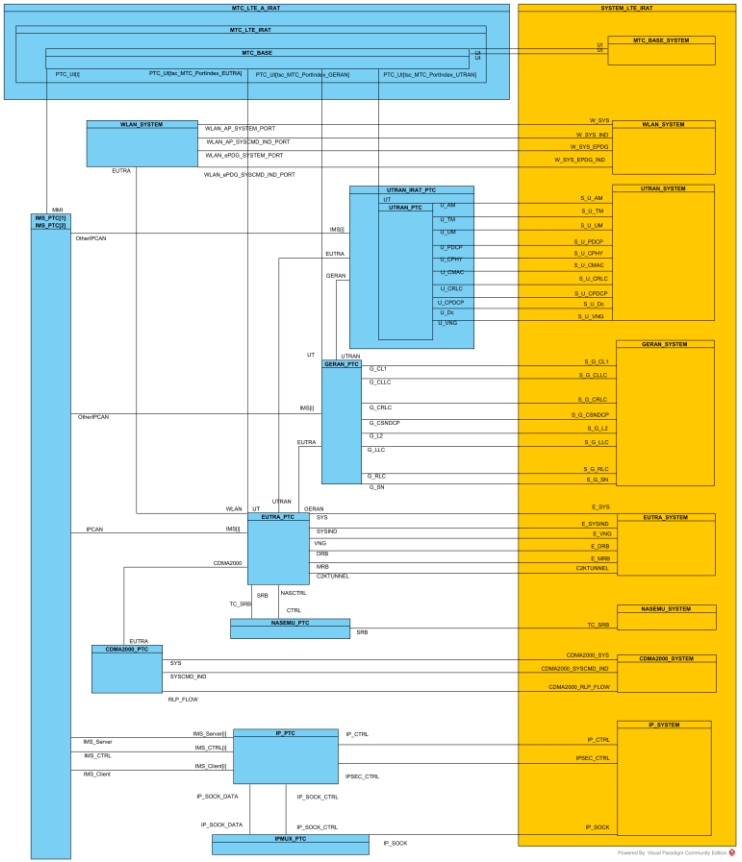
TEST SYSTEM EXAMPLE 2: 3GPP UE TESTING

- Simple scenario
- Reuse of nested component types for MTC, PTCs and TSI



TEST SYSTEM EXAMPLE 2: 3GPP UE TESTING

- More complex configuration
- Nested component types
- Illustration using Visual Paradigm

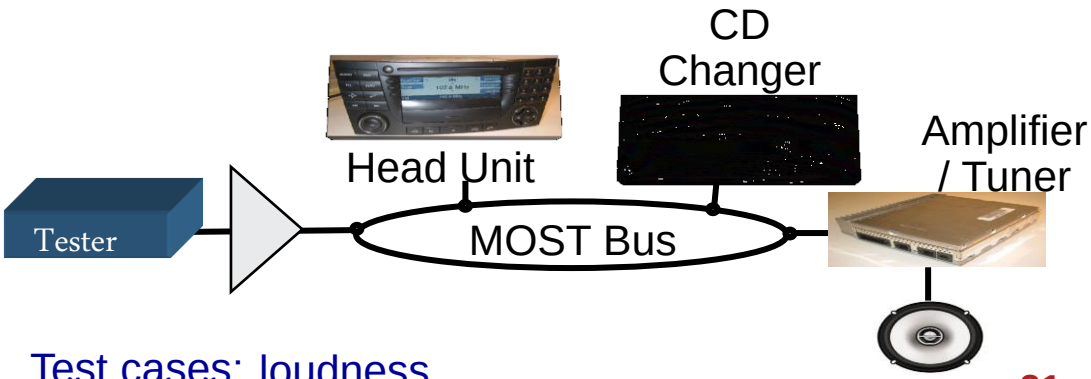


TTCN-3 DOMAINS: AUTOMOTIVE

- Car communication systems
  - Daimler, Volkswagen, SiemensVDO
  - edutainment bus system (test suite)
- Standardization groups:
  - AUTOSAR consortium
  - MOST cooperation
- Car-to-car communication

Telematics Applications in the Cockpit

- Audio (CD / Radio), Video
- Telephone, SMS
- Navigation
- Speech recognition
- User interface for body electronic



Test cases: loudness
playCDTitle

TTCN-3 DOMAINS: MEDICINE

Medicine

- SiemensMED (image processing)
- HL7 eHealth protocols (Interoperability)

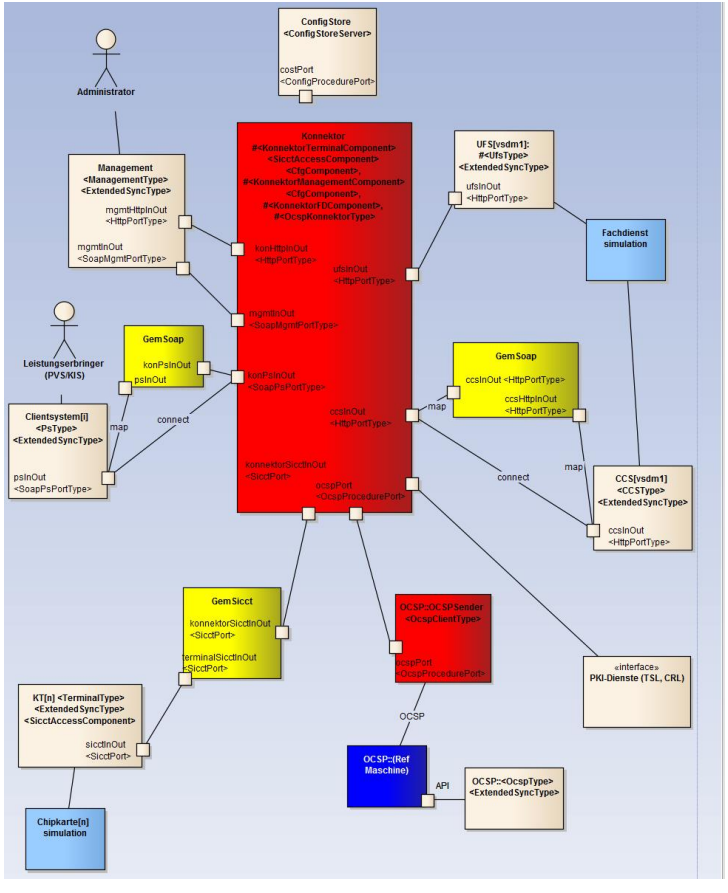
Upcoming E-Health infrastructure for Germany

- High security requirements (e.g. certificates, cryptography)
- Test development prior to SUT availability
- Multiple heterogenous interfaces:
  - cardterminals,, card simulations,
  - Webservices, OCSP server etc.

TEST SYSTEM EXAMPLE 3: E-HEALTH “KONNEKTOR”

- Complex configuration
- Illustration using IBM Rational Enterprise Architect:

  - PTC,
  - simulators,
  - SUT (mock),
  - real server,
  - adaptation code



ETSI FRAMEWORK FOR SYNCHRONISATION

- **Source** STF 276 (IPv6 project)

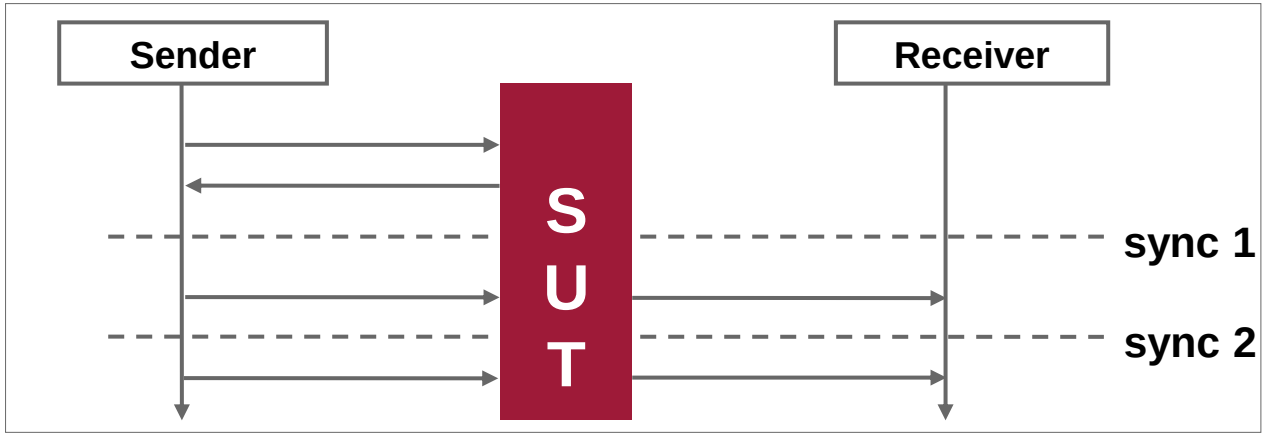
- Set of **TTCN-3 functions** to e.g.
  - Start and control parallel components
  - Exchange synchronization signals between components
- Set of **charstring constants** for **synchronization points**
  - *preambleDone, sync1, sync2*
  - *testbodyDone*

- **Predefined timers** e.g. to avoid deadlocks at synchronization points

- http://www.ttcn-3.org/index.php/development/devlibraries/devlib-libcommon

SYNCHRONIZATION SAMPLES

– Synchronization occurs between parallel TTCN-3 components (using signals via MTC)



- Sync 1 ensures the completion of senders procedure
- Sync 2 confirms the arrival of a message at receivers side

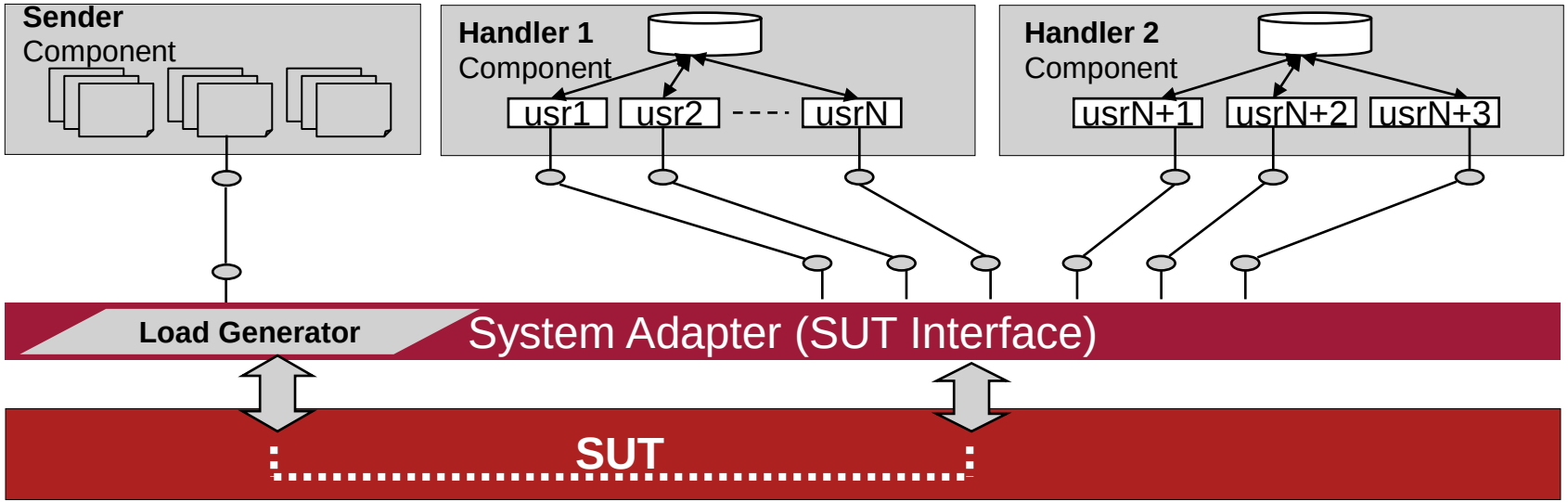
MODULE IMPORT „LAYERING“

- Test suite specific code
  - testcase, test (component) functions
- Test suite specific library
  - Component types, test configuration, pre/postamble
- Interface/protocol specific library
  - SIP, DNS, IPv6 etc.
- Interface/protocol independent library
  - synchronizaton

high level:
(low
reusability)

Low level:
(High
reusability)

EXAMPLE 4: IMS BENCHMARK TEST CONFIGURATION



- 400 subscribers per component **Handler**
- Component **Sender** initializes/provides data requests for load-generator
- 5.000 - 10.000 IMS subscribers (per server)
- Up to 250 requests per second (per server)

LESSONS LEARNED WITH TTCN-3

- **Study access interface points (Test System Interface)**
  - Available Test solution plugins?
- **Test objectives: functional, load, security?**
  - Consider synchronization overhead (e.g. ETSI's LibCommon)
  - Consider performance issues (e.g. encoded data preparation)
- **Concurrent test components with separated traces & verdicts (easier failure analysis)**
  - Consider test tool logging functions
- **Improve decomposition using libraries for**
  - handling single interface types
  - Nested component types (to be extended)
- **Use modelling tools for the illustration of the TTCN-3 architecture**

BEYOND TTCN-3: MBT

- TTCN-3 is used in several domains as binding link between modelling and execution

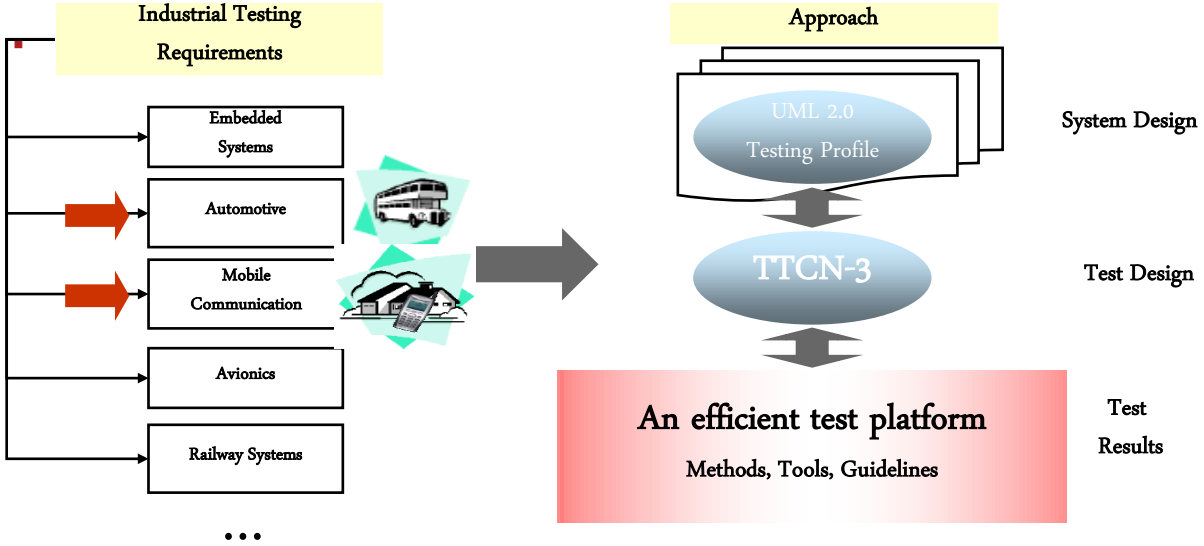
- Commercial tools do generate TTCN-3 code for test execution
  - lots of academic prototype tools

- Selection of industrial case studies: e.g. European MIDAS project
  - pilots in SOA testing automation *(later)*

TTCN-3 LINK TO UTP

Objective:

- To develop an efficient **test platform** fulfilling **industrial testing requirements**
- To **execute high-level test models**, e.g. UML testing profile



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- **Conclusions**

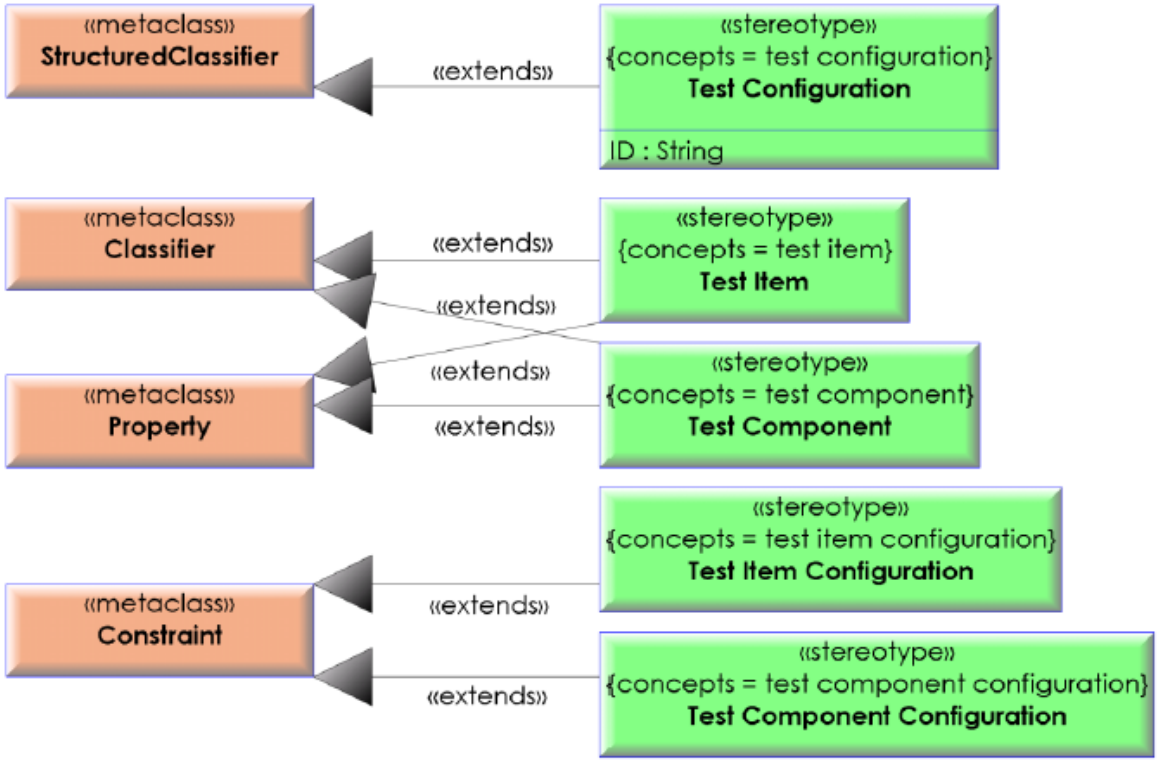
UML TESTING PROFILE (UTP)

- Standard by the Object Management Group:
  Version 1.0 (2004), current version 1.2 (2013), revised *draft* version 2.0 (Nov 2015)
- Profile of UML version 2:
  Industrial standard for (graphical) modeling of Test architectures, behavior and data.

- Conceptual Model:
  Test context, cases, objectives, data, configuration, arbitration&verdicts, logs
- UTP library:
  predefined types and values (e.g. ISO 25010 Quality model, ISTQB Test levels)
- Extras:
  Mapping to TTCN-3 **(procedure-based communication only)**

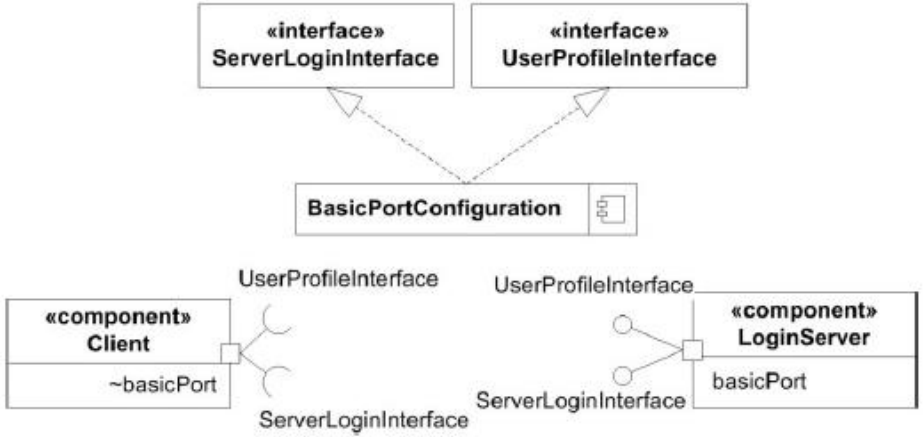
TEST CONFIGURATION OVERVIEW

– Standardized mapping of UTP stereotypes to UML metaclasses

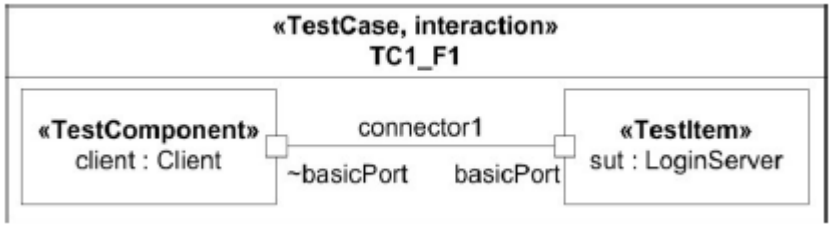


UTP TEST CONFIGURATION EXAMPLE (UTP 2.0 ONLY!)

– LoginServer
test **components**



– LoginServer
test configuration



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UTP MAJOR USE

- **Domain-independent test modeling for dynamic testing** approaches:
  - Test environments, test configurations, test case specifications (including test case derivation), test data specifications/values

- Test **evaluation**, i.e., managing and visualization **of test results**

- **Integration of best practices**
  such as keyword-driven testing, equivalence class testing, etc.

- **Combination with other UML profiles** (e.g., SysML, MARTE, SoaML)
  - E.g. to achieve requirements traceability, …

LESSONS LEARNED WITH UTP

- **Current version 1.2**
  - less industrial use since version 1.0 **ten years ago**
  - No big test suites
  - Only some tooling

- **UTP Revision 2.0 is promising**
  - E.g. covers test configuration

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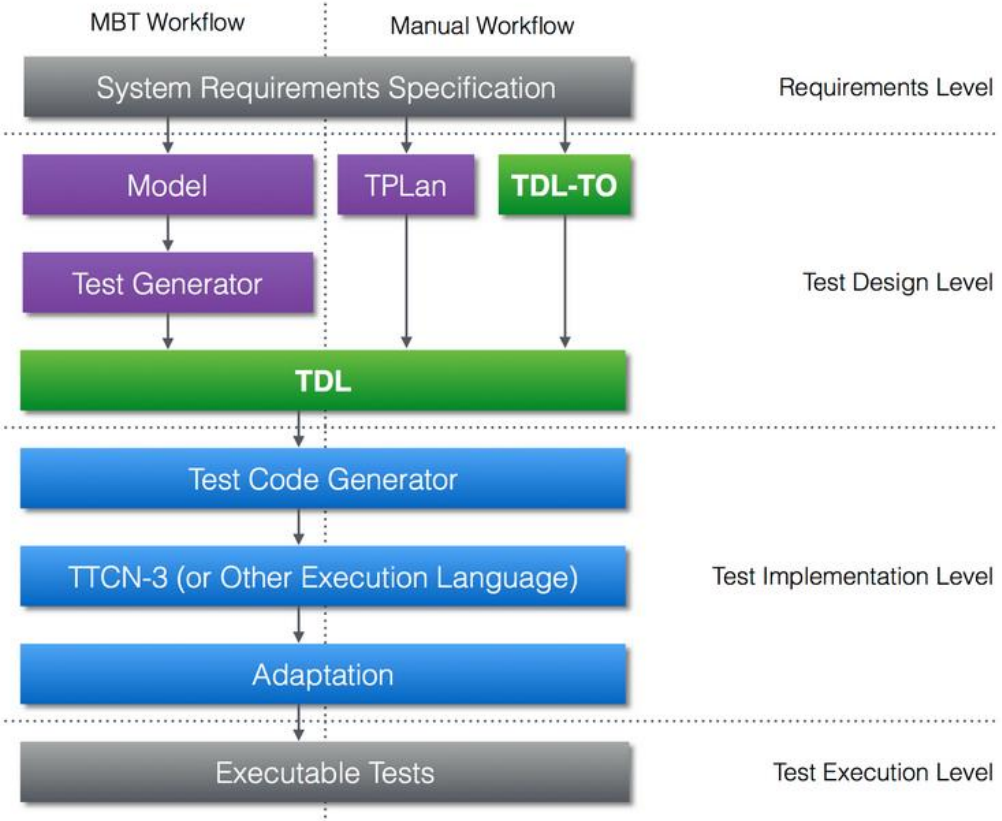
TEST DESCRIPTION LANGUAGE

- New ETSI Standard
  ES 203 119-1 (V1.2.0, 2015-04)
- Fills gap between the high-level test purposes and TTCN-3
- Simple Text notation with graphical presentation



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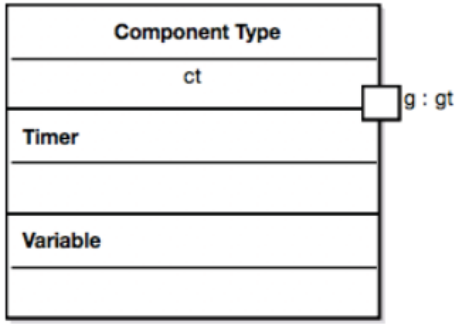
TDL TEST CONFIGURATION

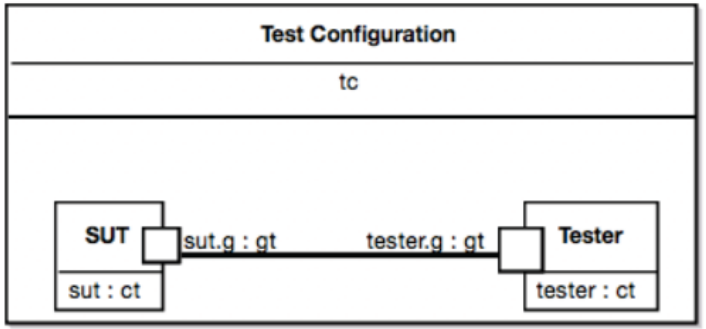
- Typed components and gates
- Timers and variables
- connections among gates
- component roles

```
Gate Type gt accepts Login, Response;

Component Type ct having {
    gate g of type gt;
}

Test Configuration tc {
    create Tester tester of type ct;
    create SUT sut of type ct;
    connect tester.g to sut.g;
}
```





LESSONS LEARNED WITH TDL

- **Pure testing view**
- **Compromise between UTP and TTCN-3**
  - Simple
  - Executable

- **Not ready to use**

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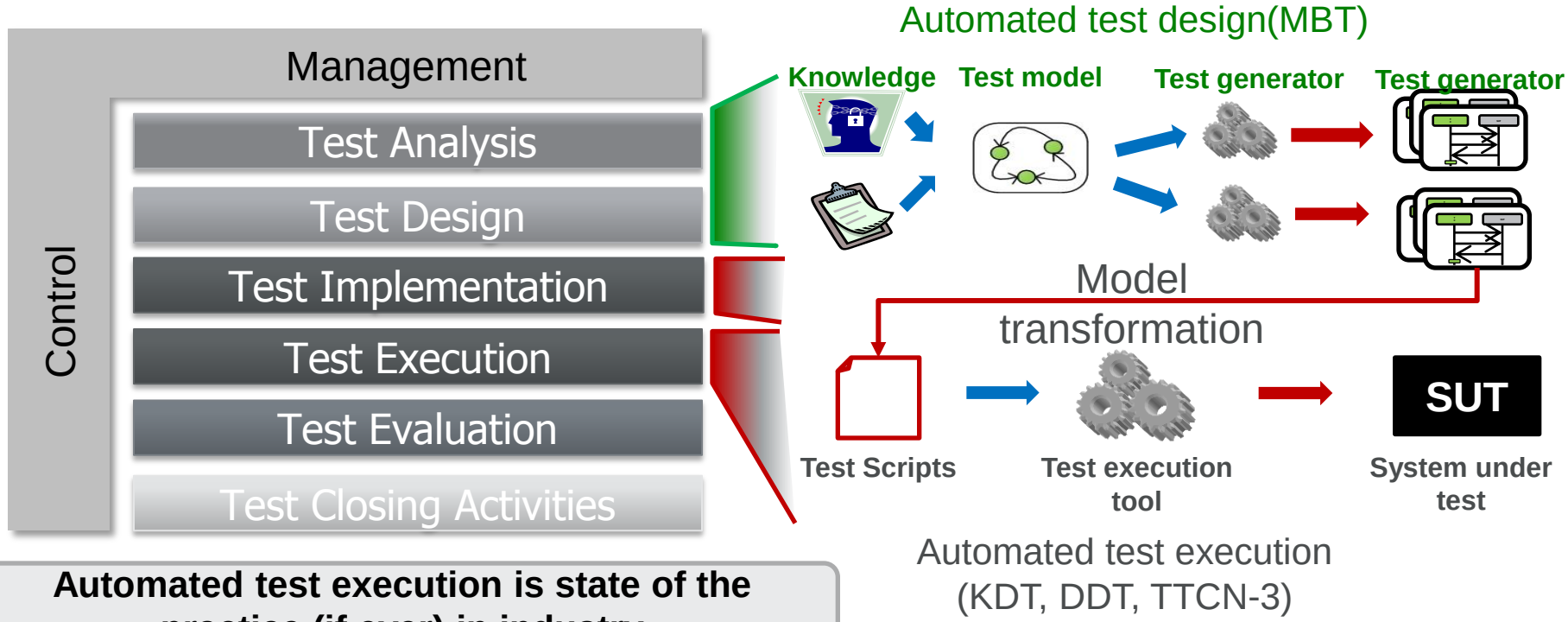
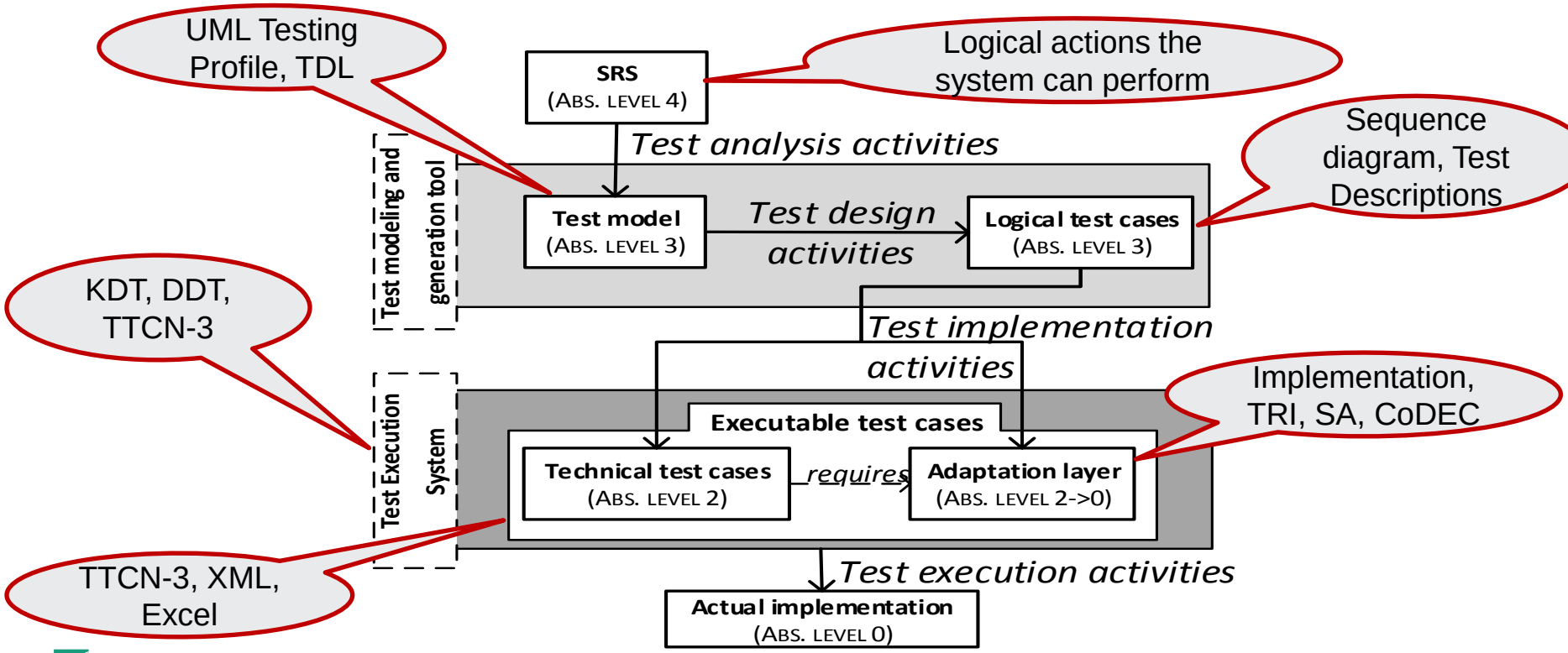
THE ISTQB FUNDEMANTAL TEST PROCESS



Automated test execution is state of the practice (if ever) in industry

ABSTRACTION LEVELS IN TEST AUTOMATION



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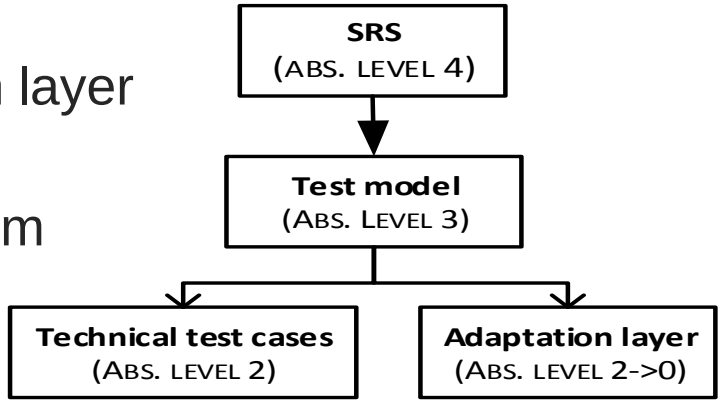
TOP-DOWN APPROACH

Model is master

- Test design independent from adaptation layer or test execution system
- No constraint on the test execution system
- Often used in academic prototypes

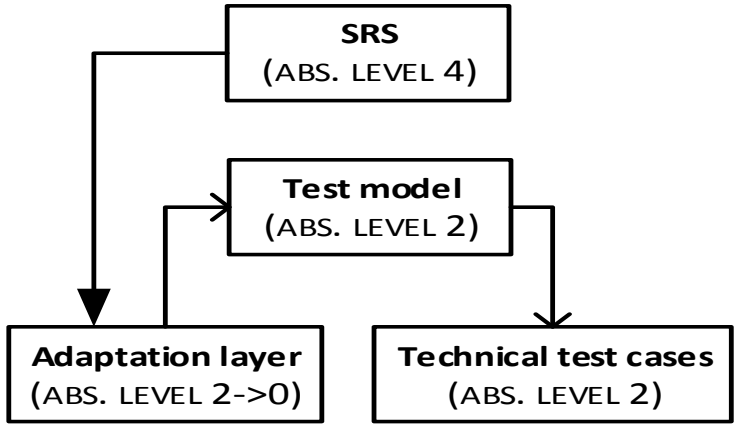


Recommendation
Feasible for ***proof-of-concepts***, limited use for industry

BOTTOM-UP APPROACH

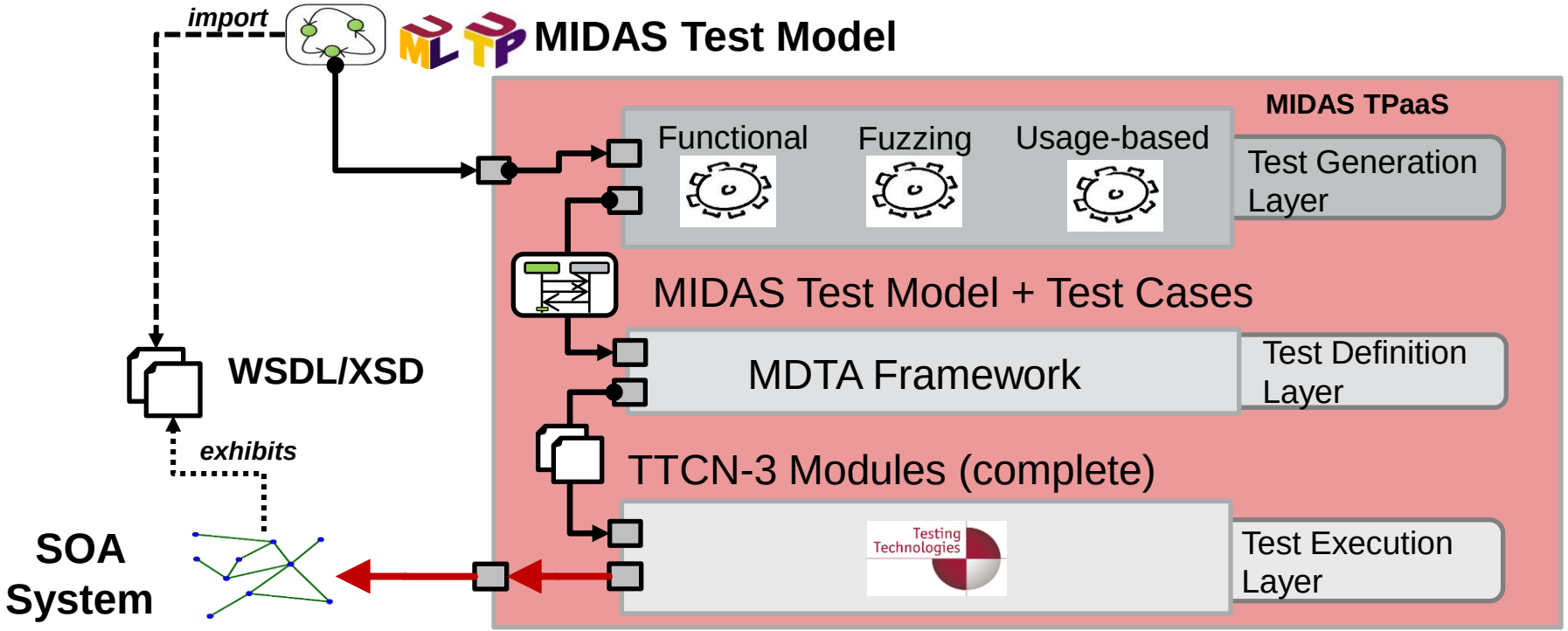
Adaptation layer is master

- Ensures immediate automated test exection
- **Requires** available adaption layer
- Test model derived from the adaption layer



Recommendation
Only if adaptation layer is clear for test developers

TEST AUTOMATION ARCHITECTURE: MIDAS



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LESSONS LEARNT FROM TEST AUTOMATION ARCHITECTURE

- Two approaches have been shown
- Bottom-up approach was realized in MIDAS

- **Integration of data types** (e.g. WSDL) is challenging

- (Initial) engineering effort can be quite high

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SUMMARY: OVERVIEW

	TTCN-3	UTP	TDL
Standardization body	ETSI, ITU-T	OMG	ETSI
History	Since 1992	Since 2004	Since 2014
Applicability	All domains and testing types	All domains	Conformance, interop
Execution tools and solutions	+	*proprietary via C-unit*	TTCN-3 mapping *in preparation*
Current user groups	Industry, Research	Academic, Research	n/a

SUMMARY: TEST ARCHITECTURE

	TTCN-3	UTP 2	TDL
Component extension	+	UML generalization	- *(reuse elements)*
Coordination/ synchronization	+*via libraries*	using general ordering	explicitly
Import of WSDL, IDL, etc.	(+)	*proprietary via SoaML*	-
Graphical Test architecture	**- needed!**	+	+
Link to UML	-	+	in preparation

GOOD REASONS FOR STANDARDIZED TEST LANGUAGES

- They significantly increases your **system quality**.
- You can focus on what to test, not on how.
- They reduce costs and efforts in test system **maintenance**.
- They are **independent** of access technology, operating system and implementation domain

- They support **communication** between system development and test department.

- You can count on available, trained and **certified experts**

CONCLUSION

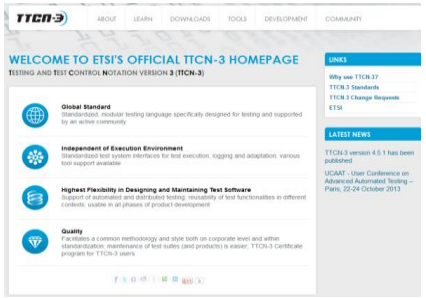
– **TTCN-3, UTP and TDL**
  - international Standards for testing
  - allow abstract definitions for testing
  - (partly) accepted in research and industry

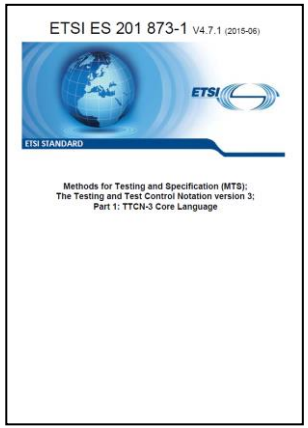
- **Tool support** (still week)
  - UML -> UTP/TDL -> TTCN-3

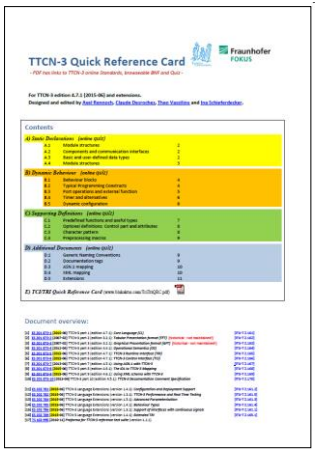
- Test automation need further enhancements

TTCN-3 SOURCES

- Online information
  → www.ttcn-3.org
- TTCN-3 User Conference
  → 2016 in in Budapest, Hungary
- TTCN-3 Standards, Papers, Book
  → http://www.ttcn.de/
- Quick Reference
  → http://www.blukaktus.com/
- Exercises and Tooling
  → research licenses

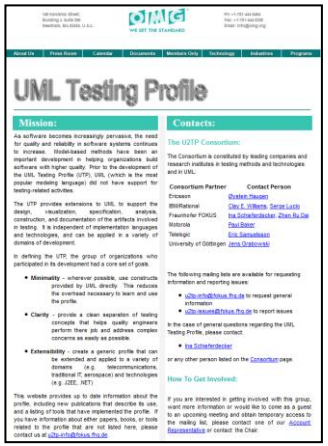


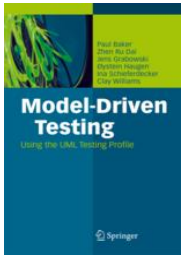


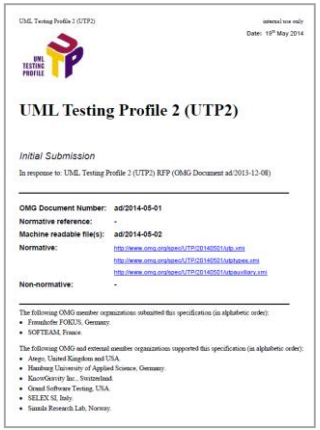


UTP SOURCES

- Online information
  →http://utp.omg.org/
- MBT User Conference
  → 2016 in Budapest, Hungary
- UTP Standards
  →http://www.omg.org/spec/UTP/
- MDT/UTP Book
  → http://www.springer.com
- Exercises and Tooling
  → research licenses







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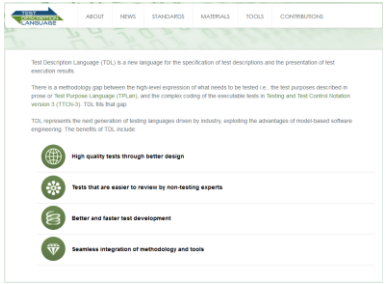
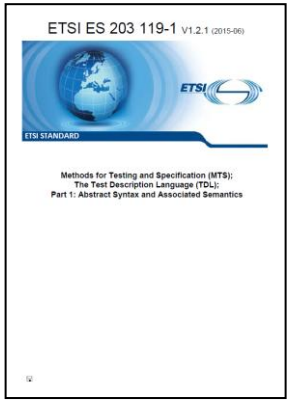
TDL SOURCES

- Online information
  → http://tdl.etsi.org/
- TDL User Conference
  → 2016 in Budapest, Hungary
- TDL Standards
  → http://tdl.etsi.org/index.php/downloads
- Exercises and Tooling
  (in preparation)
  → https://portal.etsi.org//STF/STFs/STFHomePages/STF492.aspx





Thank you
for your attention!

www.fokus.fraunhofer.de

(System Quality Center)

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