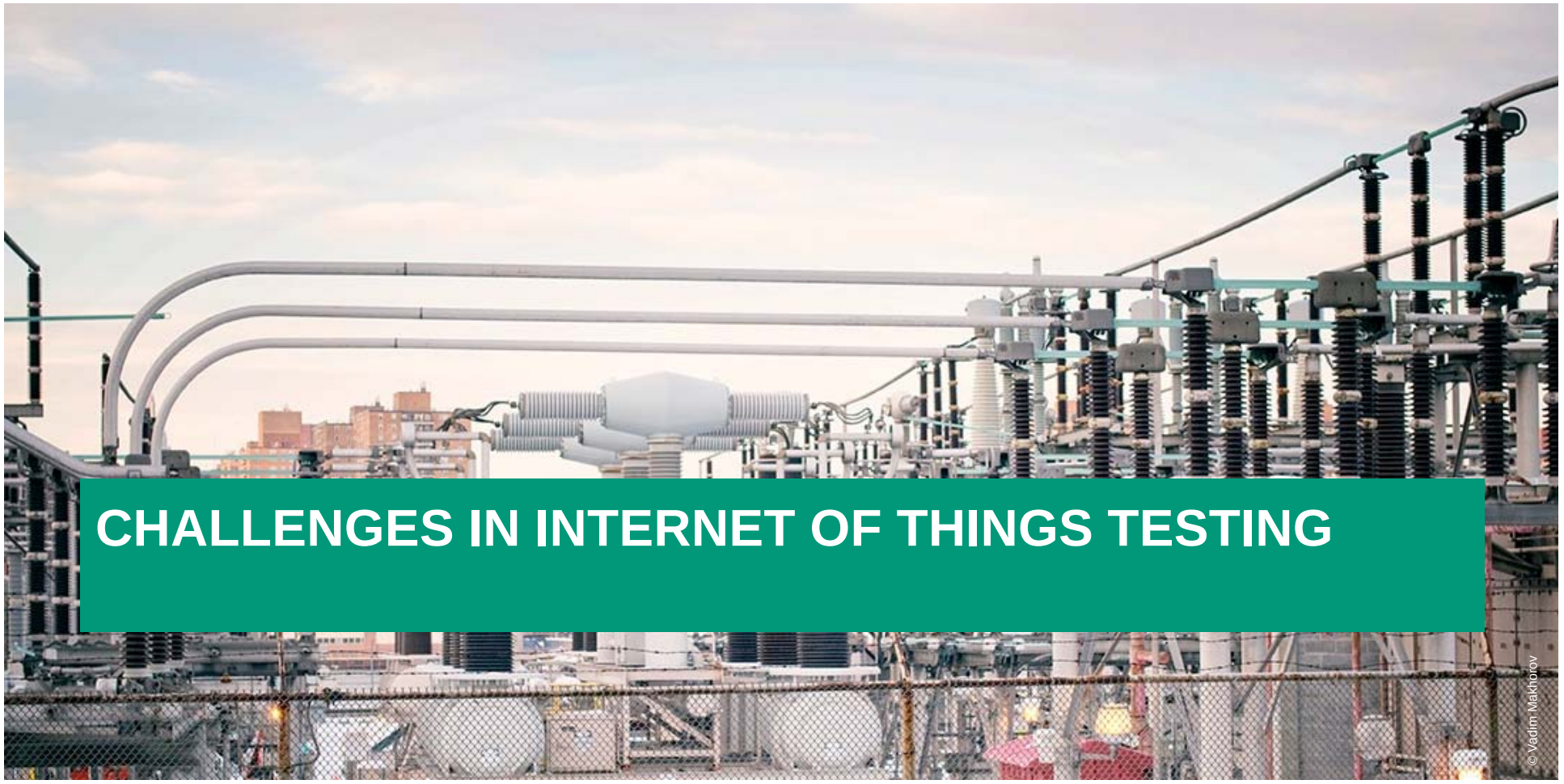


CHALLENGES IN INTERNET OF THINGS TESTING

Ina Schieferdecker

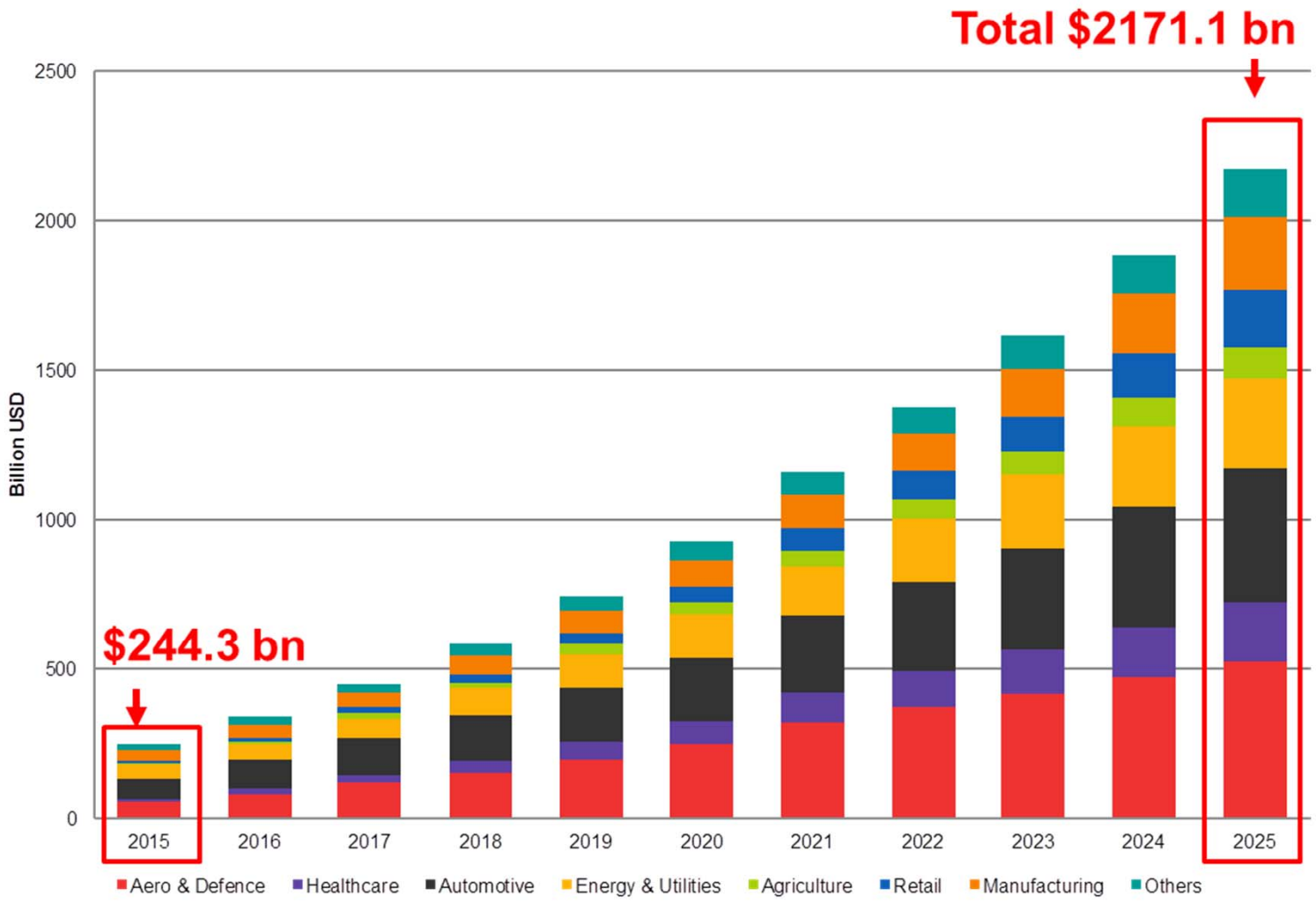
ASQF Testing Day Rhine-Main, June 20, 2016

Fraunhofer FOKUS

TALKING PLANTS, ANIMALS AND MORE

http://www.iot-a.eu/public

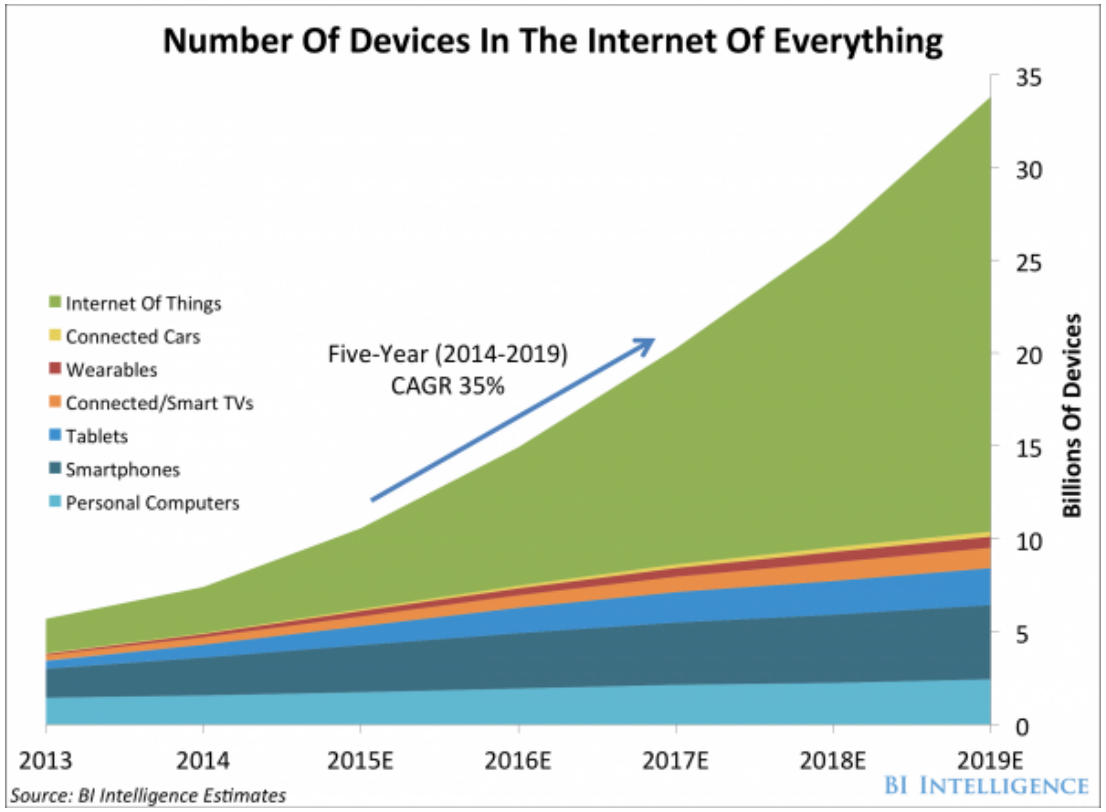
IOT MARKET FORECAST



Source: IoT Market Forecast, Visiongain

Fraunhofer FOKUS

FURTHER FORECASTS



Connected Mobiles worldwide

Source: *Cisco Global Mobile Traffic Forecast Update, Gartner*

Global data streams in the Internet per Second in Terabyte

Source: *ITU ICT Facts and Figures 2015-2020*

WHAT IS IOT

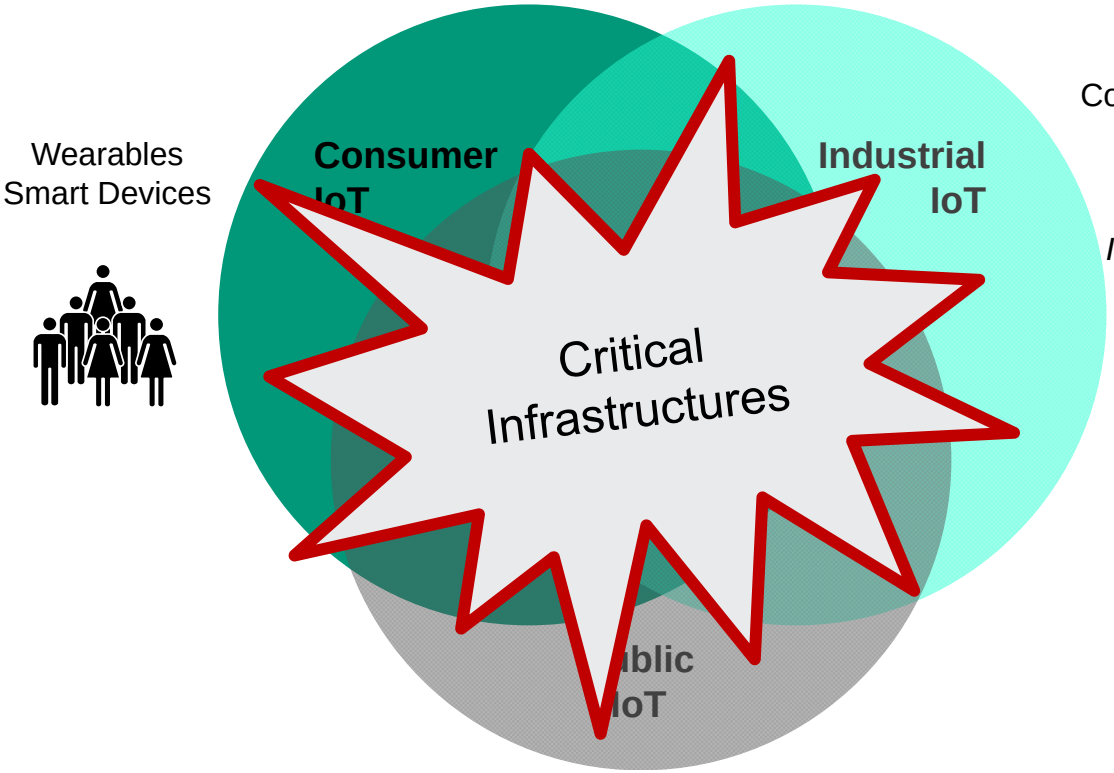
IEEE

An *IoT is a network that connects uniquely identifiable “Things” to the Internet. The “Things” have sensing/actuation and potential programmability capabilities. Through the exploitation of unique identification and sensing, information about the “Thing” can be collected and the state of the ‘Thing’ can be changed from anywhere, anytime, by anything.*

ISO/IEC

An infrastructure of interconnected objects, people, systems and information resources together with intelligent services to allow them to process information of the physical and the virtual world and react.

ANOTHER VIEW ON IOT



Selected Aspects

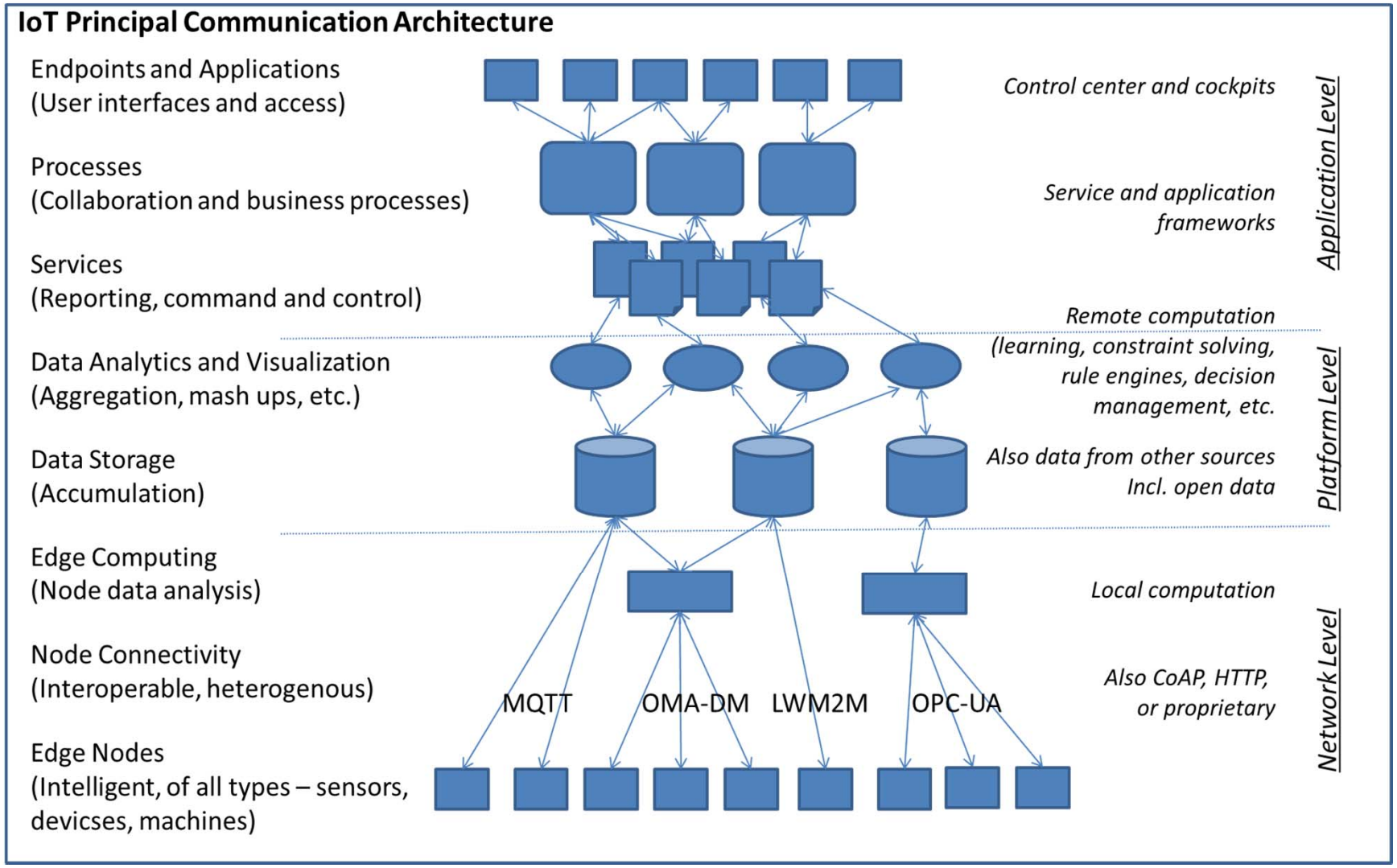
- Secure identities
- Safety
- Security
- Privacy
- Data and Metadata
- Trustworthiness

http://s.fhg.de/piot2016

IOT REFERENCE MODEL ?

- **ISO** (International Organization for Standardization, http://www.iso.org)/IEC (International Electrotechnical Commission, http://www.iec.ch) – Internet of Things Reference Architecture
- **IEEE** (Institute of Electrical and Electronics Engineers, https://www.ieee.org/) – IoT Definition
- **IETF** (Internet Engineering Task Force, https://www.ietf.org/) – Internet Protocols for IoT
- **IIC** (Industrial Internet Consortium, http://www.iiconsortium.org/) – Industrial Internet
- **ITU** (International Telecommunication Union, http://www.itu.int) – Internet of Things Global Standards Initiative
- **NIST** (National Institute of Standards and Technology in den USA, http://www.nist.gov/) – u.a. IoT-Enabled Smart City Framework
- **OASIS** (Advancing Open Standards for the Information Society, https://www.oasis-open.org/) – u.a. IoT/M2M und Security
- **OneM2M** (Global Initiative for Machine-to-Machine Standardization, http://www.onem2m.org/) – M2M für IoT, und
- **W3C** (World Wide Web Consortium, https://www.w3.org/) – Web of Things

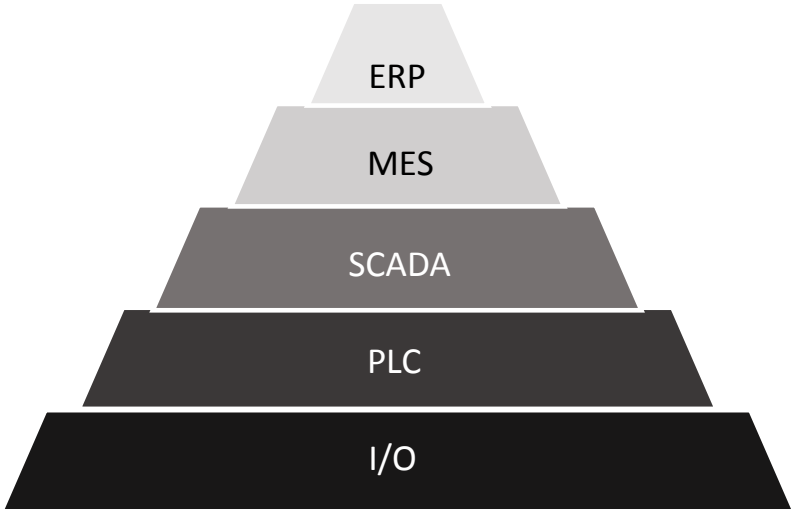
IOT REFERENCE MODEL?



NEW ARCHITECTURAL PARADIGM

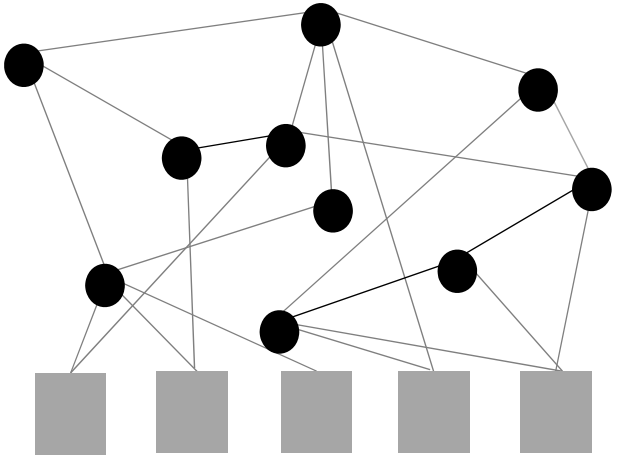
Today

Hierarchical layers



Upcoming

Orchestrated services

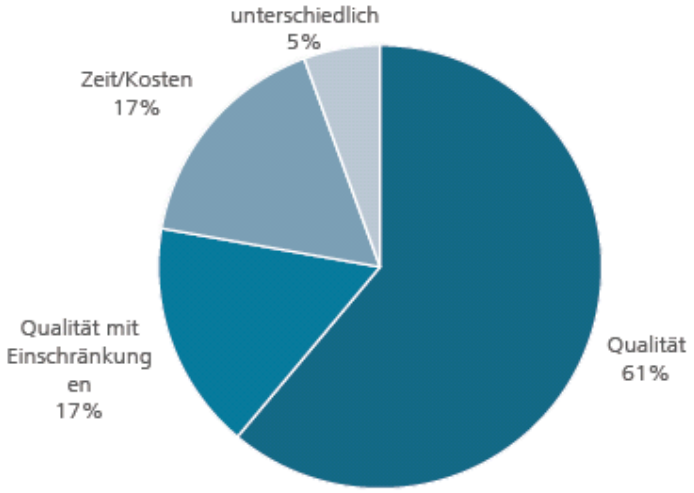


Openess, Dynamicity, Scalability

CRITICALITY IMPLY HIGH QUALITY REQUIREMENTS

»Implementation of real-time enabled CPS solutions will place **high demands on the availability of services and network infrastructure** in terms of space, technical quality and reliability.«

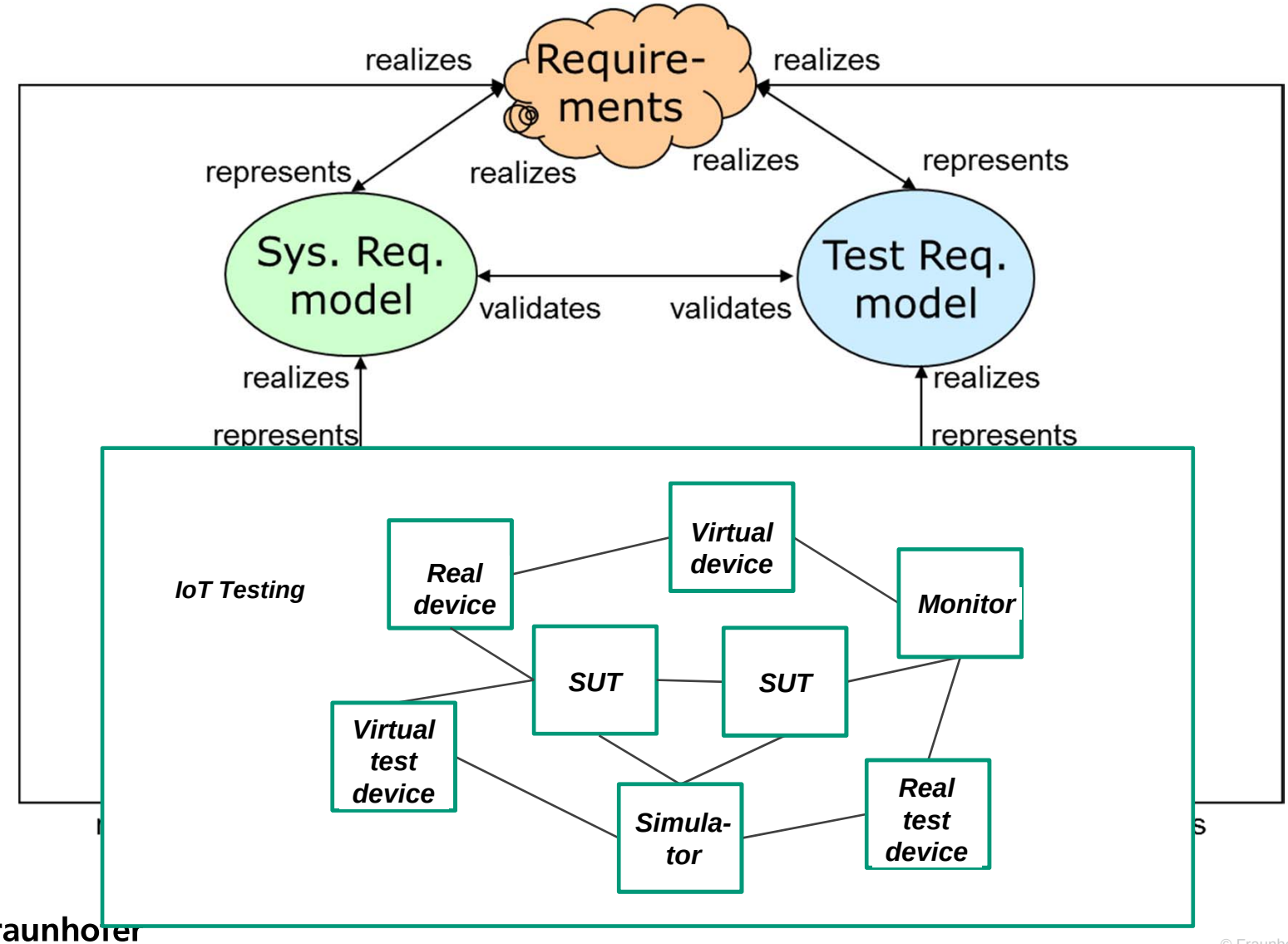
In: Securing the future of German manufacturing industry. Recommendations for implementing the strategic initiative INDUSTRIE 4.0, Forschungsunion, acatech, Apr. 2013.



Priorities of Quality, Time and Costs

In: Stand und Trends der Qualitätssicherung von vernetzten eingebetteten Systemen, Fraunhofer FOKUS Studie, Aug. 2014

SYSTEMS ENGINEERING AT A GLANCE
SIMPLIFIED VIEW



ANYTHING NEW IN IOT TESTING ?!

Similar

- Protocol stacks
  - OASIS, IETF-based: CoAP, MQTT, etc.
  - IEC-based: OPC-UA
  - ITU-based: M2M, OneM2M
- Application frameworks
  - Eclipse: Kura, Scada, etc.
  - Many others

- Protocol testing
  - Conformance
  - Interoperability
  - Performance
- Software testing
  - Component testing
  - Integration testing
  - System testing

Different

- Security
  - ISO: common criteria
  - Mitre: CWE list
  - Others
- Data
  - Semantic real-time data

- Security testing
  - Risk-oriented testing
  - Fuzz testing
  - Online testing
- Data quality

FURTHER ASPECTS

IoT solutions often are …

1. in harsh, unreliable environments

2. in highly dynamic configurations with large number of – typically diverse – sensors and actuators with open interfaces and

3. In resource-constrained environments

IoT test solutions need to …

– Integrate simulators for environmental conditions

– Systematically determine reference configurations

– Adjust and scale test configurations dynamically

– Be a real-time system by itself

– Support test scenarios for hybrid systems (both events and streams)

→ ***Test platform for the Internet of Things***

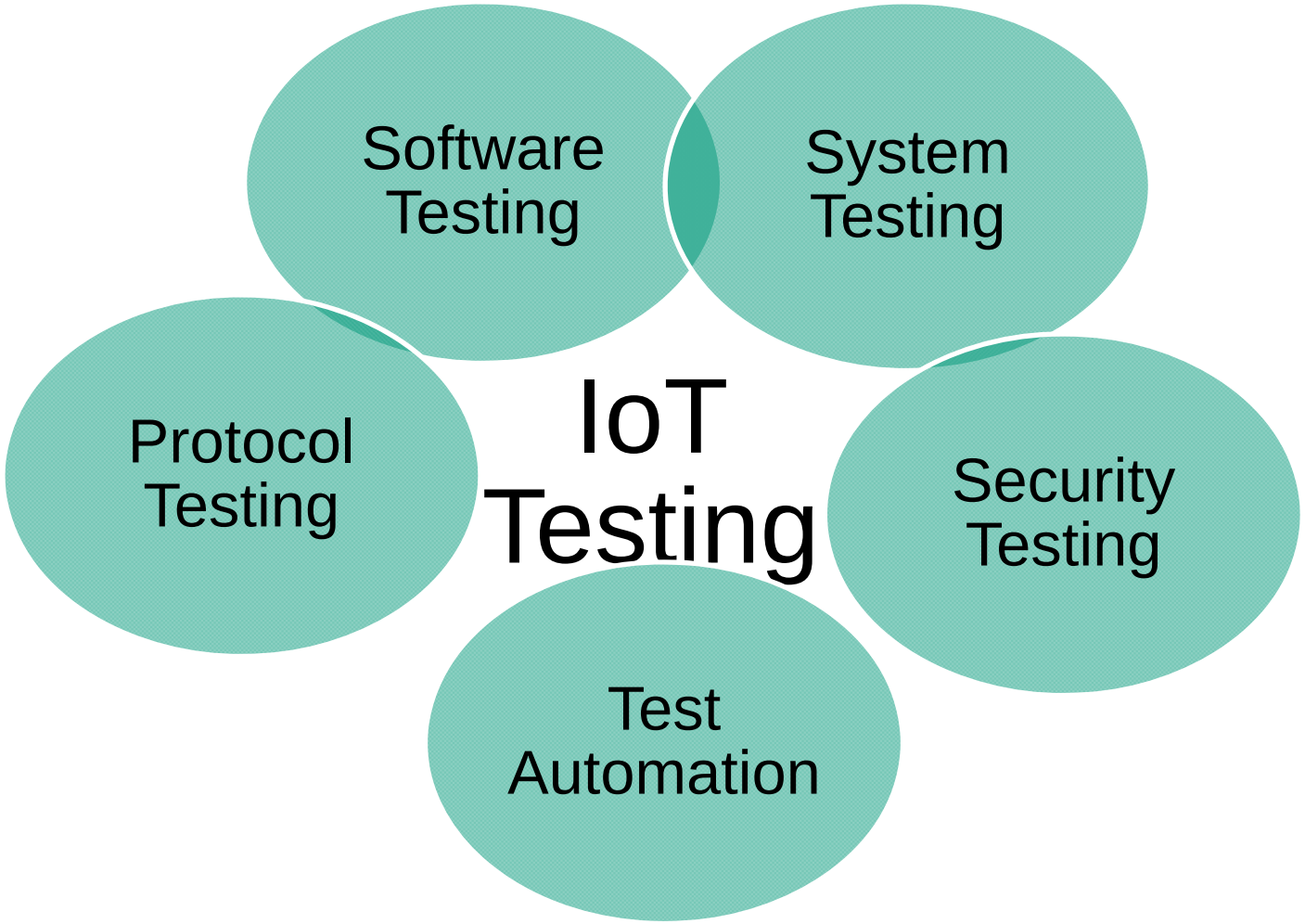
→

embedded

→

virtualized

INTEGRATION OF SEVERAL TESTING APPROACHES



CHALLENGE TEST AUTOMATION

- TTCN-3 is the Testing and Test Control Notation
- Internationally standardized testing language for formally defining test scenarios. Designed purely for testing

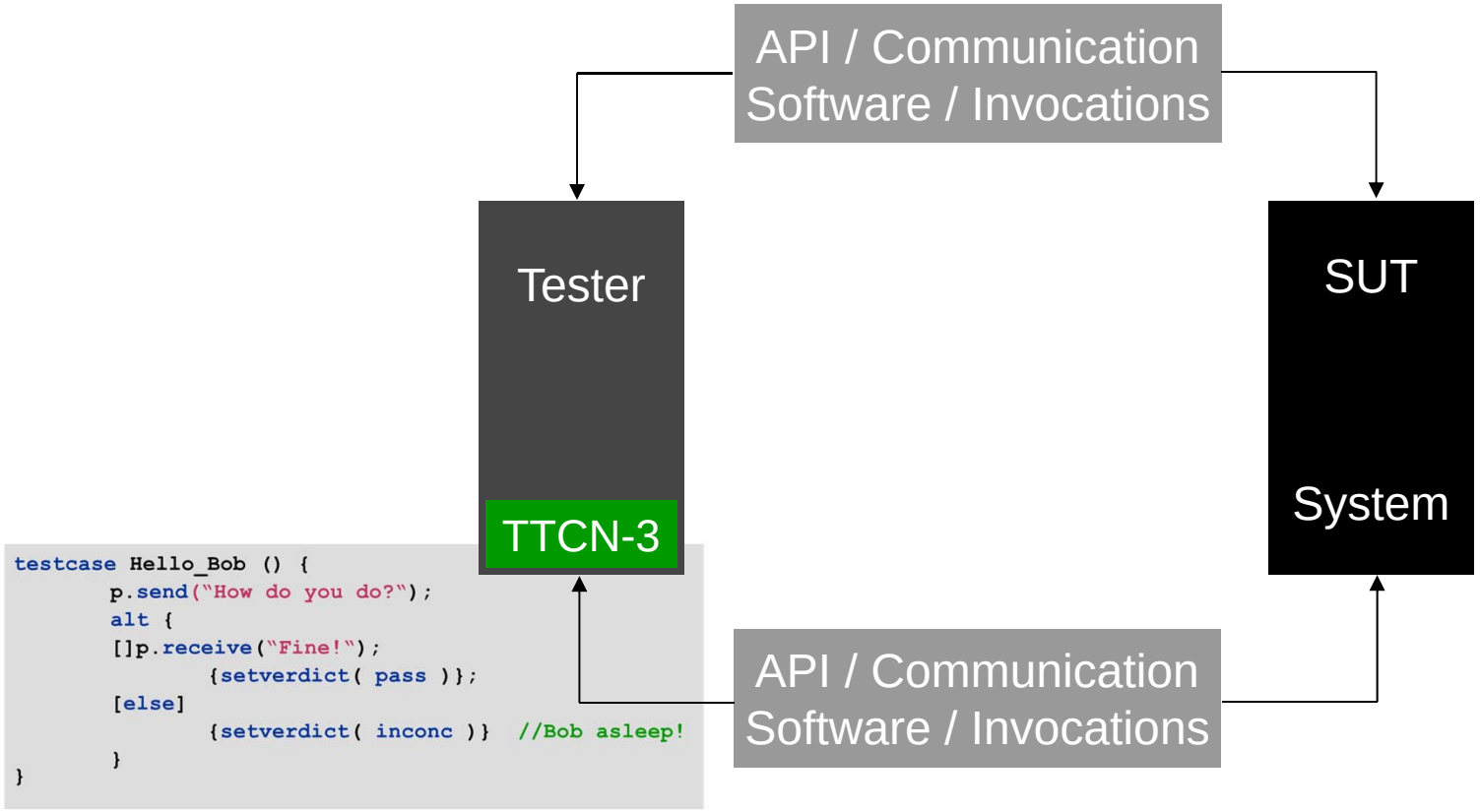
```
testcase Hello_Bob () {
        p.send(“How do you do?“);
        alt {
        []p.receive(“Fine!“);
                {setverdict( pass )};
        [else]
                {setverdict( inconc )}  //Bob asleep!
        }
}
```

DESIGN PRINCIPLES OF TTCN-3

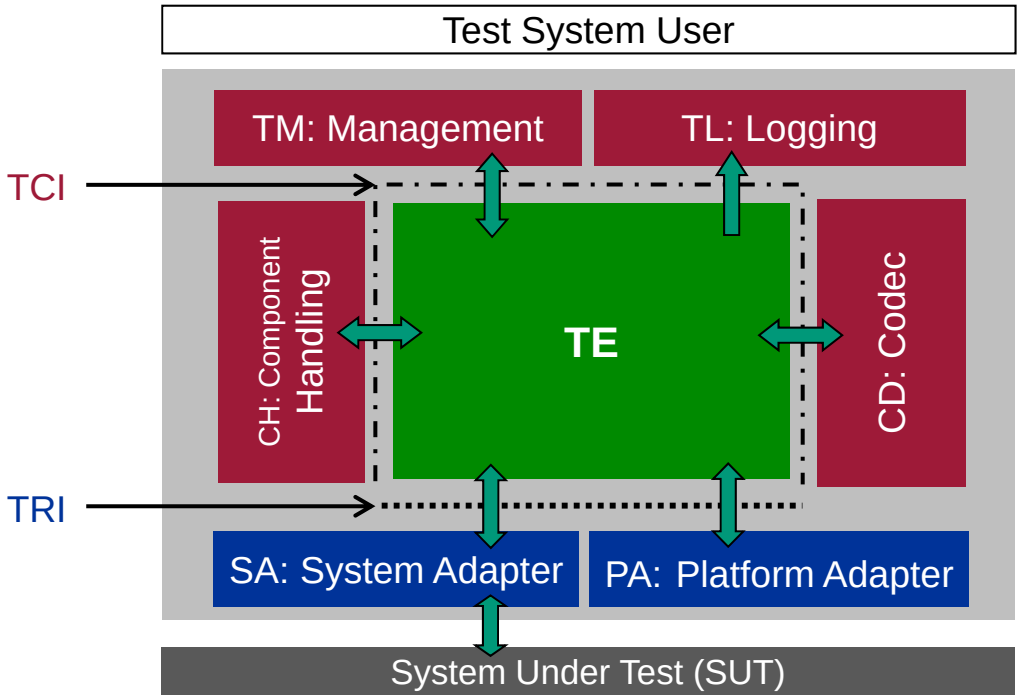
- One test technology for different tests
  - Distributed, platform-independent testing
  - Integrated graphical test development, documentation and analysis
  - Adaptable, open test environment

- Areas of Testing
  - Regression testing
  - Conformance and functional testing
  - Interoperability and integration testing
  - Real-time, performance, load and stress testing
  - Security testing

TTCN-3 EXECUTION



A TTCN-3 TEST SYSTEM

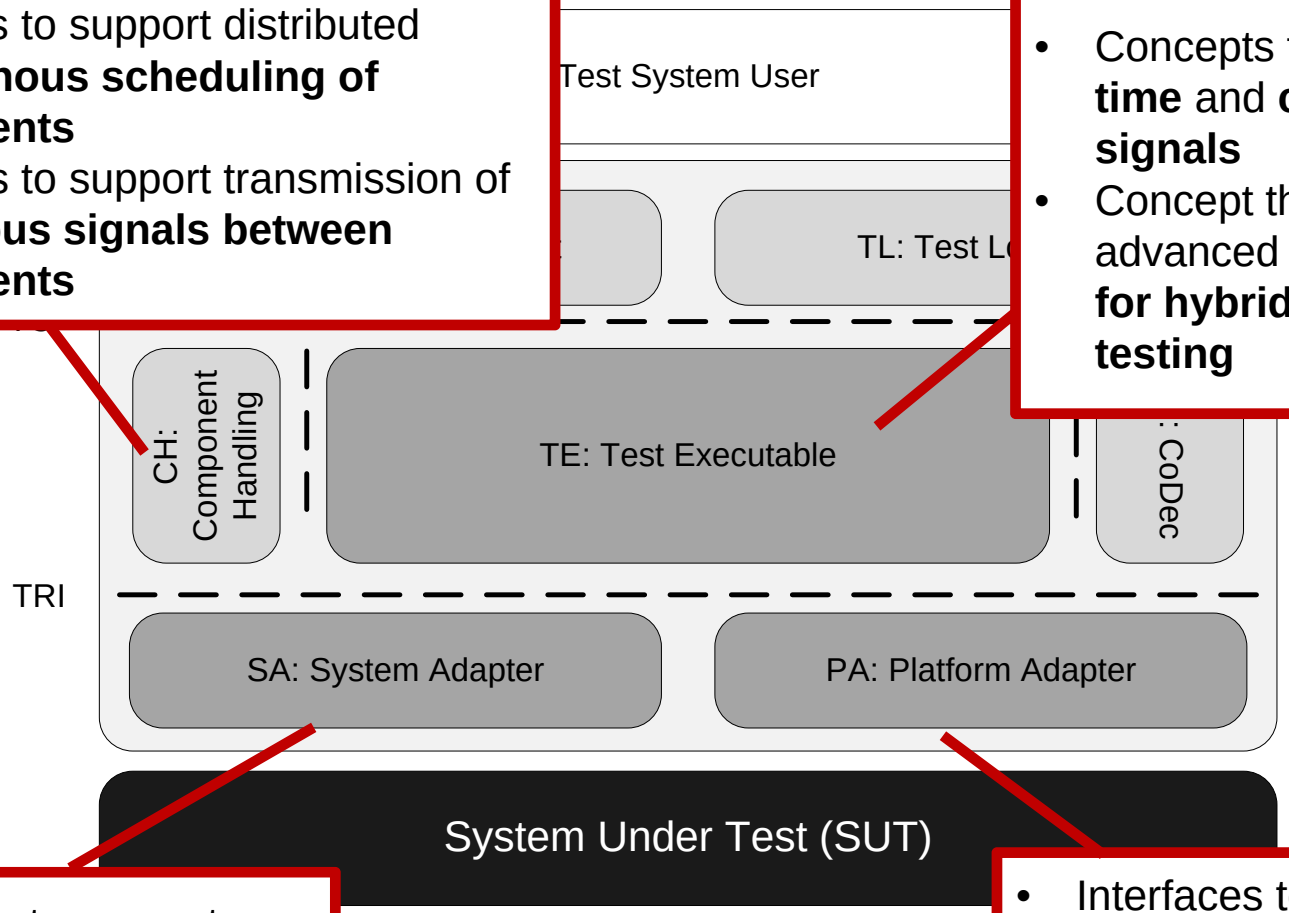


TE – TTCN-3 Executable
TM – Test Management
TL – Test Logging
CD – Codec
CH – Component Handling
SA – System Adapter
PA – Platform Adapter
SUT – System Under Test

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)

CHALLENGE EMBEDDED SYSTEMS

- Interfaces to support distributed **synchronous scheduling of components**
- Interfaces to support transmission of **continuous signals between components**

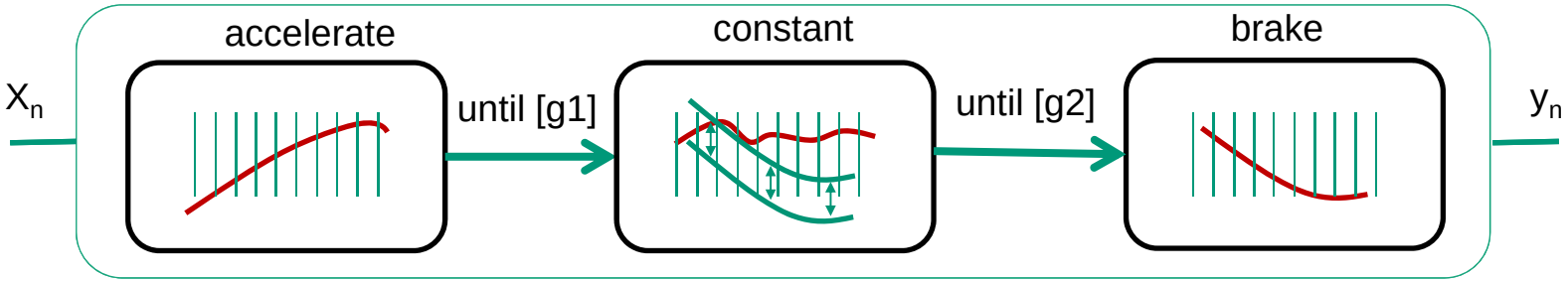


- Concepts to deal with **time** and **continuous signals**
- Concept that allow advanced **control flow for hybrid system testing**

- Interfaces to support **stimulation** with and **evaluation** of **continuous signals**

- Interfaces to support **access to time** and **sampling**

TTCN-3 EMBEDDED MODES

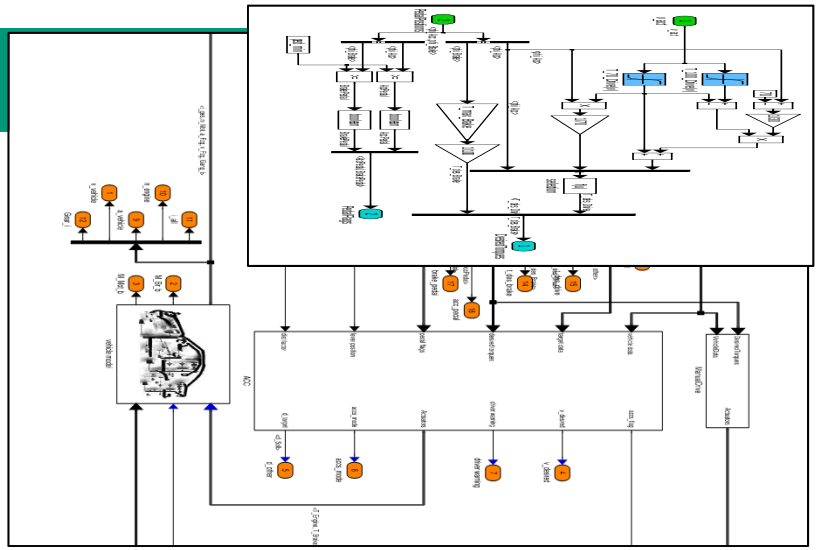


SIGNAL GENERATION BUILDING BLOCKS

```
testcase signal_generation() runs on mtcType{
 seq{
  apply_noise(Throttle, 5.0, 5.0);
  apply_noise(Throttle, 10.0, 5.0);
  apply_ramp(Throttle, 10.0, 10.0, 2.0, 3);
  …}
```

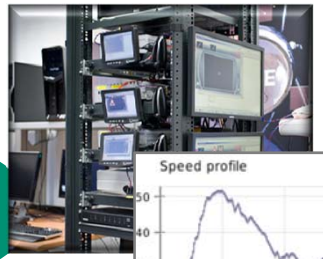
INTEGRATION IN ML/SL

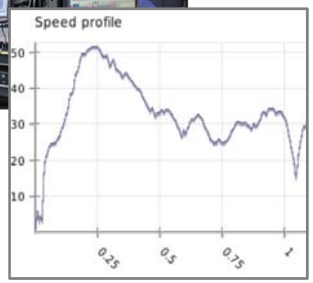
```
// accelerate vehicle until 35
//  ms and activate ACCS

cont{
  onentry{v_other.value:= 25.0}
  phi_acc.value:=80.0;
}
until{
 [v_ego.value > 35.0] {
   phi_acc.value:=0.0;
   lever_pos.value:= MIDDLE;
 }
}
// wait for several seconds
wait(now+10.0);
// evaluate
cont{
  assert(v_ego.value <= 38.0); }
until{
 [d_other.value < sd] { ...
```



1. Introduce a vehicle ahead
2. Accelerate the ego vehicle until its velocity rises to more than 35 m/s.
3. Activate the cruise control.

AUTOMATED V2X TEST BED

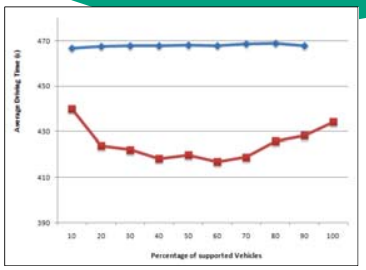


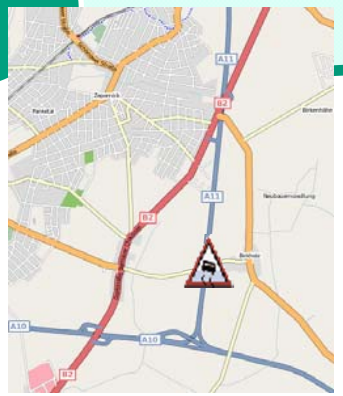


Test Execution

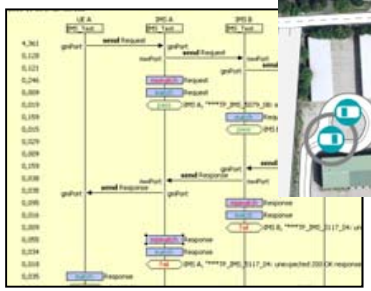
V2X Test Bed and Tool Suite

Test Data Generation (e.g. Traffic Simulation Data)





Log File Analysis and Visualization



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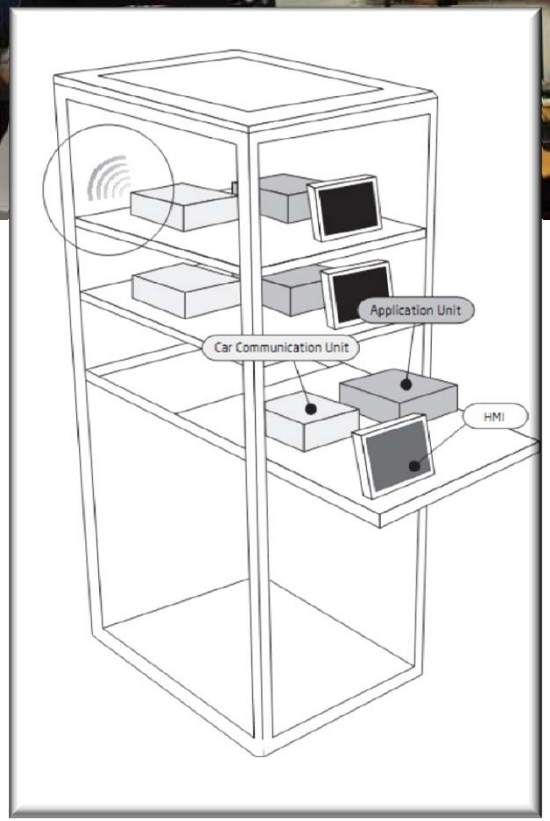
THE SIM^{TD} SET UP IN THE LAB

sim^{TD} Sichere Intelligente Mobilität Testfeld Deutschland



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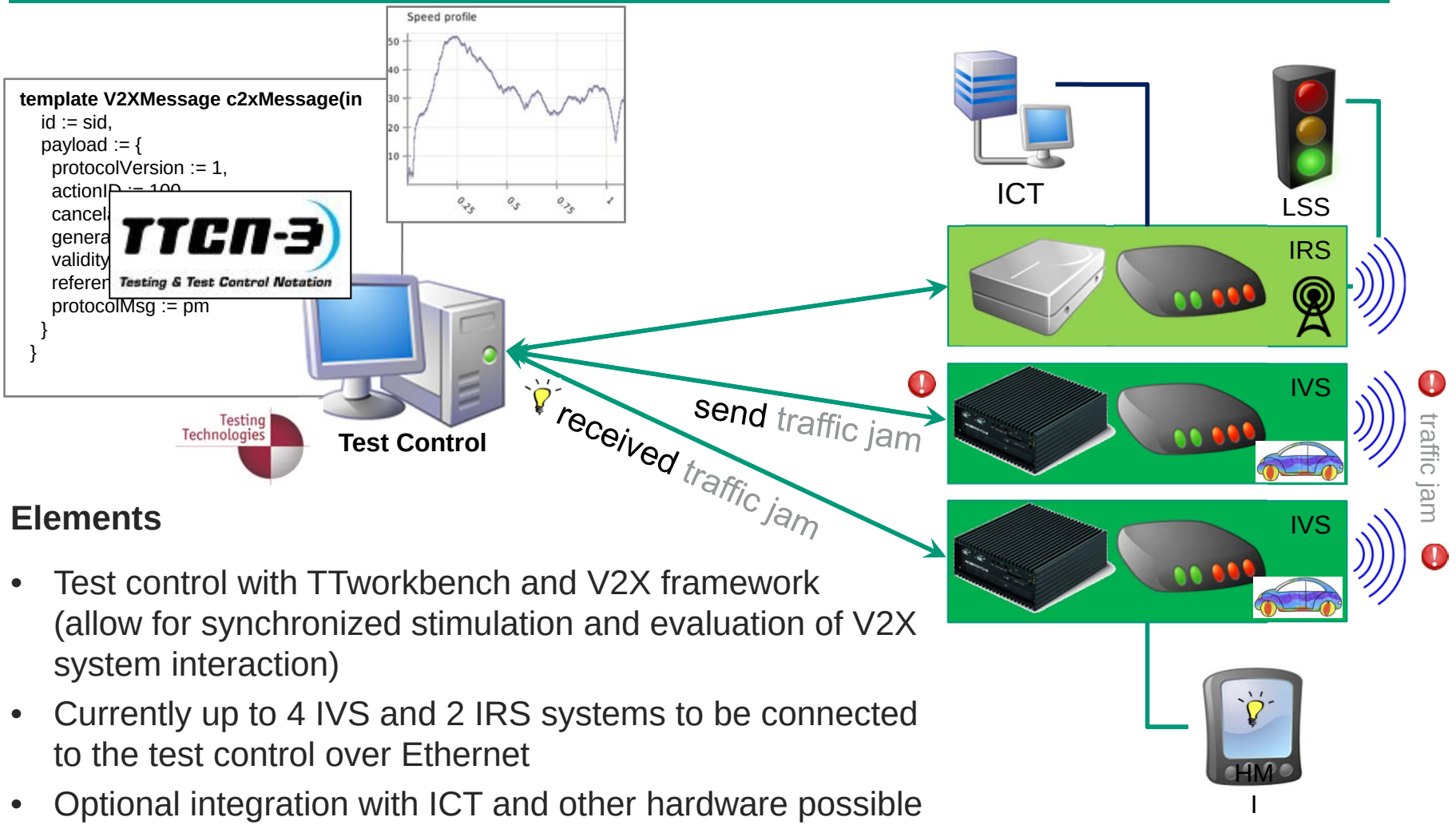
V2X TEST BED ARCHITECTURE



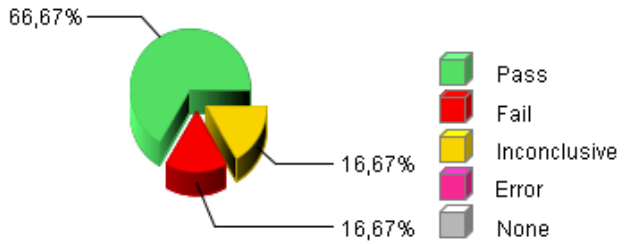
Elements

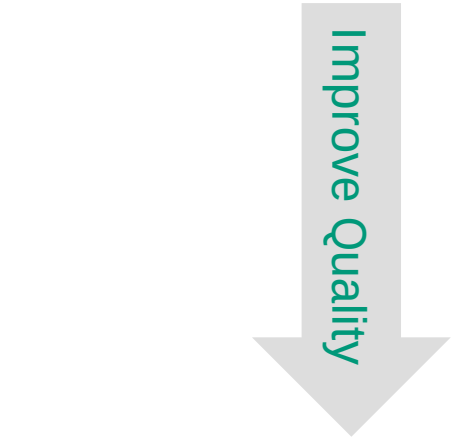
- Test control with TTworkbench and V2X framework (allow for synchronized stimulation and evaluation of V2X system interaction)
- Currently up to 4 IVS and 2 IRS systems to be connected to the test control over Ethernet
- Optional integration with ICT and other hardware possible

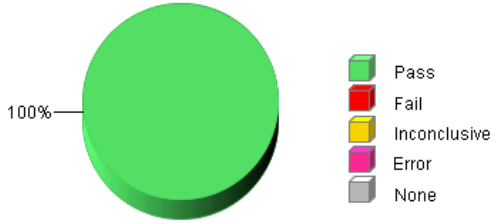
SIM^{TD} REFERENCE TESTS

- **40 Communication tests and test variants**
  - CAM variants
  - CAM frequencies, message life time handling etc.
  - DENM variants
- **20 Application tests**
  - testing event detection, propagation, handling and user notification for several V2X applications
- **Reference circuit**
  - event handling and user notification for several V2X applications
- **Reference circuit with load**
  - event handling and user notification for several V2X applications by applying networked and CPU load
- **Goals: <u>Integration</u>, <u>regression</u> and acceptance testing**

Project with Audi, Bosch, BMW, Continental, Daimler, Opel, Telekom, VW



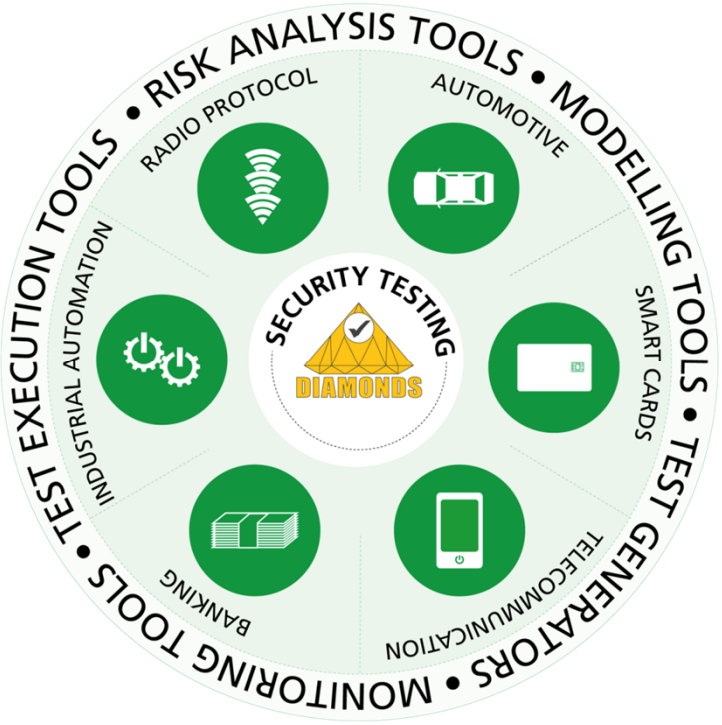


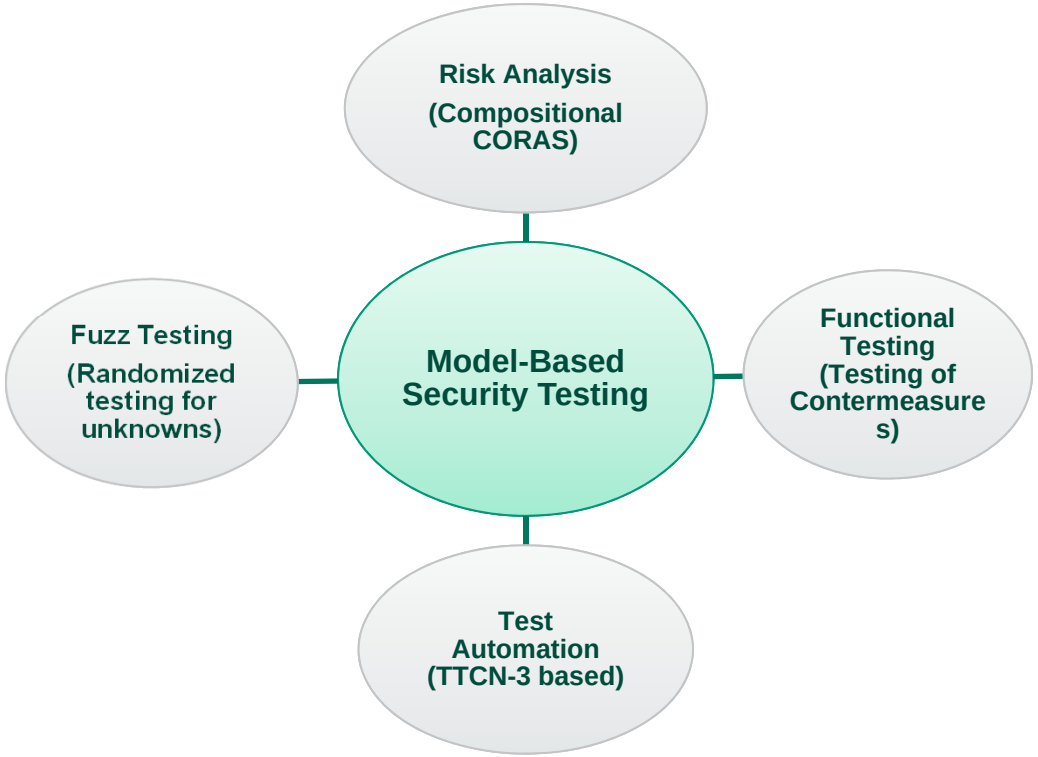


CHALLENGE SECURITY TESTING

Security testing solutions for six industrial domains

http://www.itea2-diamonds.org/

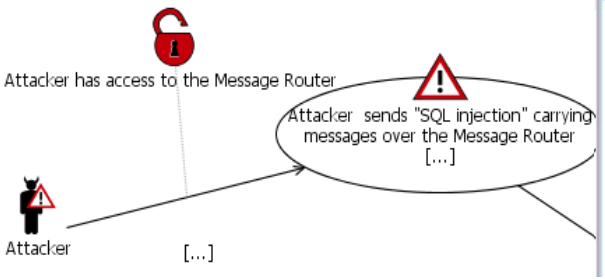


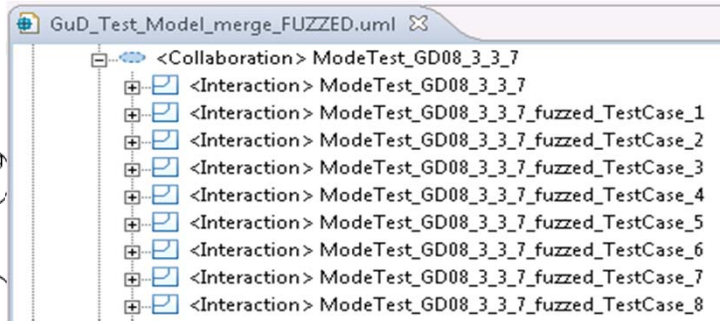


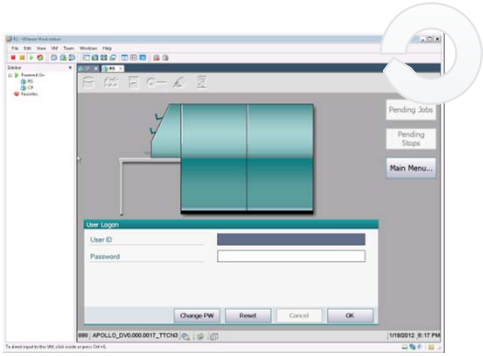
Ina Schieferdecker, Model Based Security Testing: Selected Considerations (Keynote) Sectest 2011, Workshop on the 4th IEEE International Conference on Software Testing, Verification and Validation Berlin, Germany

G&D Case Study
Banknote Processing Machines

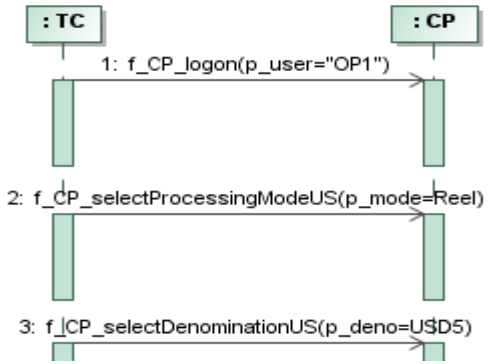
G&D Case Study
Methodology







Risk analysis → Modeling → Test generation → Test code generation → Test execution




```
testcase ModeTest_GD08_3_3_7_fuzzed_TestCase_219 ()
runs on Comp_CP_RS
system System_CP_RS
{
    var integer i, v_total, v_rjc;

    f_mtcSetup_CP_RS(CPRSStartingMode:All);

            f_CP_logon("OP1");
            f_CP_selectProcessingModeUS(ProcessingModeUS:Reel);
```

TTCN-3

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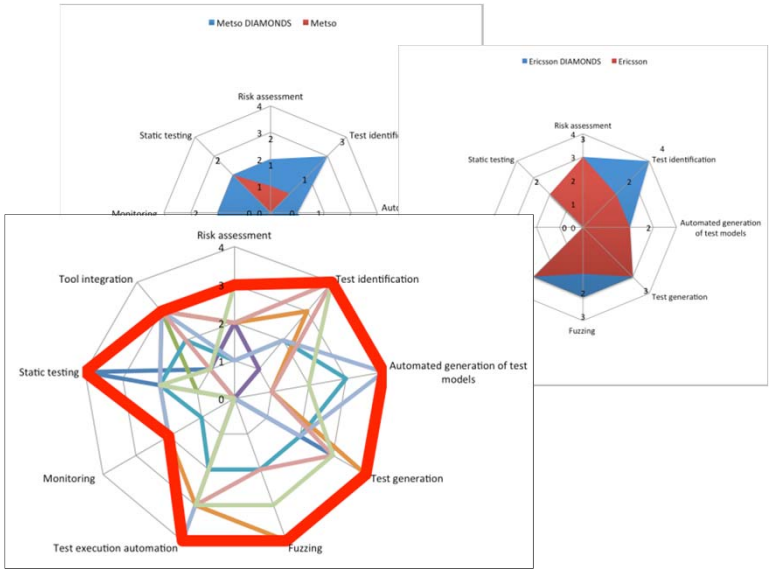
CASE STUDY RESULTS

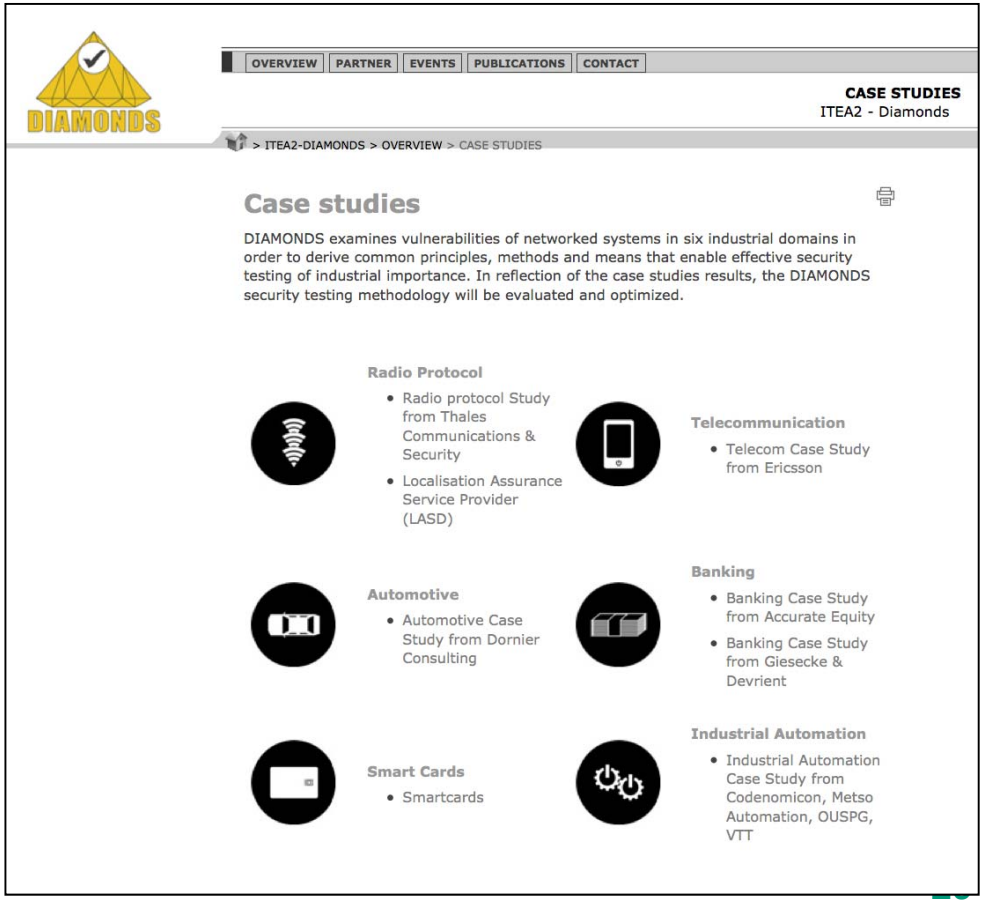
1. Collection of the experiences and results for all case studies

- Case study experience sheets (DIAMONDS web site)
- Case study experience report (ETSI document)

2. STIP Evaluation

- Shows progress in all case studies





CERTIFIED TESTER FOR IOT ?!

	Main modules	Supplementary modules
CTEL	EL-ITP EL-TM	
CTAL	AL-TM AL-TA AL-TTA	Security Test Autom **Industrial IoT ?!** **Consumer IoT ?!**
CTFL	Software Foundation **Embedded Systems Foundation ?!**	Agile Auto motive MBT Usability Mobile **IoT ?!**

ASQF/GTB WORKING GROUP IOT-QE

Quality Engineering of IoT Solutions

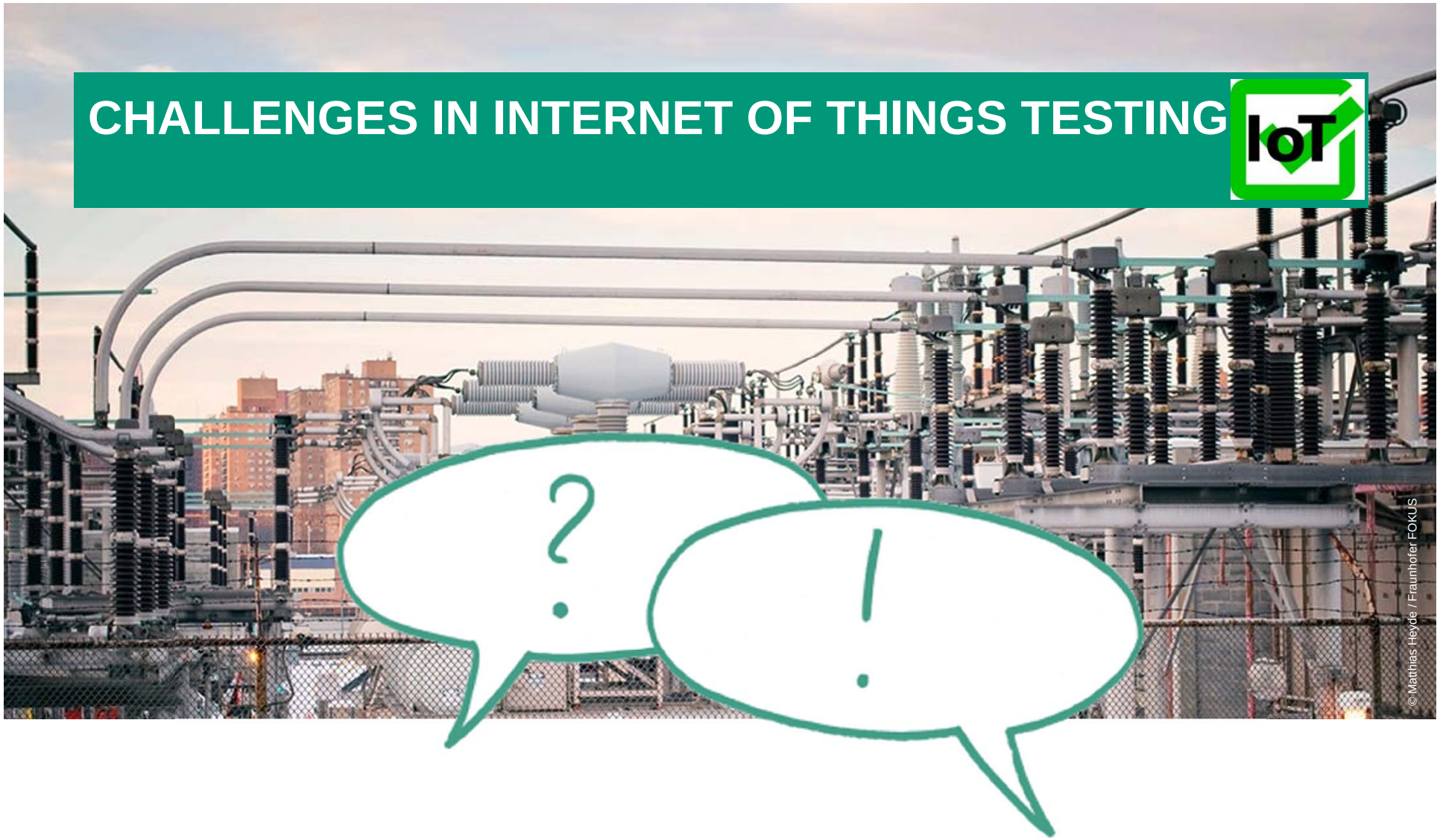
- Team members from DB Systel GmbH SAP Deutschland, Atos Deutschland, Sulzer GmbH, imbus AG, tecmata GmbH, sepp.med GmbH, Konsortium Testing4You, Fraunhofer FOKUS

- Draft Issues
  - **Motivation**: Why Quality Engineering for IoT?
  - **Context**: Which architectures? Which quality requirements?
  - **Processes**: How to design, develop, run, maintain and secure IoT solutions in view of business processes?
  - **Constructive quality engineering**: How to make IoT solutions robust, scalable, functional, secure and trustworthy by design? Which methods and tools to use?
  - **Analytical quality engineering:** How to assure and manage the quality of IoT solutions efficiently in development and production?

CHALLENGES IN INTERNET OF THINGS TESTING

1. “Software is eating the world”, online pioneer and entrepreneur Marc Andreessen, 2011.
2. And makes more and more critical infrastructures like IoT
3. Security, safety, privcay and trustworthiness are key – and training and expertise thereof
4. We do not only have to quality assure of software, but also of protocols, services, data and systems of systems
5. Advanced approaches for IoT testing and online certification / safeguarding are needed
6. These are essential for Smart Cities, Smart Grid, Industry 4.0, Open Government, etc.

CHALLENGES IN INTERNET OF THINGS TESTING



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