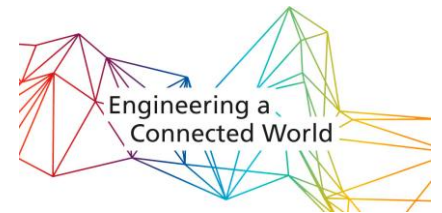


# QUALITY ENGINEERING FOR THE IOT

Axel Rennoch, Sascha Hackel  
TestingStage, Kiev, April 13, 2018



# BERLIN CENTER FOR DIGITAL TRANSFORMATION

## Digital Transformation from A to Z



# AGENDA

- IoT test **objects, goals, and configuration**
- IoT **test automation**
  - IoT test language **TTCN-3**
  - **IoT-Testware** project
- IoT-T **testlab**
- IoT-Quality Engineering **outlook**

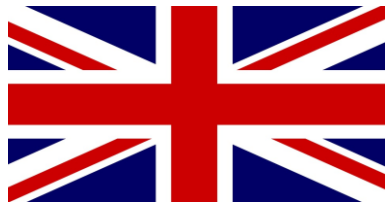
# INTRODUCTION

Where are we?



# MOTIVATION – DEFINITION IOT

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.  
(ISO JTC 1/SWG 5 July 29-31, 2014)



## MOTIVATION FOR QUALITY

- **Mirai botnet**, October 2016:
  - botnet using **insecure configured** IoT-devices
  - attack causes **blackout** and **disruption** (e.g. Amazon, Netflix, Twitter, Github)
- **Wannacry**, May 2017: cyber attack on steel mill in Germany, ...
- **KRACK** (Key Reinstallation Attack), October 2017: Replay attack on Wi-Fi Protected Access protocol (WPA2), ...
- **Spectre** and **Meltdown**, January 2018
  - **Spectre**: vulnerability that perform branch prediction in modern microprocessors
  - **Meltdown**: hardware vulnerability that allows to read all memory

# TRENDS IN IOT

## TOP IoT CONCERNS | CONNECTIVITY PROTOCOLS MESSAGING STANDARDS

Sec

*What messaging protocol(s) do you use for your IoT solution?*

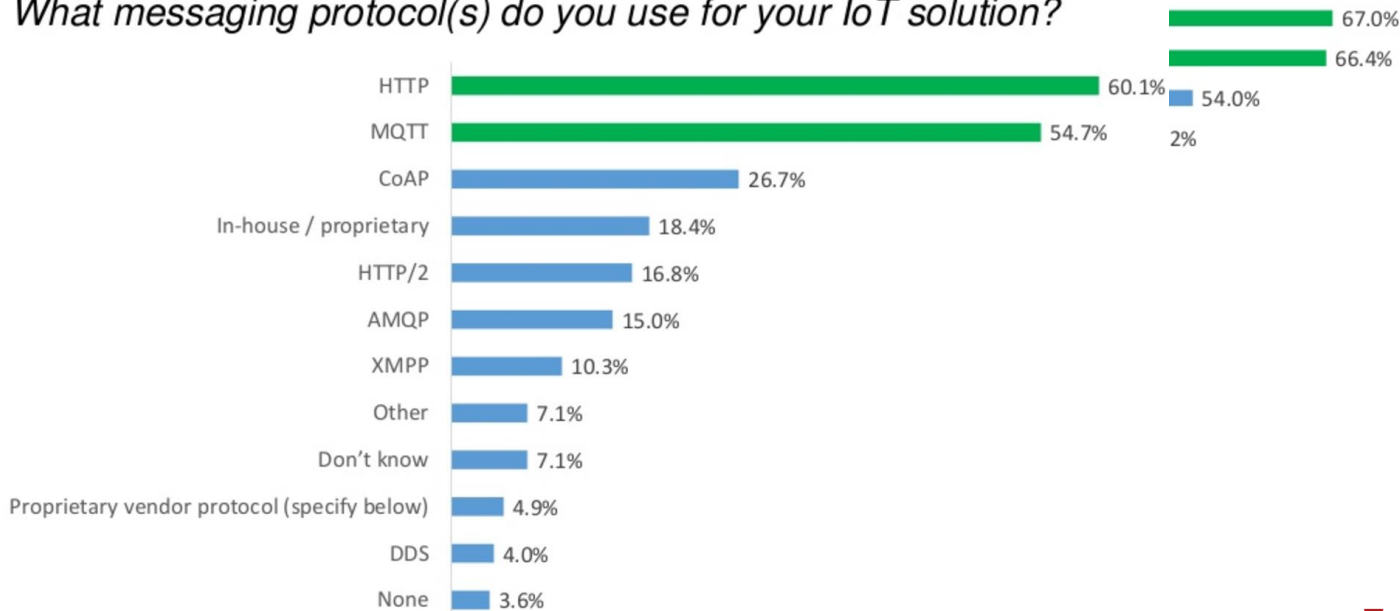
solution?

Interopera

Connec

Integration  
hardwai

IoT Developer Survey 2017 - Copyright



# CHALLENGES IN IOT

## ➤ Wide portfolio of competences required

- Devices (sensors, HW, embedded SW)
- Platforms (Cloud, platform domain knowledge)
- Applications (SW, dashboard, business logic)

## ➤ IoT platforms

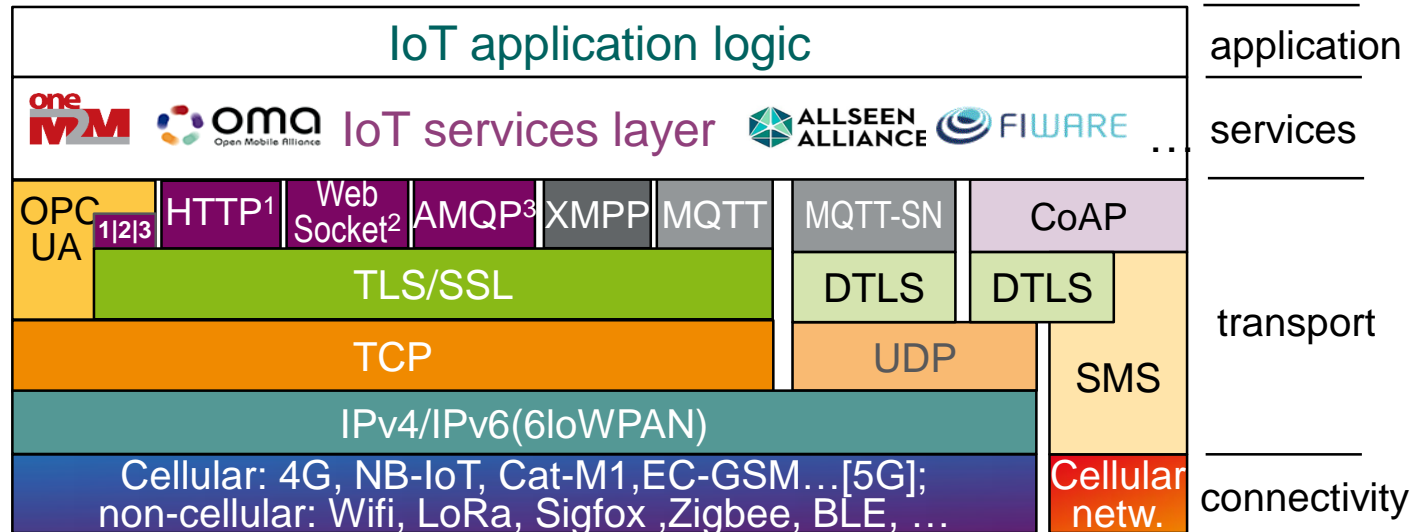
- 360+ worldwide

## ➤ IoT protocols

- Rich selection
- IP-based
- non-IP based

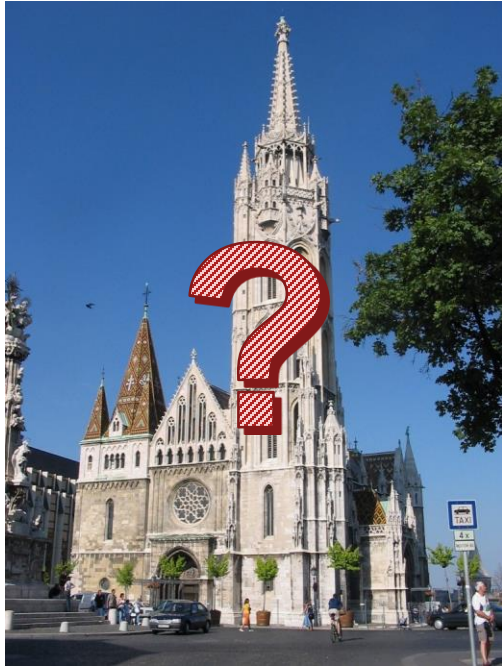
## ➤ Connectivity options

- Throughput
- Latency
- Power efficiency
- Packet size





# QUO VADIS IOT?



Cathedral  
OR  
Bazaar?



# STARTING: TEST OBJECTS

- IoT devices,
  - Mikrocontroller (**MCU**),
  - **Gateways** (Bosch XDK, IoT starterkits)
- IoT platforms
  - RIOT, relayr, Thread, mbed...
  - service layer (oneM2M, FiWare)
- IoT protocols
  - Constrained Application Protocol (**CoAP**)
  - MQ Telemetry Transport (**MQTT**)



oneM2M	
HTTP, AMQP, MQTT	CoAP
TCP	UDP
IPv4, IPv6, 6LoWPAN	
MAC, IEEE 802.15.4	LPWAN
PHY	LoRa

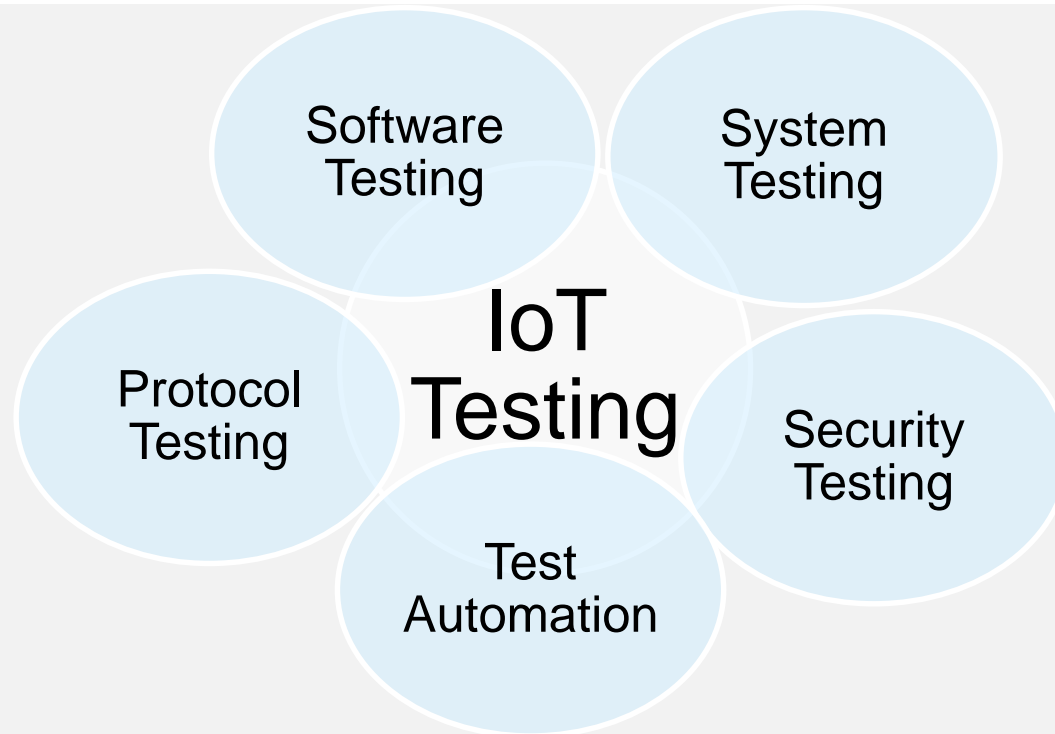
IoT challenges: complexity, asynchronism, long operation phase, resource constraints

## LONG OPERATION LIFETIME

- **After the acceptance** and system tests there will be a long operation phase => **new test phase** „*operation*“
- Some parts of the IoT solution may be **inaccessible (updated during the operation phases)**



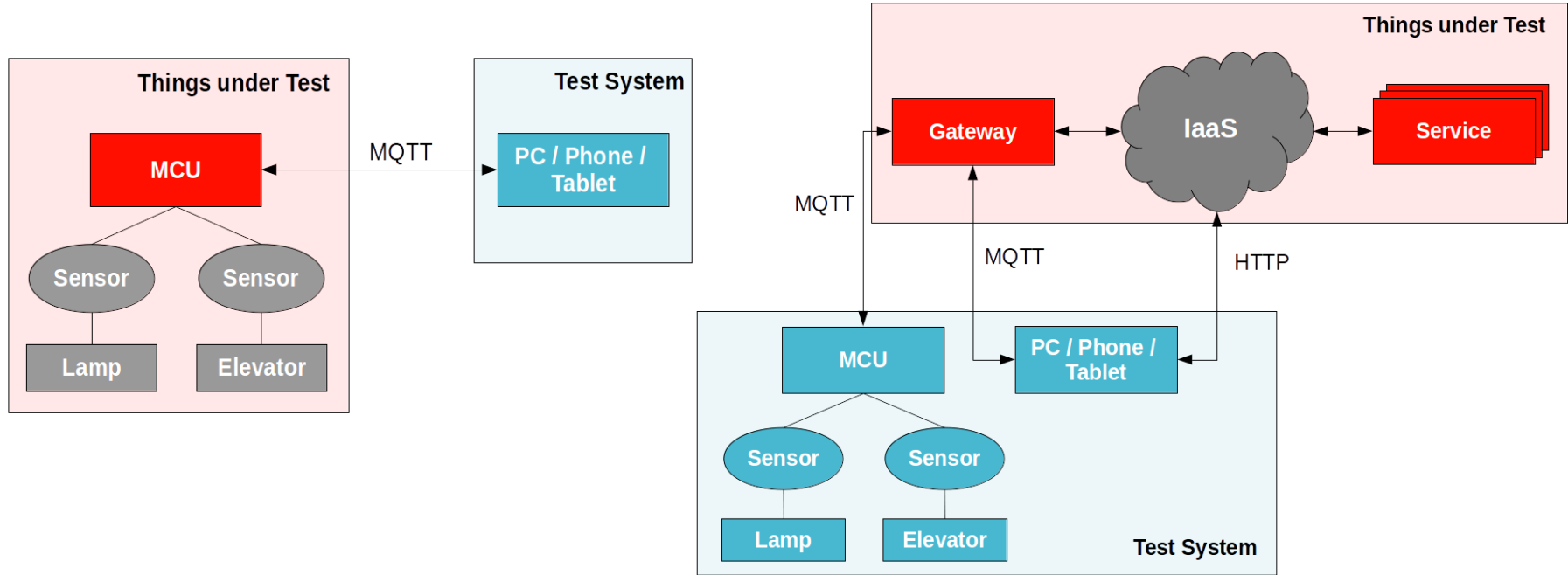
# INTEGRATION OF SEVERAL TESTING APPROACHES



# TEST AUTOMATION

- Less **resources** needed (time and money)
- **Avoid** human **mistakes** due to manually testing
- During test **development and execution**
- **Speed-up** of **regression** tests and product **time-to-market**

# MULTIPLE TEST CONFIGURATION (SAMPLES)



# TESTWARE

- **Toolset** (*selection of available means*)

**Protocol tester/monitor** (Eclipse Titan, Wireshark)

**Test devices** (RFID kit, Bluetooth test device)

**GUI tester** (Selenium, SikuliX, Chrome headless)

**Web services tester** (soapUI)

...

- **Public Testsuites** (*in preparation*)
  - Application of a standardized notation
  - Abstract and platform-independent



# IOT TEST LANGUAGE

Did you know that **YOUR PHONE...**



What do we use?





# 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**



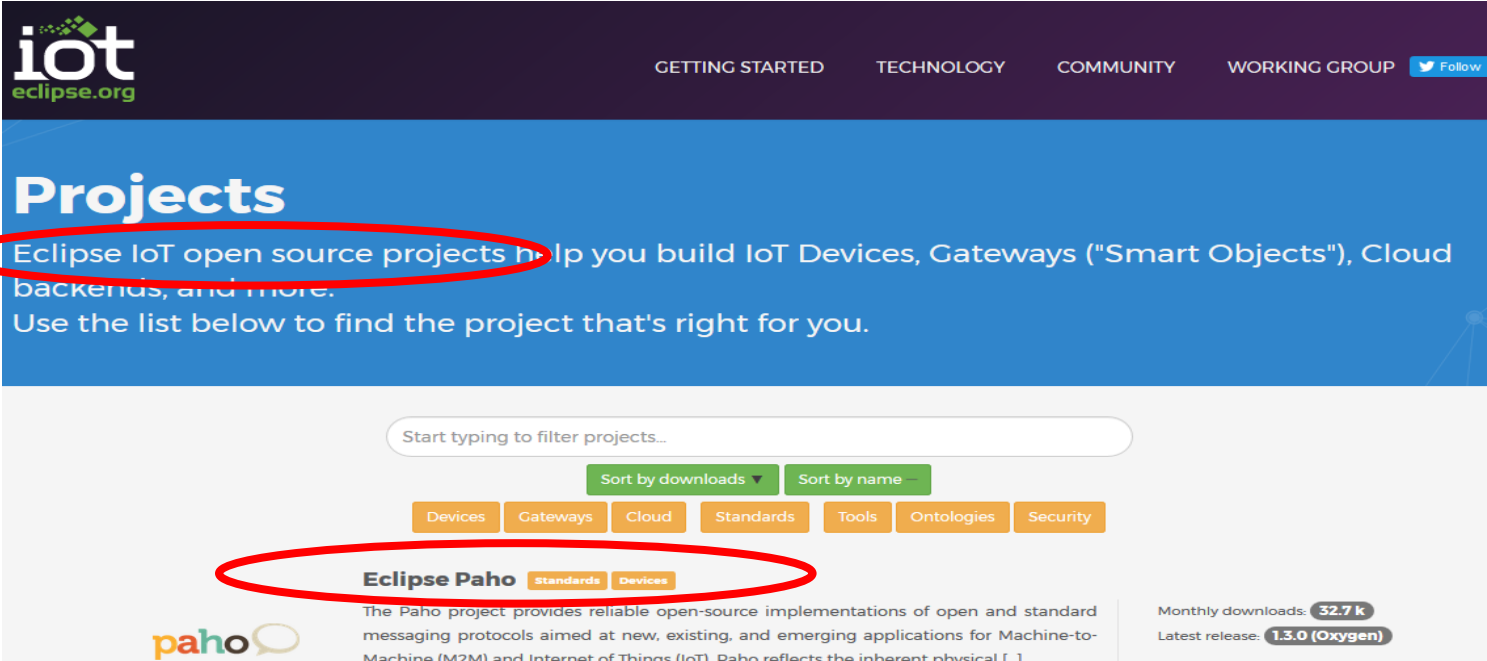
```
testcase Hello_Bob () {  
    p.send("How do you do?");  
    alt {  
        [p.receive("Fine!");  
            {setverdict( pass )};  
        [else]  
            {setverdict( inconc )} //Bob asleep!  
    }  
}
```

# CONTRIBUTION TO IOT TESTING

What else?



# THE CONTEXT



The screenshot shows the Eclipse IoT Projects page. At the top left is the Eclipse IoT logo with the URL [eclipse.org](http://eclipse.org). The navigation menu includes 'GETTING STARTED', 'TECHNOLOGY', 'COMMUNITY', and 'WORKING GROUP', along with a 'Follow' button. The main heading is 'Projects'. Below it, a blue banner contains the text: 'Eclipse IoT open source projects help you build IoT Devices, Gateways ("Smart Objects"), Cloud backends, and more. Use the list below to find the project that's right for you.' A search bar with the placeholder 'Start typing to filter projects...' is present. Below the search bar are two sorting buttons: 'Sort by downloads' and 'Sort by name'. A row of category filters includes 'Devices', 'Gateways', 'Cloud', 'Standards', 'Tools', 'Ontologies', and 'Security'. The 'Eclipse Paho' project is highlighted with a red circle, showing sub-filters for 'Standards' and 'Devices'. To the right of the project name, it displays 'Monthly downloads: 32.7 k' and 'Latest release: 1.3.0 (Oxygen)'. The Paho logo and a brief description are visible at the bottom left of the project entry.

# THE ECLIPSE PROJECT

- **Supplement to running Eclipse projects**
  - Paho, OM2M, Titan
- **New project** at Eclipse Foundation:
  - <https://projects.eclipse.org/projects/technology.iottestware>
    - TTCN-3 test suites for **CoAP, MQTT, OPC-UA**, LoRa?
- Assured **licenses** for users
- **Currently in cooperation with** relayr GmbH, Ericsson, LAAS/CNRS, itemis AG, Spirent Communications, Easy Global Market, Iskratel/Sintesio, ...



# IOT-TESTWARE



GETTING STARTED MEMBERS PROJECTS MORE ▾

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Google Custom Search

DOWNLOAD

HOME / PROJECTS / TECHNOLOGY PROJECT / ECLIPSE IOT-TESTWARE / ECLIPSE IOT-TESTWARE

This proposal has been approved and the **Eclipse IoT-Testware** project has been created.

## Eclipse IoT-Testware

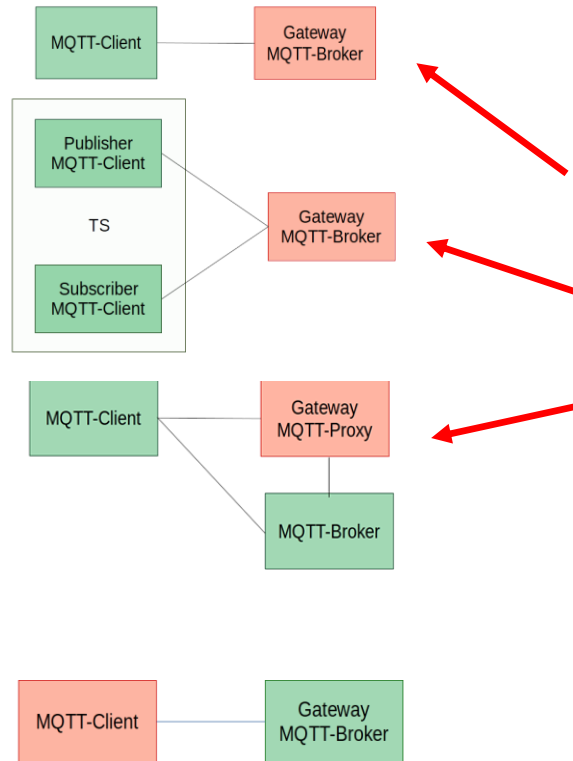
### BASICS

This proposal is in the Project Proposal Phase (as defined in the **Eclipse Development Process**) and is written to declare its intent and scope. We solicit additional participation and input from the community. Please login and add your feedback in the comments section.

**Parent Project:**  
Technology Project



# SAMPLE TESTSUITE STRUCTURE: MQTT



## – Broker as SUT

- All mandatory **message data** fields
- Regular and illegal data (Fixed/variable header, payload)

## – Protocol features

- General
- Connect/disconnect (session)
- Subscribe/unsubscribe
- Immediate publish
- Last will and Testament (LWT)
- Heartbeats keepAlive values
- Topic
- Error handling

## – Client as SUT

- ...

# TEST DEVELOPMENT SAMPLE: MQTT

- ✓ **Test configurations**
- ✓ **Test Suite Structure**
- ✓ **Test purpose (catalogue)**
- ✓ **Test implementation (TTCN-3)**

TP-ID	TP_MQTT_Broker_CONNECT_001
Selection	PIC_Broker
Summary	The IUT MUST close the network connection if fixed header flags in CONNECT Control Packet are invalid
Reference	[MQTT-2.2.2-1], [MQTT-2.2.2-2], [MQTT-3.1.4-1], [MQTT-3.2.2-6]
Initial condition	
<b>Test purpose</b>	
<p>Ensure that the IUT</p> <p style="padding-left: 40px;">on receipt of an CONNECT message containing header_flags := '1111'B</p> <p style="padding-left: 40px;">sends no RESPONSE message and closes the Network Connection</p>	
<b>Comments</b>	

# MQTT BROKER EVALUATION (JULY 2017)

Broker	Version	PASS		FAIL		INCONCLUSIVE	
		#	%	#	%	#	%
Mosquitto	1.4.14	40	88,89%	3	6,67%	2	4,44%
VerneMQ	1.1.0	39	86,67%	3	6,67%	3	6,67%
HiveMQ	broker.hivemq.org	39	86,67%	4	8,89%	2	4,44%
EMQ	2.0	36	80,00%	7	15,56%	2	4,44%
Iannister	?	31	68,89%	12	26,67%	2	4,44%
ActiveMQ	5.14.5	31	68,89%	12	26,67%	2	4,44%
RSMB	?	26	57,78%	17	37,78%	2	4,44%
RabbitMQ	3.5.7	21	46,67%	24	53,33%	0	0,00%
Mosca	2.5.1	19	42,22%	24	53,33%	2	4,44%
Moquette	0.10	16	35,56%	29	64,44%	0	0,00%
HBMQTT	0.9	15	33,33%	30	66,67%	0	0,00%



# TESTWARE: SECURITY

- Vulnerability **scanner**:
  - in particular for **web applications**, zero-day/**fuzzing**, consideration of **data bases**, traffic/network **analyser**, **program code** scanner
- **Penetration** tester, e.g. “SQL injection”
- Intrusion **detection** tools
- **Load** test/Scalability
- *Further **utilities**: Model-based testing (UML testing profile) and risk modelling*

## TESTLAB (TESTING AND CERTIFICATION)

- Focus on **open source** test tools (Eclipse)
- Support of **test suites configuration**
- Providing several **end devices**
- Remote test service (online)

### Future certification

- „**light weight**“ selection of criteria
- „**self** certification“ if tests are successful
- consideration of **operational phase**
- use of standardized test purpose catalogs (*in preparation at ETSI*)




# SUMMARY AND OUTLOOK

What comes next?



# APPROACH

✓ Advanced + mature testing technology: 

✓ (open source) community: 

✓ Standardized basis (for certification): 

## ETSI TC MTS

- **New Working Group (TST)** will develop IoT test catalogues and specifications (not covered elsewhere).
- The **types of testing** include conformance, interoperability, security and performance testing.
- The initial technical **focus** will be:
  - **IoT network layer**  
(communication protocols, node connectivity, edge computing etc.),
  - **IoT layer** (data accumulation and aggregation),
  - **Application layer** (interfaces, business processes etc.).



## APPROACH

✓ Advanced testing technology:



✓ (Open source) IoT-Testware (code):



✓ Standardized IoT test purposes:



✓ Certified Professionals for IoT

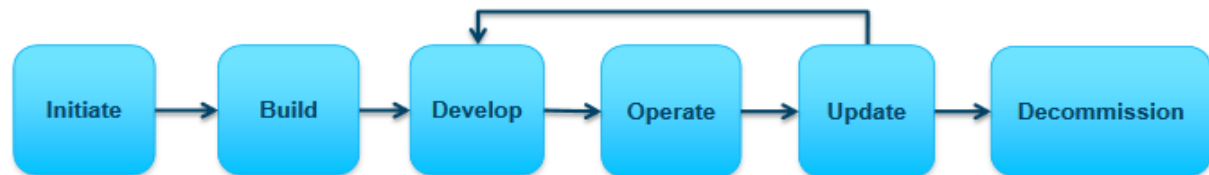


# IOT QUALITY ENGINEERING

- ASQF/GTB Certified Professional for IoT Foundation Level
- New syllabus for 3-day lectures

## QUALITY ENGINEERING FOR THE INTERNET OF THINGS (IOT-QE)

- 1) **Motivation/challenges**
- 2) Constructive QE – Quality **characteristics**
- 3) Constructive QE – IoT **architecture**
- 4) Constructive QE – **Processes** and **methods**
- 5) Analytic QE (incl. **testing**)
- 6) **Lifecycle**



# CONTACTS

**Thank you for your attention!**

<https://www.fokus.fraunhofer.de/sqc>

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