F-Interop – Online Platform of Interoperability and Performance Tests for the Internet of Things

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Abstract. This article presents an initial set of results from the F-Interop European research project researching online platform for interoperability and performance tests for the Internet of Things. It presents some of the challenges faced by the IoT and online testing, and how F-Interop is addressing them, in order to provide an extensive experimental platform for online tests. It gives an overview of its overall architecture.

Keywords: Internet of Things · Tests · Testbed as a service · Interoperability · Conformance · Performance · Scalability · Privacy

1 Introduction and Project Presentation

The Internet of Things (IoT) is recognized as being the next technological revolution impacting all application domains. It will be massive and pervasive, with 50 to 100 Billion smart things and objects connected by 2020. Its role will be transversal and will impact diverse application domains, including: smart cities, agriculture, industries, eHealth, etc.

Since 1995, the interoperability is recognized by the International Telecommunication Union (ITU) as being the main obstacle to IoT development and adoption by the market. The success of this new technological revolution will hence be closely related to its capacity to overcome its current fragmentation. It will require supporting adequate standardization and interoperability.

F-Interop (www.f-interop.eu) [1] is a European research project addressing this challenge, by researching and developing an online platform of interoperability and performance testing tools for the IoT.

2 Problematic

In order to be widely adopted, new technologies, products and solutions go through several steps:

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- Standardization: stakeholders discuss and align their views to converge towards common standards and specifications.
- Conformance & Interoperability: stakeholders test and validate that their implementation is conform to the standard.
- Optimization: in terms of Quality of Service, scalability, energy consumption, etc.
- Market Launch: the solution is ready for roll-out into the market.

Each phase traditionally requires extensive testing, where different vendors meet face-to-face to test interoperability by going through an exhaustive list of "interoperability tests". The consequence is that:

- The current process is extremely labor-intensive, as engineers travel across the globe often only to find out what they need to make a minor fix;
- The cost associated with engineering time and travel expenses is often too high for SMEs;
- Time-to-market is unnecessarily stretched, giving vendors who want to adopt emerging standards a disadvantage compared to vendors who come to market with entirely proprietary solutions.

F-Interop is leveraging on the European FIRE research infrastructure to develop online and remote interoperability and performance test tools supporting emerging technologies from research to standardization and to market launch. The outcome will be a set of tools enabling:

- Standardization communities to save time and resources, to be more inclusive with partners who cannot afford travelling, and to accelerate standardization processes;
- SMEs and companies to develop standards-based interoperable products with a time-to-market cut by 6–12 months, and significantly lowered engineering/financial overhead.

3 Technical Approach and Outcomes

The goal of F-Interop is extending FIRE+ with online interoperability and performance test tools supporting emerging IoT-related technologies from research to standardization and to market launch for the benefit of researchers, product development by SME, and standardization processes. Specifically, F-Interop will combine three complementary approaches:

Online Testing Tools. First and foremost, F-Interop is researching and developing online testing tools for the IoT, enabling to test interoperability, conformance, scalability, Quality of Service (QoS), the Quality of Experience (QoE), and energy efficiency of IoT devices and services.

Testbeds federations with a shared "Testbed as a Service". F-Interop brings together 3 testbed federations and facilities, encompassing over 32 testbeds and over 4'7000 IoT nodes, with:

- Fed4FIRE, which federates 24 FIRE+ testbeds, bringing together cloud, IoT, wireless, wireless mobile, LTE, cognitive radio, 5G, openflow, SDN, NFV and network emulation technologies.
- OneLab, which federates testbeds for the future Internet, including IoT, cognitive radio, wireless and overlay network technologies
- IoT Lab, which federates IoT and crowdsourcing/crowd-sensing testbeds, including smart campus, smart building and smart office testbeds.

In order to support this integration, F-Interop is extending the testbeds federation architecture model with a new layer enabling shared services among several testbed federations. This approach enables to interface "Testbed as a Service" (TBaaS) with existing federations through a clearly specified API, enabling remote access and interaction with various experimental platforms.

Support and to IoT Standardization and Industry. F-Interop works in close collaboration with several standardization bodies, and is directly contributing to three IoT standardization processes: oneM2M, 6TiSCH (IETF) and the Web of Things (W3C). It will also explore the possibility to support and enable new online certification and labelling mechanisms such as the IPv6 Ready logo. More generally, F-Interop intends to enable an easier participation of researchers and industry in standardization processes. It will also run an open call for SMEs and developers, inviting them to use and enrich the platform with additional modules and extensions.

Flexible Testing Schemes. F-Interop is researching and exploring various testing schemes and configurations, by interconnecting devices under tests with the server testing tools, resources provided by the F-Interop connected federations of testbeds, and resources provided by other users, as illustrated in Fig. 1, where the salmon hexagon represents a device under test.

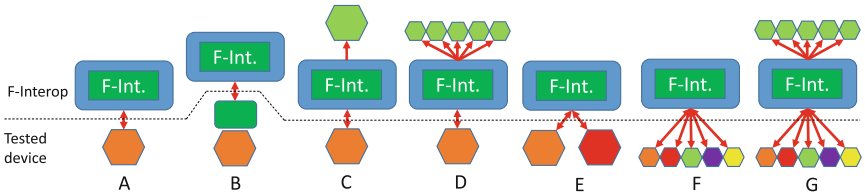

Fig. 1. Multiple testing schemes

4 Initial Architecture and Approach

The initial architecture has been designed by leveraging on the experience acquired by the three federations of testbeds participating in the project. It provides an additional layer of Testbed as a Service, on top of the three federations. But rather than a super federation, F-Interop should be considered as an autonomous testbed as a service with specific testing tools exploiting resources from the federated testbeds. Indeed, F-Interop is interested only in using relevant and targeted IoT resources (Fig. 2).

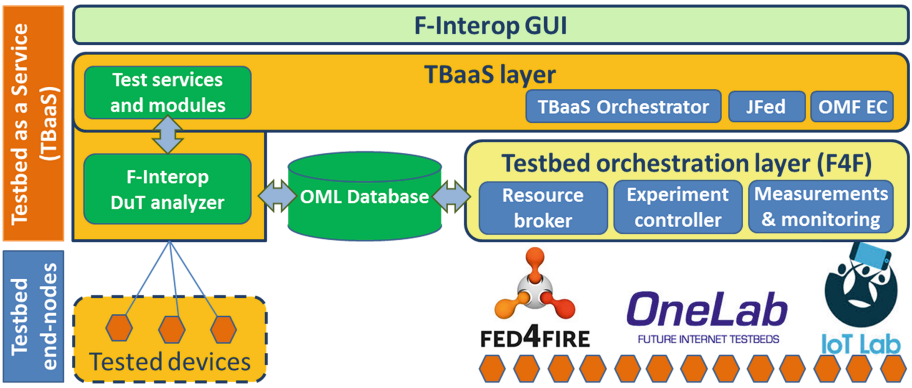

Fig. 2. Initial architectural view.

F-Interop-Platform distinguishes two main types of participants: F-Interop-Contributor and F-Interop-User. An F-Interop-Contributor (FI-Contributor) is any entity that provides testing tools into the F-Interop-Platform as well as testbeds and devices that are added to extend the existing testbeds. An F-Interop-User (FI-User) is any person or entity that has an IoT device, system or application to be tested (called IUT, Implementation Under Test) and wants to use the F-Interop-Platform to test it (Fig. 3).

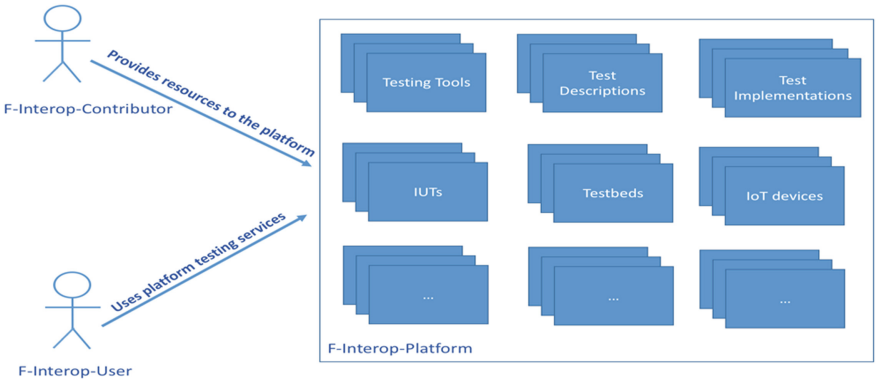

Fig. 3. F-Interop main components

We have considered the two types of testing tools that the F-Interop has to deal with: Online Interoperability testing and Online performance testing. We decided to select some of the targeted emerging IoT technologies that cover as many layers/aspects as possible of the IoT protocol stack. We decided to focus first on the two following protocols: 6TiSCH and CoAP. We have investigated the state of the art (existing methods and tools) for testing, and we have studied and compared existing IoT related testing solutions and tools.

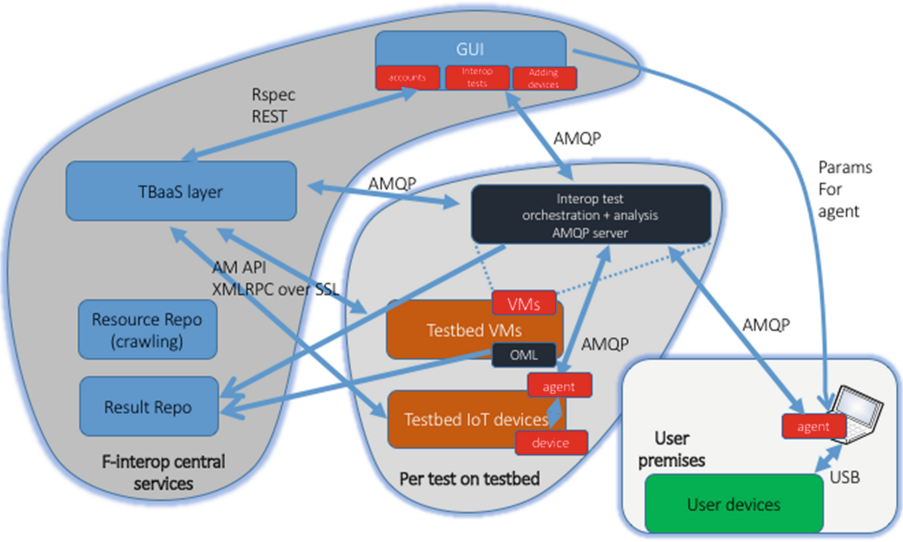

Fig. 4. F-Interop general architecture

Based on the test scenarios that have been developed and used during previous and recent interoperability face-to-face (F2F) interoperability testing events, we started studying what is needed for doing the same but in an online and remote manner. This work helped us in identifying key requirements and main components for online remote testing, as well as F-Interop-User and F-Interop-Contributor needs for running online remote testing. This work led to the definition of the first version of the overall architecture below (Fig. 4).

The following architecture has been defined more specifically for the case of remote online interoperability testing. It allows distinguishing the control plane in charge of managing the interactions between components and the data plane in charge of the test execution itself. Based on this architecture, a first proof of concept has been developed and authorizes CoAP online remote interoperability testing. The corresponding demo has been selected to be presented at the 25th Edition of the European Conference on Networks and Communications conference (EuCNC) in Athens, Greece, June 27-30, 2016. The proof of concept for 6TISCH and for oneM2M are under development (Fig. 5).

The remaining challenges to be addressed are synthesized as follow:

- To define a clear API enabling the interconnection of F-Interop as a service with the various testbed federations (or federated testbeds).
- To develop the targeted online testing tools: interoperability, conformance, and performance tests.
- To develop a generic and modular platform with an API enabling to extend the interoperability and conformance testing tools to new protocols and standards, including by voluntary third parties (FI-Contributors) or selected through the open call.

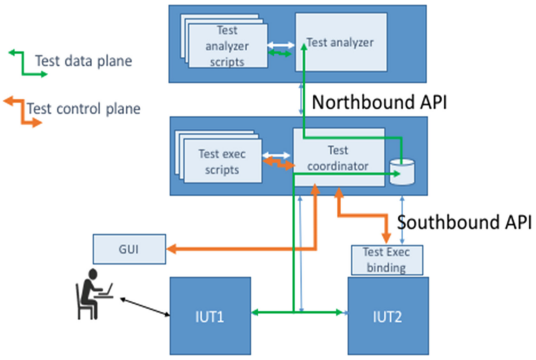

Fig. 5. F-Interop online interoperability testing architecture

- To develop a generic and modular platform with an API enabling various testing tool modules integration, including by voluntary third parties or selected through the open call.

5 Conclusions – Towards Online Interop and Performance Tests

In order to support the IoT research, development and industrial exploitation, F-Interop is developing a platform of online testing tools encompassing interoperability, compliance and performance tests. It is progressing towards a new model of interop test, enabling a larger participation with remote ad distributed tests.

The F-Interop platform is still in its development phase. However, it already announces an open call with funding to develop new partnerships with third parties research projects interested to develop complementary testing tools, address additional standards and/or organize F-Inerop based interop tests in standardization processes. More information is available on the project website at: www.f-interop.eu.

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