

# FUNDAMENTALS FOR IOT TESTING



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**Cibersociedad 2019**

# OUTLINE

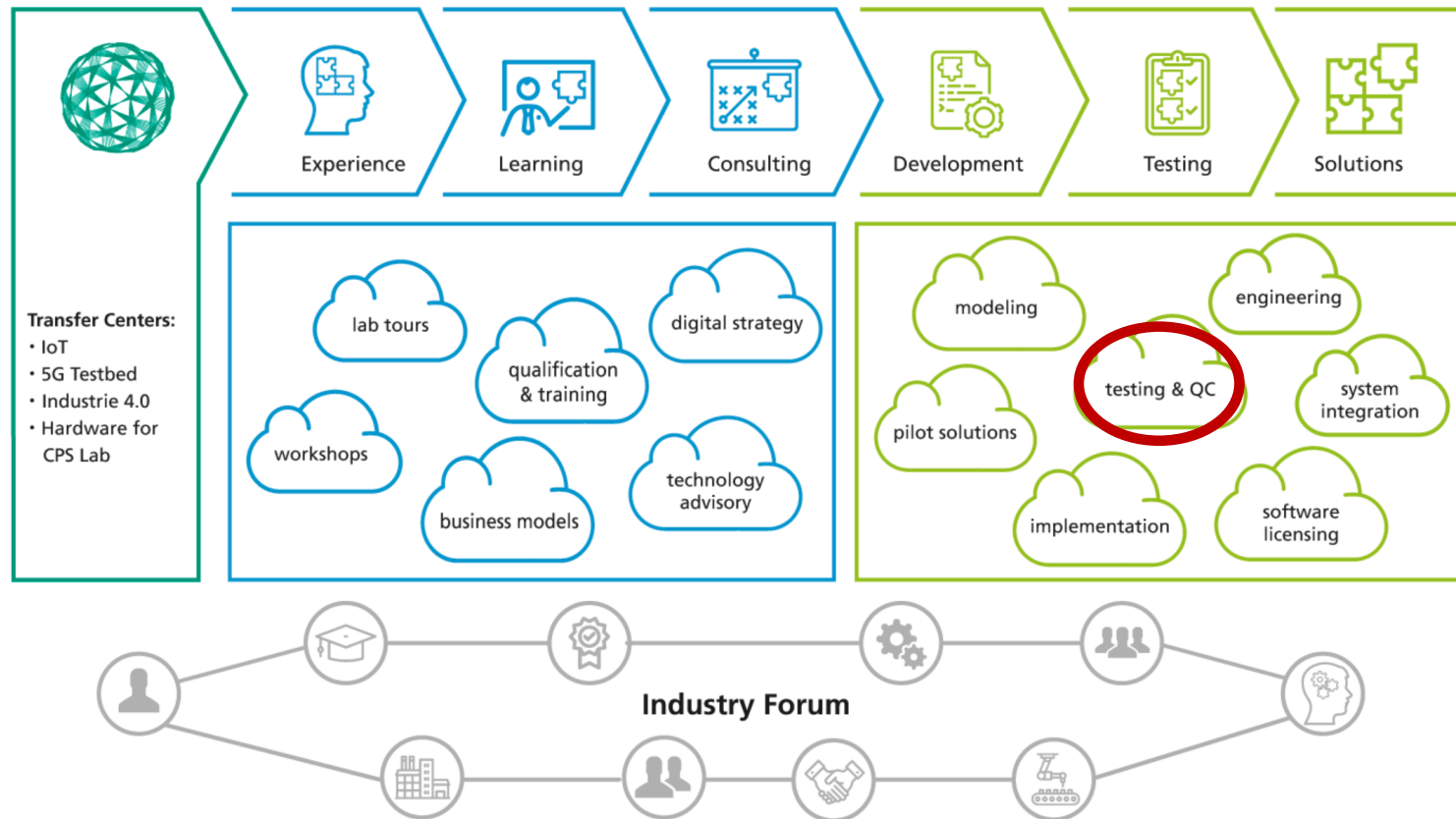
- **Our Context**
- **IoT challenges**
- **Standards and Open Source**
  - **Eclipse Foundation**
  - **ETSI standardization**

Fraunhofer FOKUS  
Institute for Open Communication Systems

**WE CONNECT EVERYTHING**  
SECURE, RELIABLE, TRUSTWORTHY

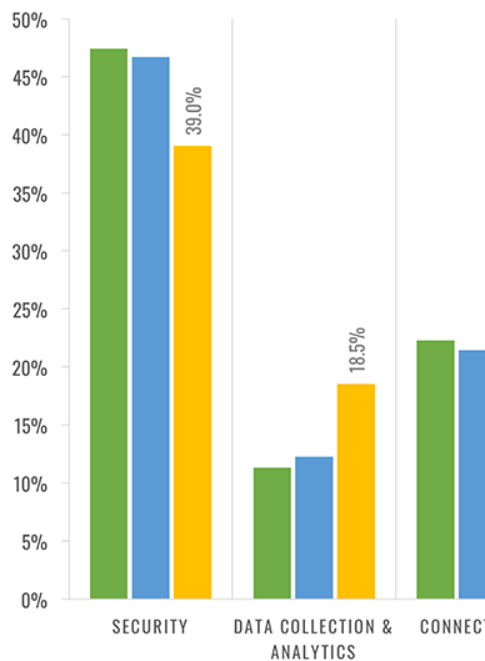
# BERLIN CENTER FOR DIGITAL TRANSFORMATION

## Digital Transformation from A to Z



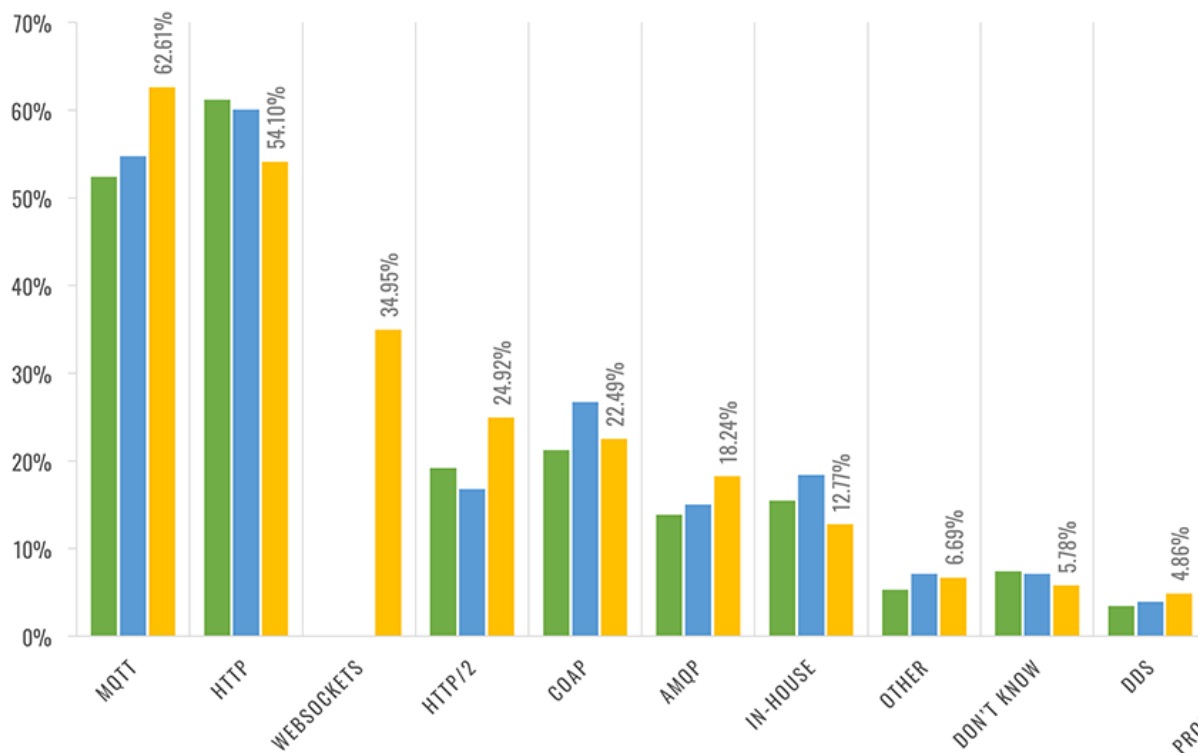
# TRENDS IN IOT

## TOP IOT CONCERNS / TRENDS 2016-2018

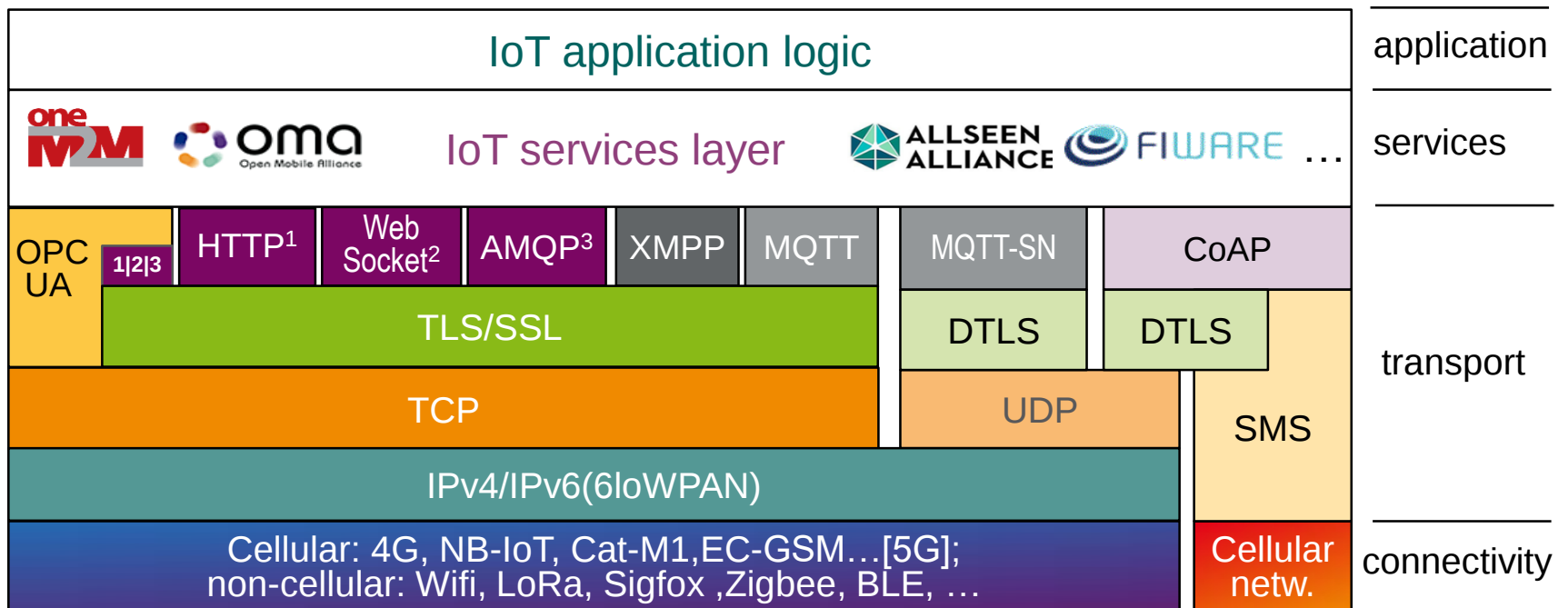


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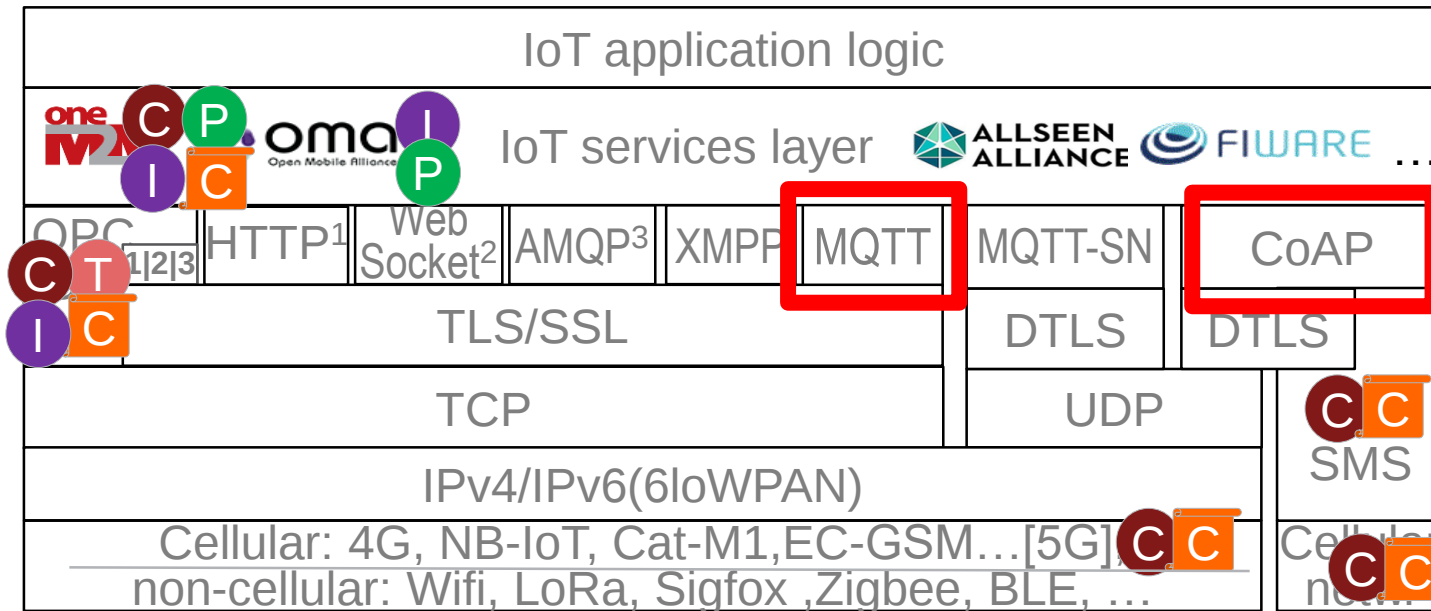
## MESSAGING STANDARDS - TRENDS

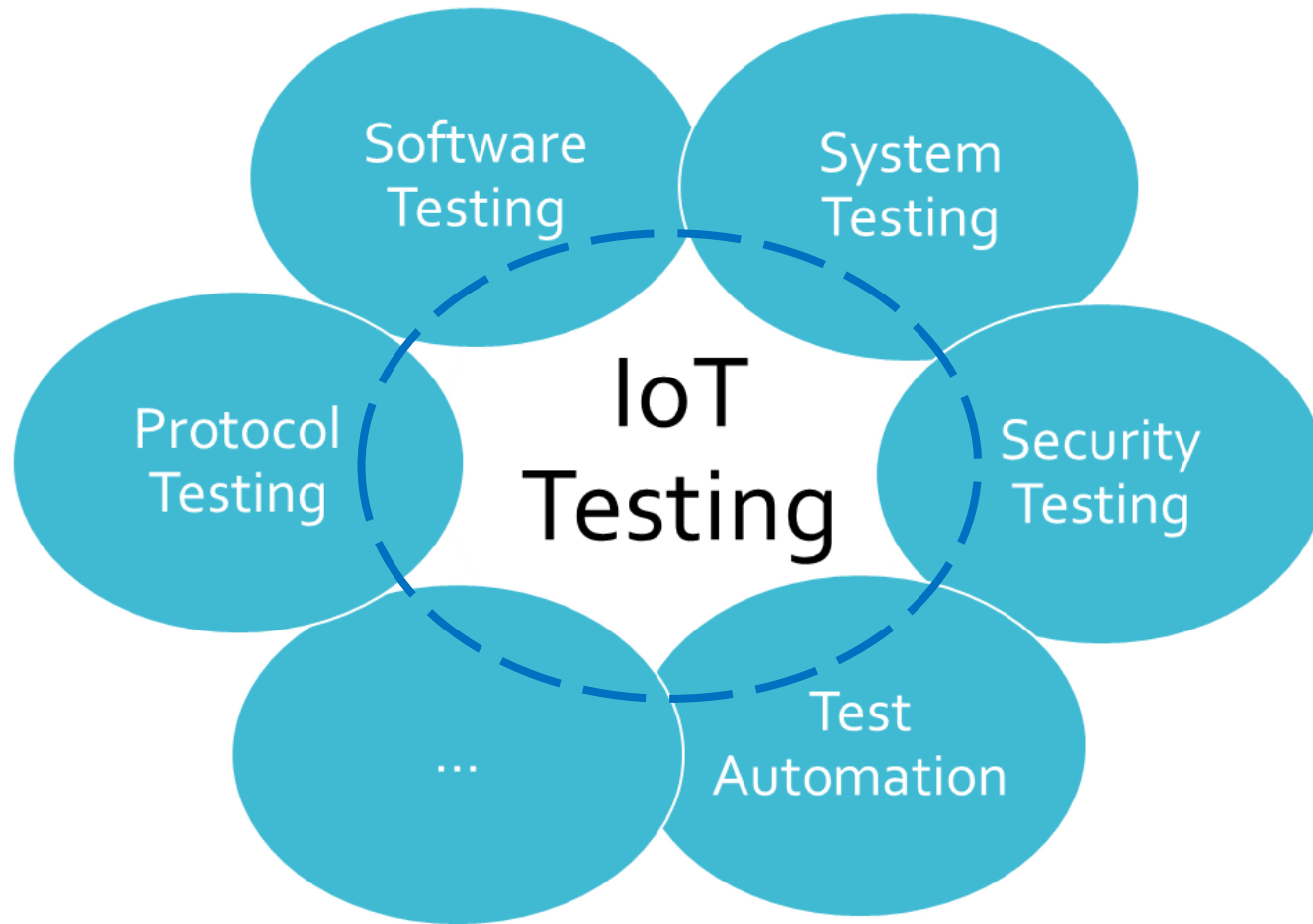


# CHALLENGES IN IOT

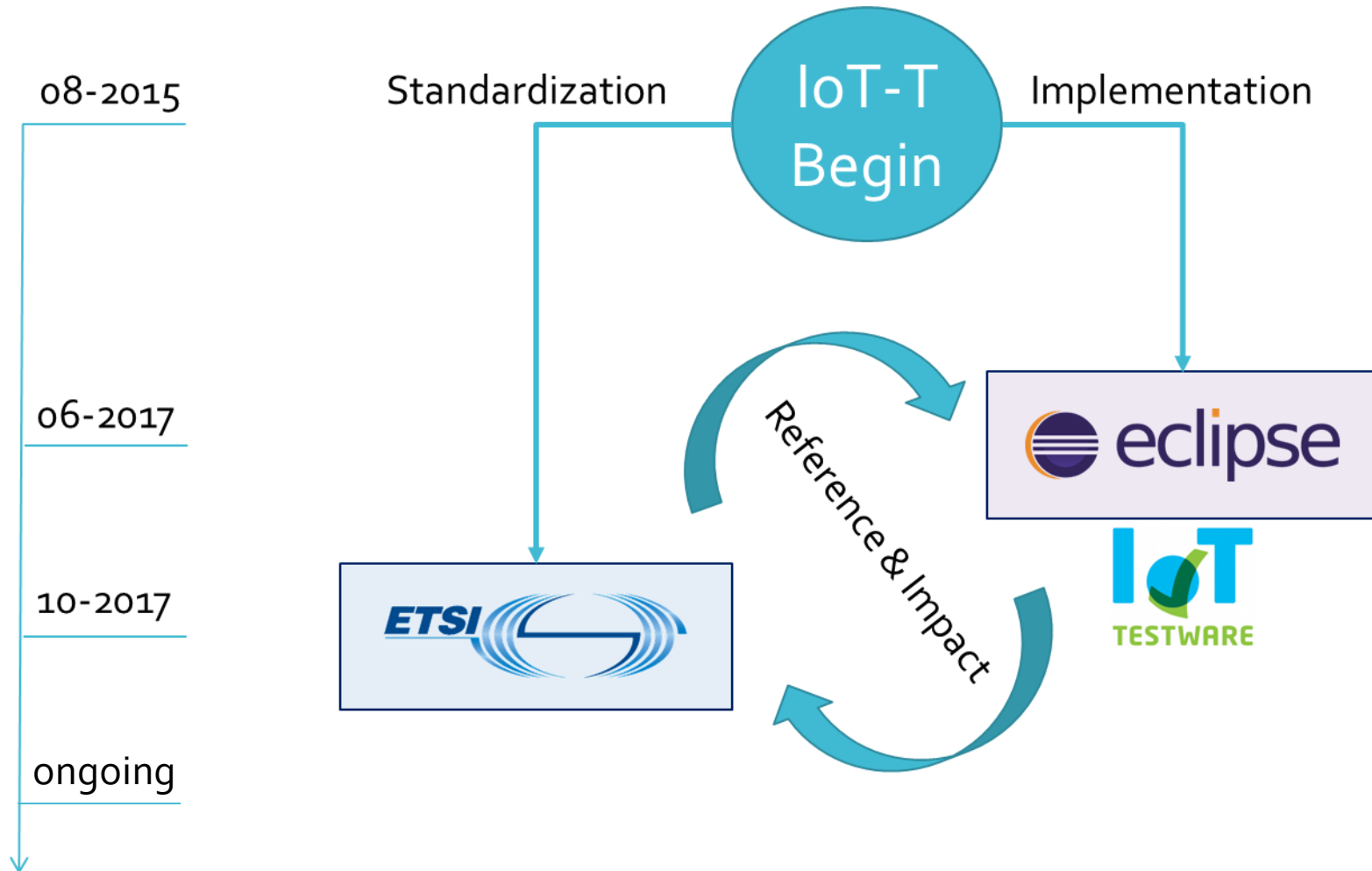


# TEST COVERAGE





# BIG PICTURE



# THE ECLIPSE PROJECT

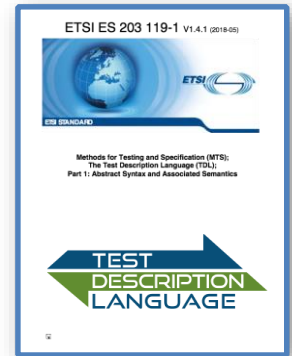
- Supplement to running and active Eclipse projects
  - Paho, OM2M, Titan...
- **Running project** at Eclipse Foundation:  
<https://projects.eclipse.org/projects/technology.iottestware>
  - TTCN-3 test suites for **CoAP, MQTT, OPC-UA** (demo), LoRa?
- Assured **licenses** for users
- **Currently cooperation between**  
Fraunhofer FOKUS, relayr GmbH, Ericsson, LAAS/CNRS, itemis AG,  
Spirent Communications, Easy Global Market, Iskratel/Sintesis, ...



# BACKGROUND

## Test Description Language

- Design, documentation, representation of formalised test descriptions
- Scenario-based approach



## Testing and Test Control Notation

- Specification and implementation of all kinds of black-box tests
- Component-based approach



# IOT TEST LANGUAGE

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



# 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



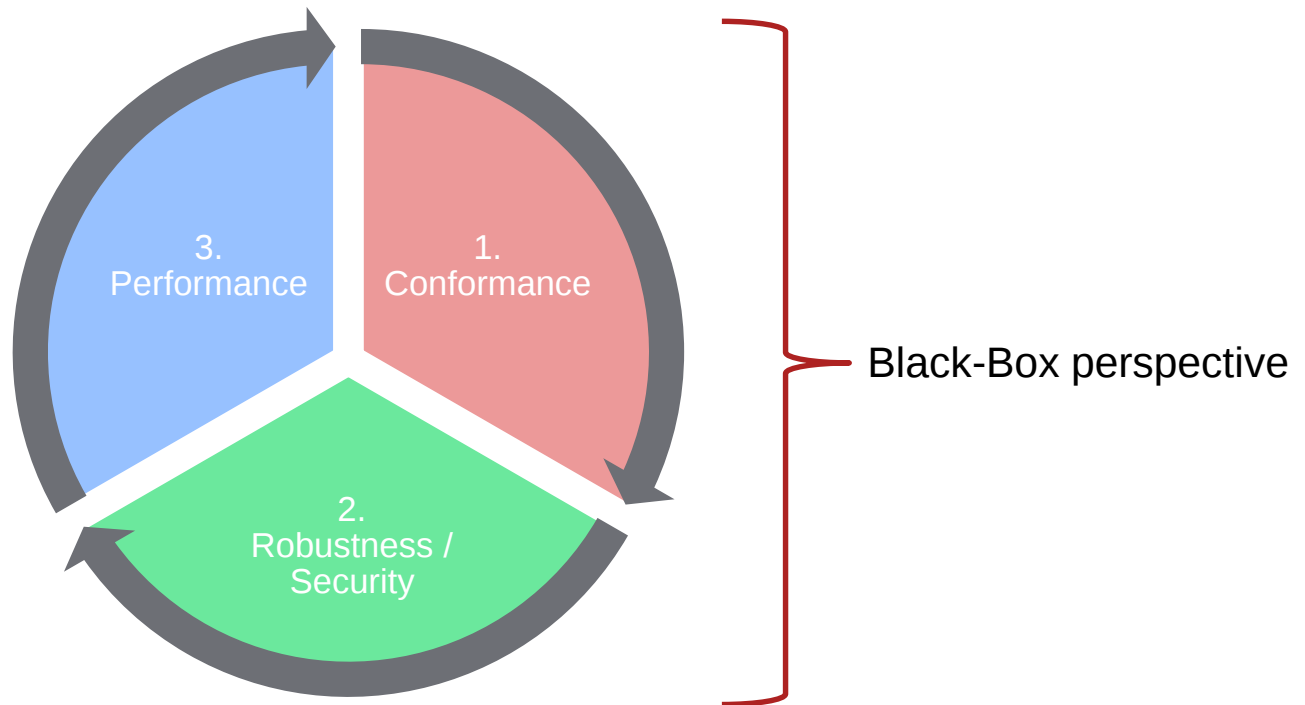
- **Areas of Testing**

- *Conformance and functional testing*
- *Interoperability and integration testing*
- *Real-time, performance, load and stress testing*
- *Security testing*
- *Regression testing*



- **Used for system and product qualification and certification**

# IOT QUALITY



# SAMPLE: MQTT EVALUATION

| Broker          |         | PASS |        | FAIL |        | INCONC |       |
|-----------------|---------|------|--------|------|--------|--------|-------|
| Name            | Version | #    | %      | #    | %      | #      | %     |
| Mosquitto       | 1.5.5   | 90   | 85,71% | 11   | 10,48% | 4      | 3,81% |
| HiveMQ CE       | 2019.1  | 86   | 81,90% | 15   | 14,29% | 4      | 3,81% |
| lannister       | v0.9.8  | 68   | 64,76% | 33   | 31,43% | 4      | 3,81% |
| Apache ActiveMQ | 5.15.9  | 58   | 55,24% | 43   | 40,95% | 4      | 3,81% |
| Aedes           | 0.38.0  | 58   | 55,24% | 43   | 40,95% | 4      | 3,81% |
| RSMB            | 1.3.0.2 | 50   | 47,62% | 51   | 48,57% | 4      | 3,81% |
| Mosca           | 2.8.3   | 43   | 40,95% | 58   | 55,24% | 4      | 3,81% |
| Apache Apollo   | 1.7.1   | 34   | 32,38% | 70   | 66,67% | 1      | 0,95% |

**April 2019 – 105 Test Cases**

# PERFORMANCE EVALUATION METHODOLOGY

## Step 1: **Load Testing**

- establishing working range
- include all dimensions of scale: kinds operations, no. of clients

## Step 2: **Endurance Testing**

- exclude degradation over time, leaks, stale entries..

## Step 3a: **Stress Testing**

- establishing limit range

## Step 3b: **Degradation Analysis / Spike testing**

- analyse behavior when reaching limit:
- graceful degradation or crash, resilience, recovery properties

# PERFORMANCE EVALUATION METHODOLOGY

## Step 4: **Benefit validation, validation against baseline implementation**

- quantify advantages against baseline

## Step 5: **Configuration Testing**

- derive recommendations / BCP for practical usage

## Step 6: **Demonstration Scenarios**

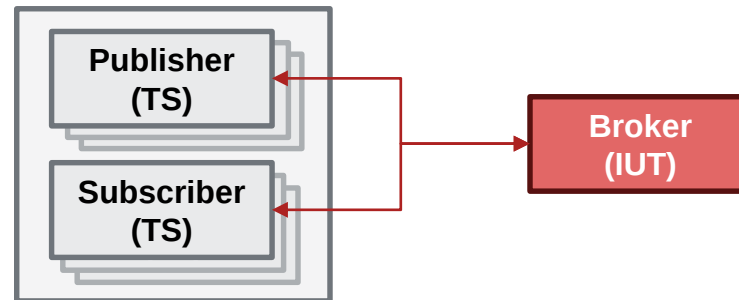
- gaining and strengthening trust in the solution

# CONFIGURATION EXAMPLES

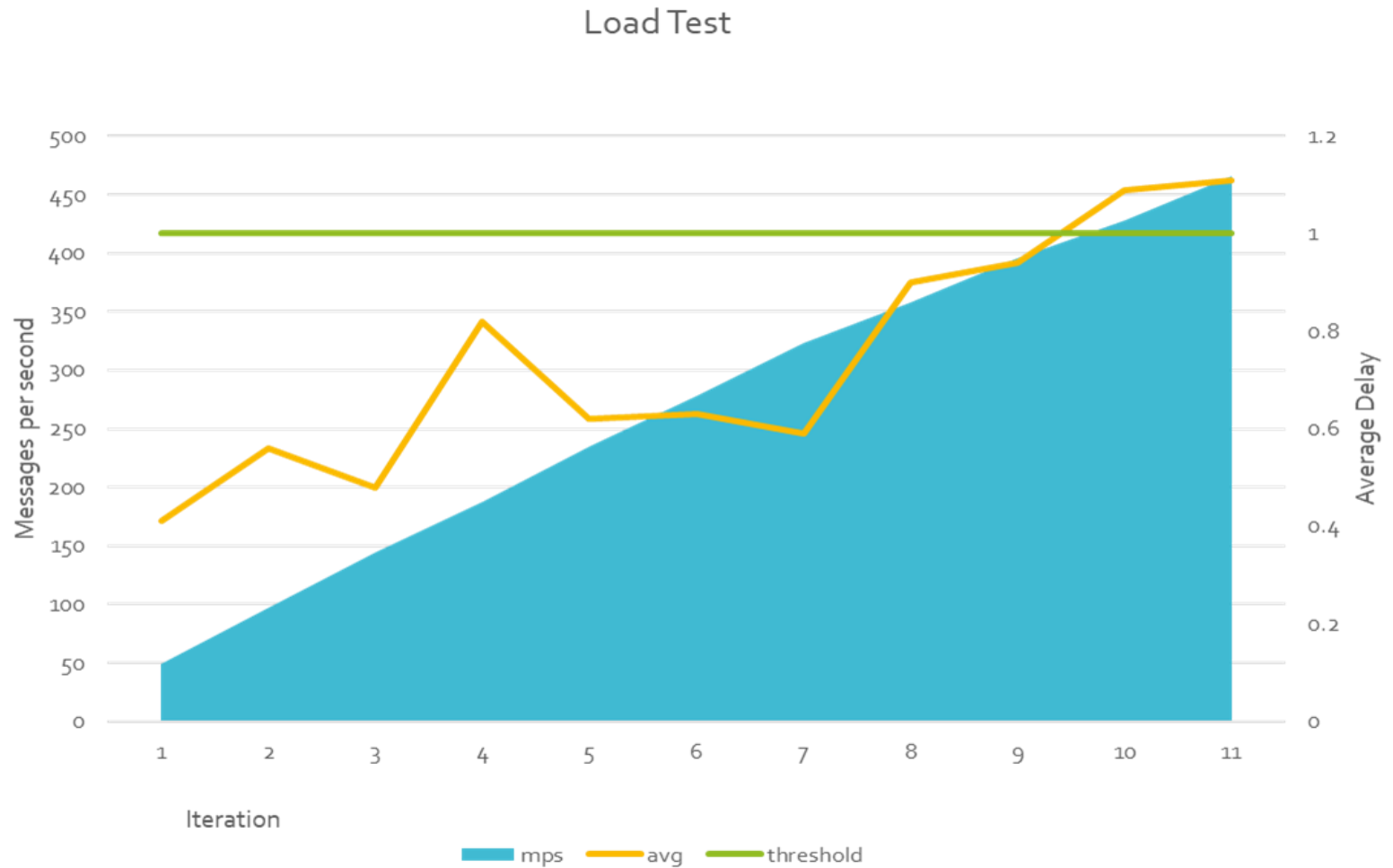
## Configuration 1:



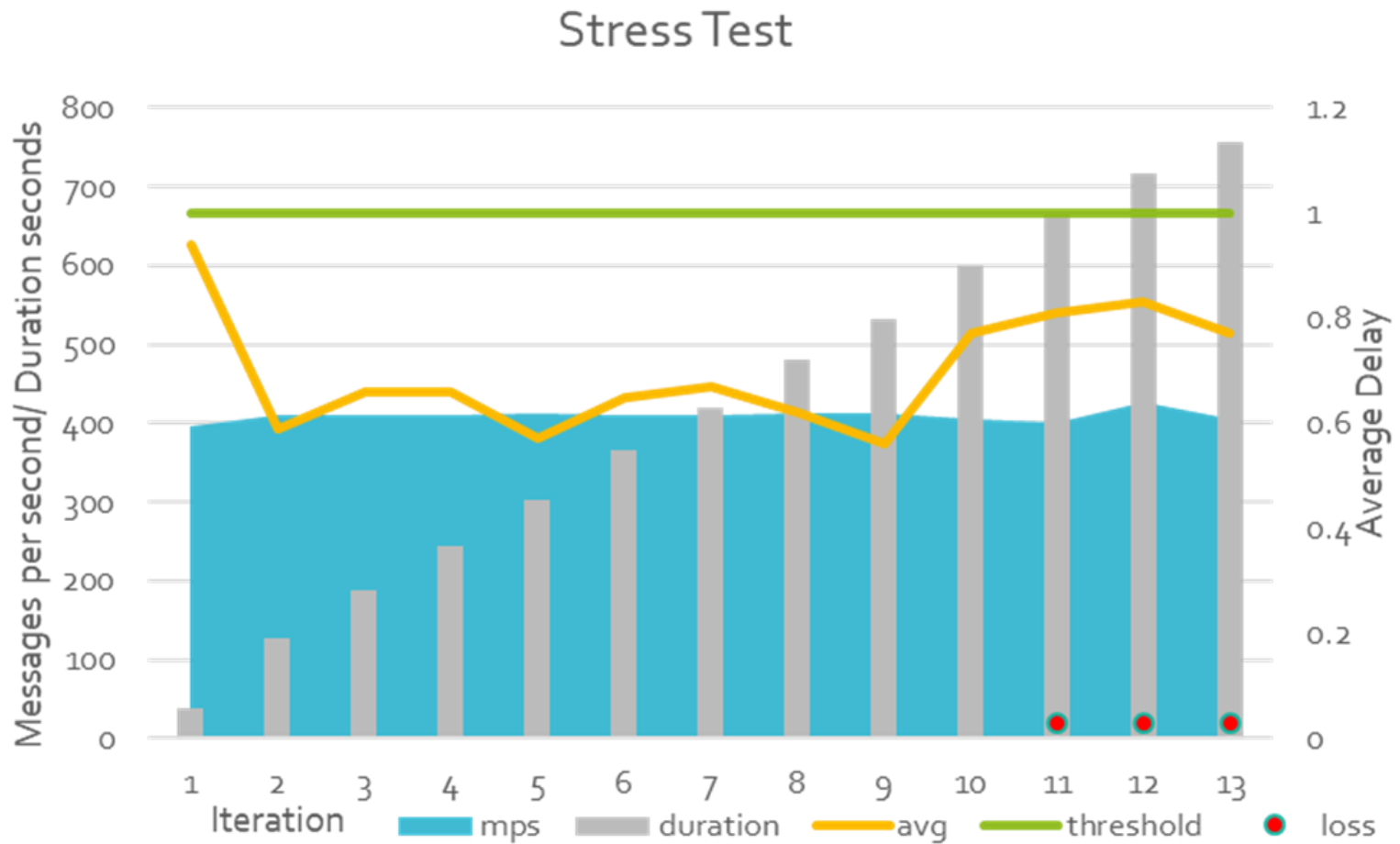
## Configuration 2:



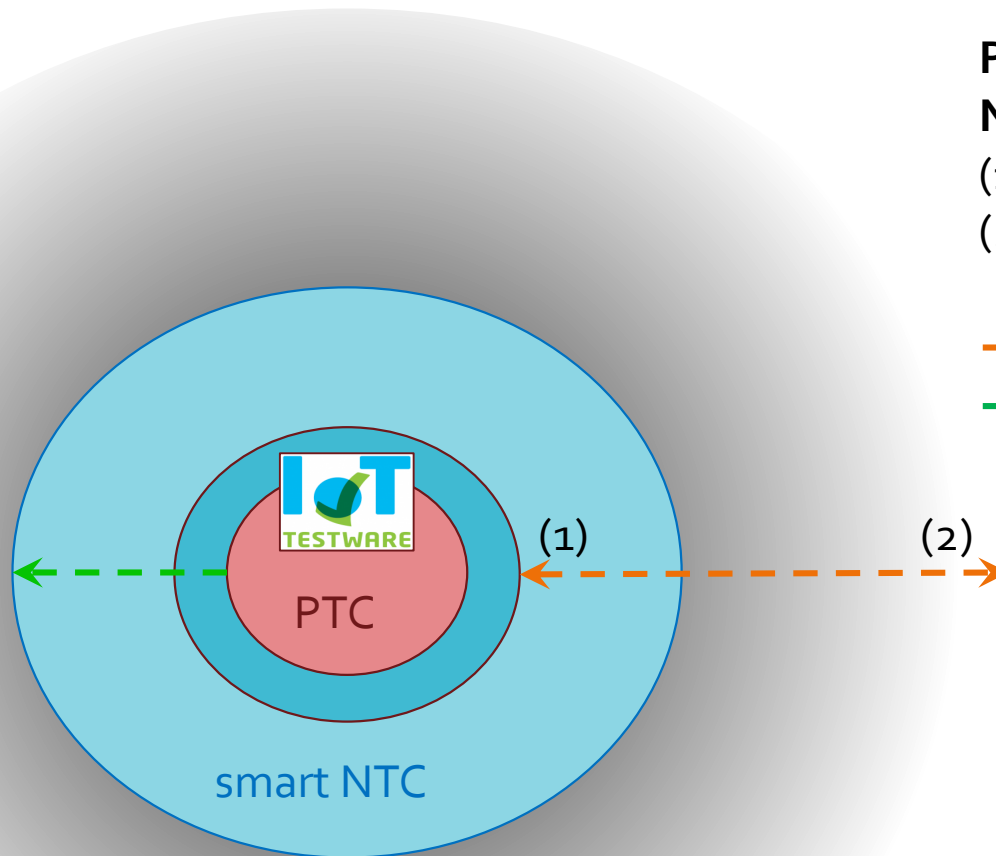
# CONFIGURATION 1: LOAD TEST



## CONFIGURATION 1: STRESS TEST



# INFINITY OF NEGATIVE TESTS



**PTC:** positive test cases

**NTC:** negative test cases

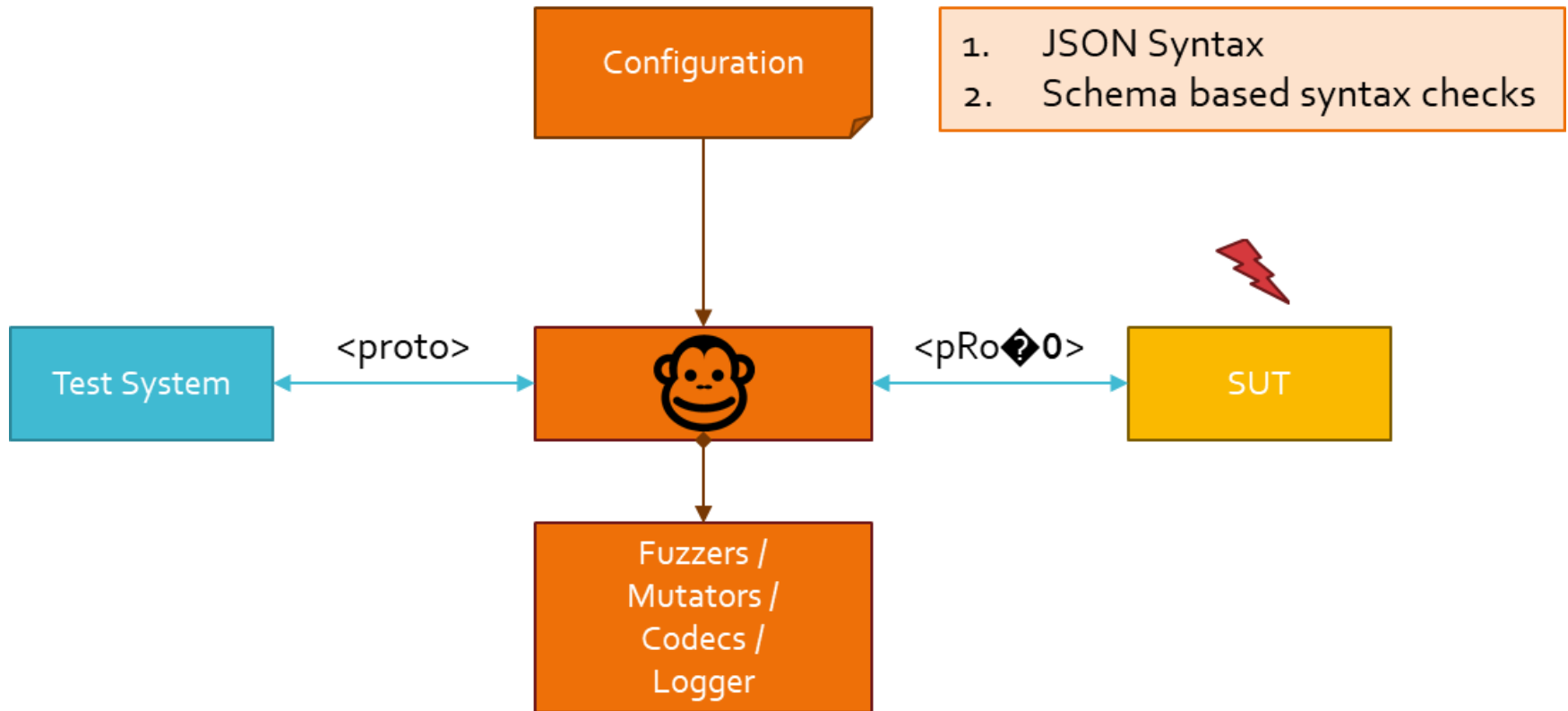
(1): Mutation-based

(2): Generation-based

---> dumb fuzzing

---> smart fuzzing

# SMART FUZZING PROXY



```
> ./monkey [command] [args]
```

# IOT-TESTWARE

Take **available** software and tools ...



... and adding public testuites as a result of insights from IoT testing:



<https://projects.eclipse.org/projects/technology.iotestware>

- **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.),
  - **Basic security** of IoT devices

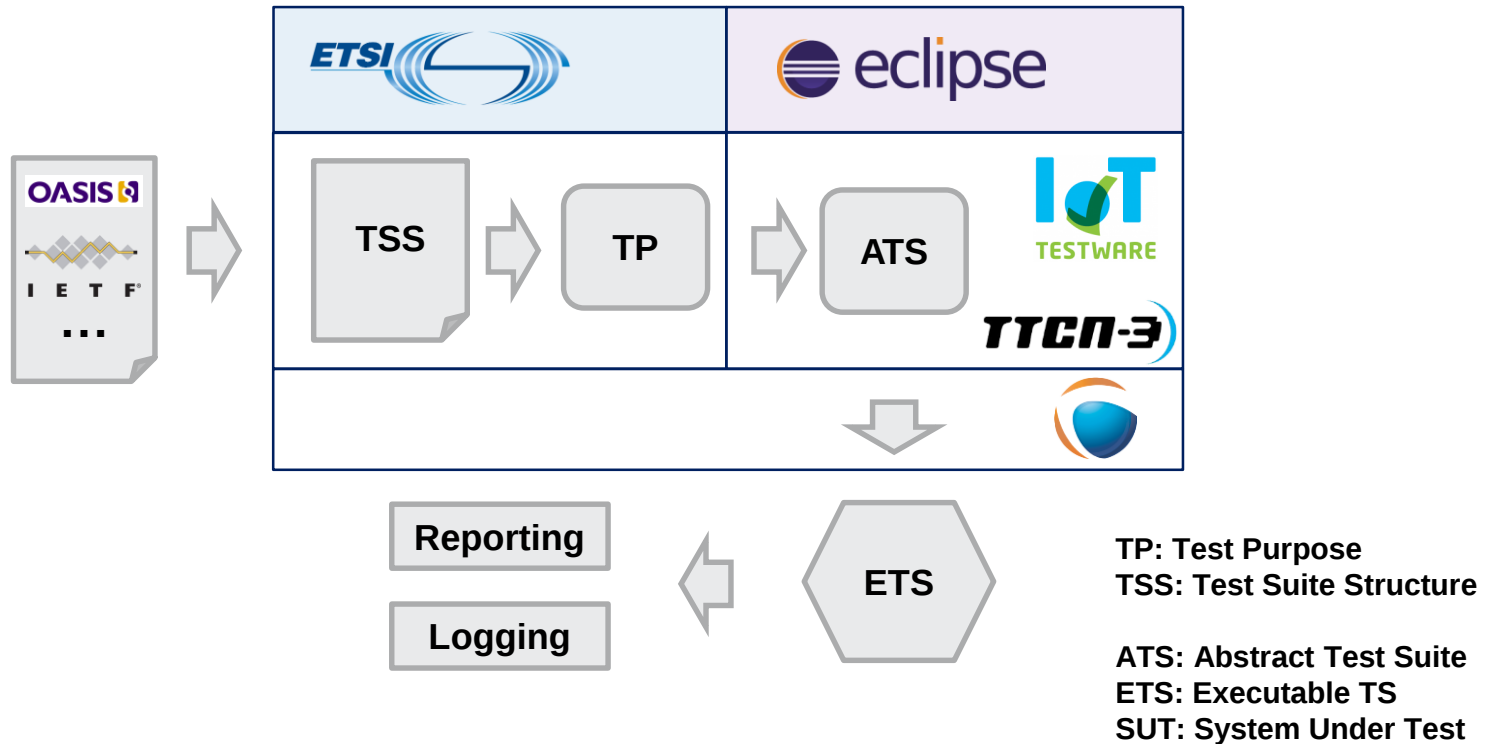


# MTS TST WORK PROGRAMME

| Work Item Monitoring - MTS TST                   |                                                                                           |                                                                                                                            |                              |                  |                      |
|--------------------------------------------------|-------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|------------------------------|------------------|----------------------|
| 9 WIs, Work in progress, displaying 1 to 9       |                                                                                           |                                                                                                                            |                              | Displays         | 30 ▾                 |
| Work item number                                 | Version                                                                                   | Current status                                                                                                             | Next status                  | Rapporteur name  |                      |
| <b>MTS TST</b>                                   |                                                                                           |                                                                                                                            |                              |                  |                      |
| <a href="#">DTS/MTS-TST8 (TS 103 646)</a>        |  0.0.6   |  <a href="#">Early draft (2019-09-09)</a> | <a href="#">Stable draft</a> | Wardaschka Andre | <b>IEC 62443-4-2</b> |
| <a href="#">DTS/MTS-TSTCoAP-1 (TS 103 596-1)</a> |  0.0.5   |  <a href="#">Early draft (2019-09-04)</a> | <a href="#">Stable draft</a> | Hackel Sascha    |                      |
| <a href="#">DTS/MTS-TSTCoAP-2 (TS 103 596-2)</a> |  0.0.1   |  <a href="#">Early draft (2019-09-03)</a> | <a href="#">Stable draft</a> | Hackel Sascha    | <b>CoAP</b>          |
| <a href="#">DTS/MTS-TSTCoAP-3 (TS 103 596-3)</a> |  0.0.1   |  <a href="#">Early draft (2019-09-03)</a> | <a href="#">Stable draft</a> | Hackel Sascha    |                      |
| <a href="#">DTS/MTS-TSTLoRaWAN (TS 103 598)</a>  |  0.0.1   | <a href="#">Early draft (2019-03-27)</a>                                                                                   | <a href="#">Stable draft</a> | AHMAD Abbas      | <b>LoRaWAN</b>       |
| <a href="#">DTS/MTS-TSTMQTT-1 (TS 103 597-1)</a> |  0.0.5   |  <a href="#">Early draft (2019-09-04)</a> | <a href="#">Stable draft</a> | Pintar Bostjan   | <b>MQTT</b>          |
| <a href="#">DTS/MTS-TSTMQTT-2 (TS 103 597-2)</a> |  0.0.1   |  <a href="#">Early draft (2019-09-03)</a> | <a href="#">Stable draft</a> | Pintar Bostjan   |                      |
| <a href="#">DTS/MTS-TSTMQTT-3 (TS 103 597-3)</a> |  0.0.1   |  <a href="#">Early draft (2019-09-03)</a> | <a href="#">Stable draft</a> | Pintar Bostjan   |                      |
| <a href="#">DTR/MTS-TSTSecTM (TR 103 599)</a>    |  0.0.1 | <a href="#">Early draft (2019-03-27)</a>                                                                                   | <a href="#">Stable draft</a> | AHMAD Abbas      | <b>Vul. database</b> |

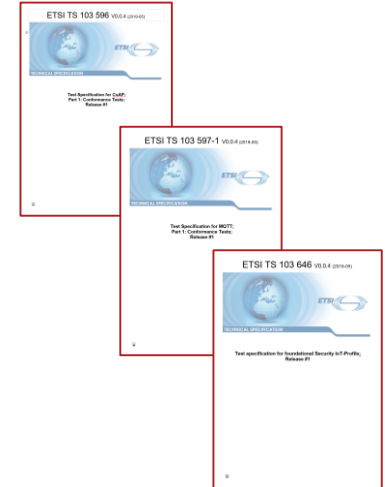
<https://portal.etsi.org/tb.aspx?tbid=860&SubTB=860>

# IOT-TESTWARE - SUMMARY



# SUMMARY

- Standardized IoT test purposes
  - Used in multiple **domains**:  
e.g. mobile, access/core networks, ITS
  - **Test types**, e.g. conformance, interop, security



- Advanced testing technology:
  - Used for **certification**:  
e.g. UMTS, LTE, 5G, oneM2M



- Open source IoT-Testware (code):
  - Executable with **open source** or commercial TTCN-3 **tools**



**Gracias!**  
**Thank you for your attention!**

**<http://www.iot-t.de/en/>**

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**[Axel.Rennoch@fokus.fraunhofer.de](mailto:Axel.Rennoch@fokus.fraunhofer.de)**