# Key takeaways

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1. The recent technological developments require more realistic tests and new use cases to be validated in real conditions. The consequence is that the testbeds are more important. There is a need of testbed federation and interconnection between testbeds. It requires a set of clearly Standardized Reference Model for Testbeds Federation and APIs as being standardized by ITU-T & ETSI (with other SDOs/Fora joining the efforts), and this is a good step.

2. Vertical industry needs to experiment and pilot their "5G enabled" business case before moving to commercial.

3. There is a need to standardize a generic 5G and beyond application testing and validation framework which validates the vertical application in a systematic manner under different 5G technology choices.

4. Vertical needs to be involved in the design and result evaluation phase. This is beyond current CSPs network testing paradigm.

5. The ETSI INT is currently producing a Technical Report which captures recommendations on such validation framework and methodologies, leveraging the experience from EU 5G PPP trial projects. The next standardization steps are under discussion.

6. ITU-T SG11 and ETSI TC INT are developing Open APIs for interoperable testbed federations which will define reference model of testbed federations. All Stakeholders are encouraged to contribute to this work in order to achieve global interoperability of testbed federations.

7. The generic vertical validation framework will expose APIs to enable federation with other platform/testbeds.

Points covered and discussed on Testbeds Federations Model being developed for standardization by the SDOs/Fora

1. Reference Model for Testbeds Federation: Generic Federated Testbed Model

2. Specializations of the Testbed Domain Concept

3. "Federations of Federations", a level above the level of the Universal E2E Resource Broker

4. Abstraction Levels for Resources in a Testbed, and how individual Resources may take part in a Test Scenario

5. Types of APIs for Testbed Federations based on the Testbeds Reference Model; and APIs specifications, implementations and invocations approaches

6. Examples of Testbeds Federation APIs requirements

7. Roles of various stakeholders to the emerging Ecosystem around the Testbeds Federation Reference Model, its APIs and its instantiations using various Testbeds that get federated

8. Summary of the Objectives of this Workshop with regard to Stakeholders Engagement around the Testbeds Federation Reference Model and associated Ecosystem to emerge

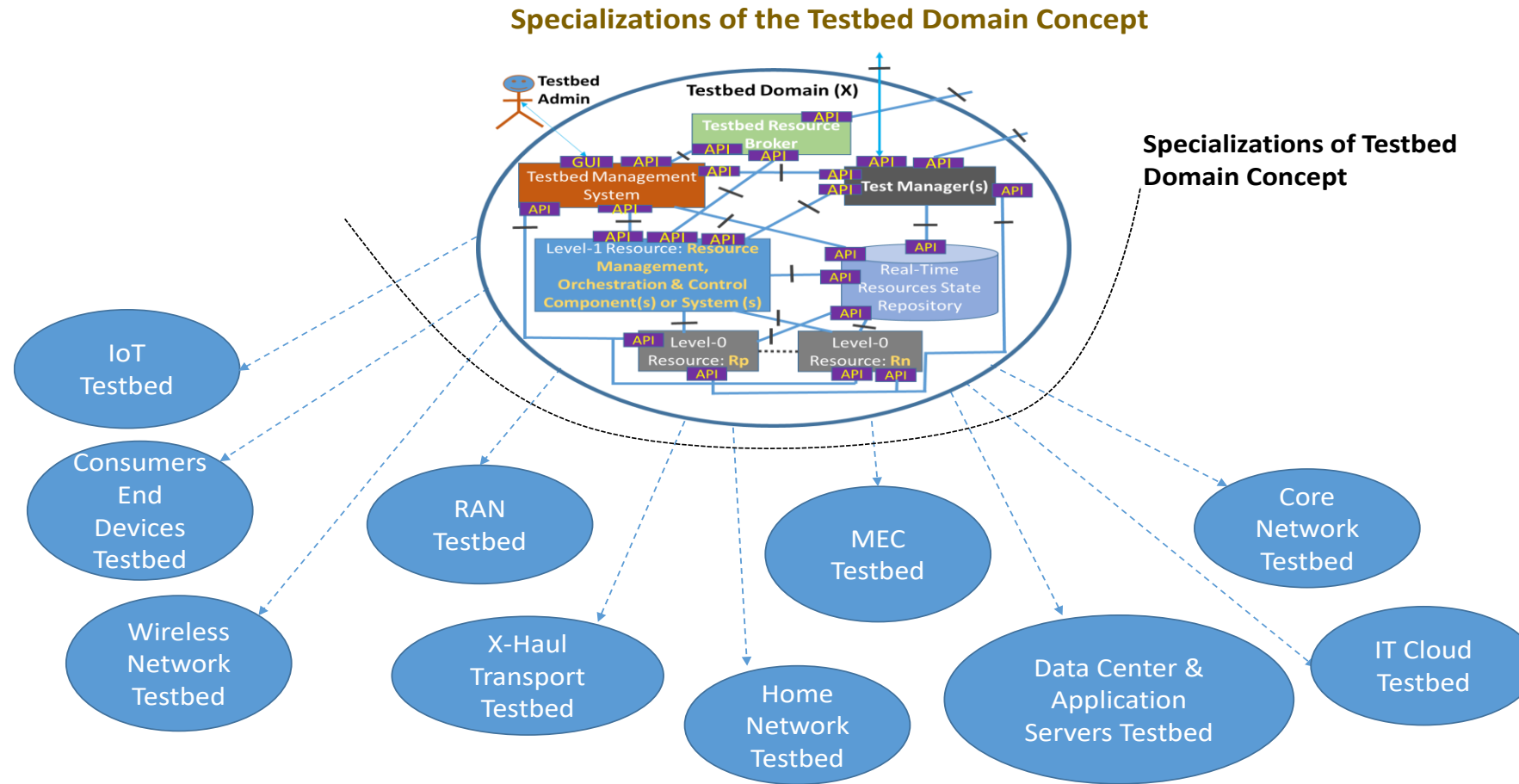# Reference Model for Testbeds Federation: Generic Federated Testbed Model
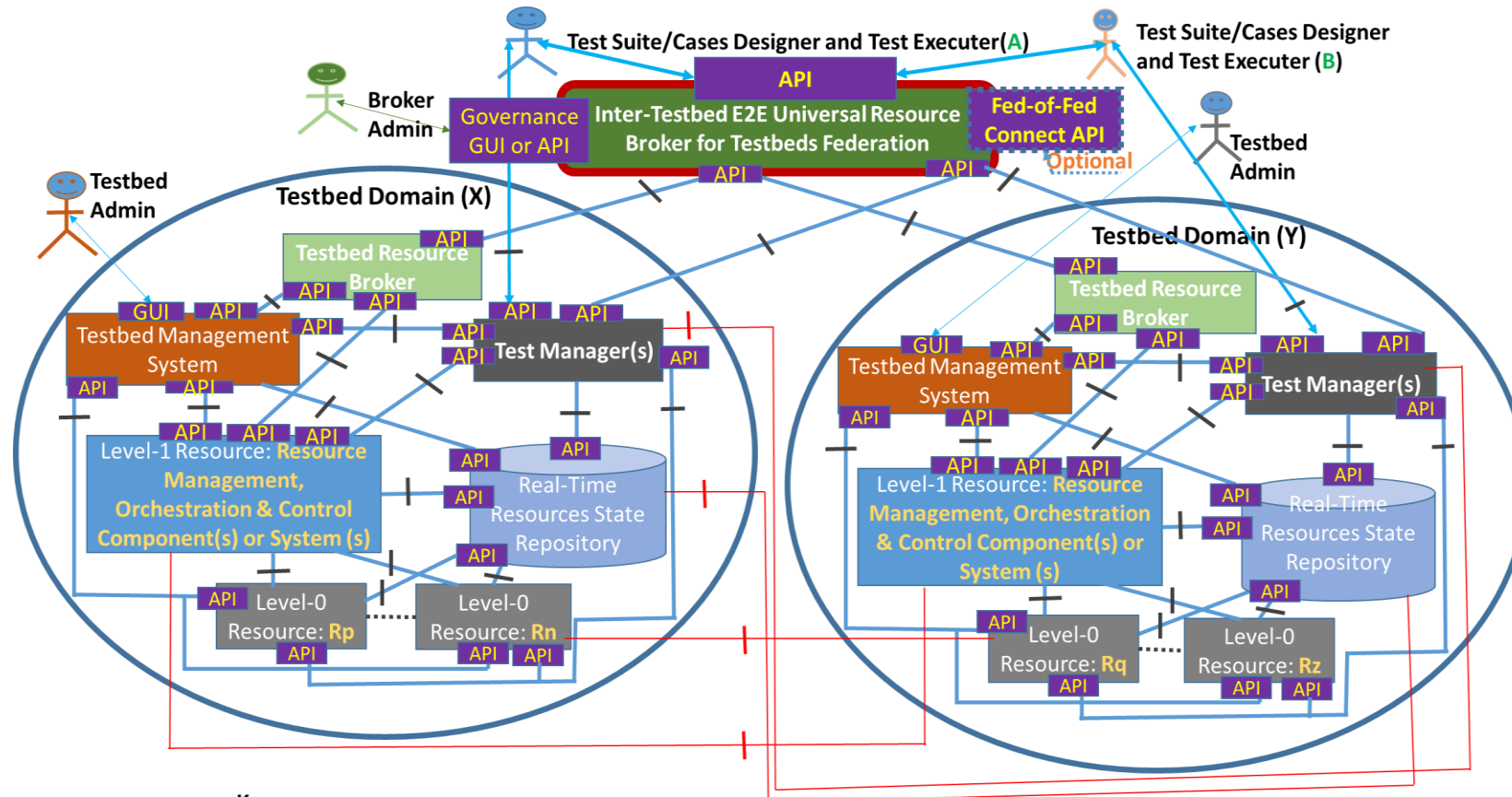
NOTE: **The APIs shall be named** (to have a way to distinguish them) and we shall start describing the APIs and how the Generic APIs get extended (specialized) by Testbed Type specific APIs and how Generic APIs make calls to the Testbed Type specific APIs.
Elements of the APIs for Security Perspectives should be added, as well as other security and Trust oriented perspectives
Non-technical perspectives, e.g. cost of providing "Testbed-as-Service", must be considered in defining the APIs

Key: There may be established Horizontal and/or Hierarchical/Vertical Federations of Assets/Components or Resources at specific Levels across Federated Testbeds

Specializations of the Testbed Domain Concept

"Federations of Federations", a level above the level of the Universal E2E Resource Broker
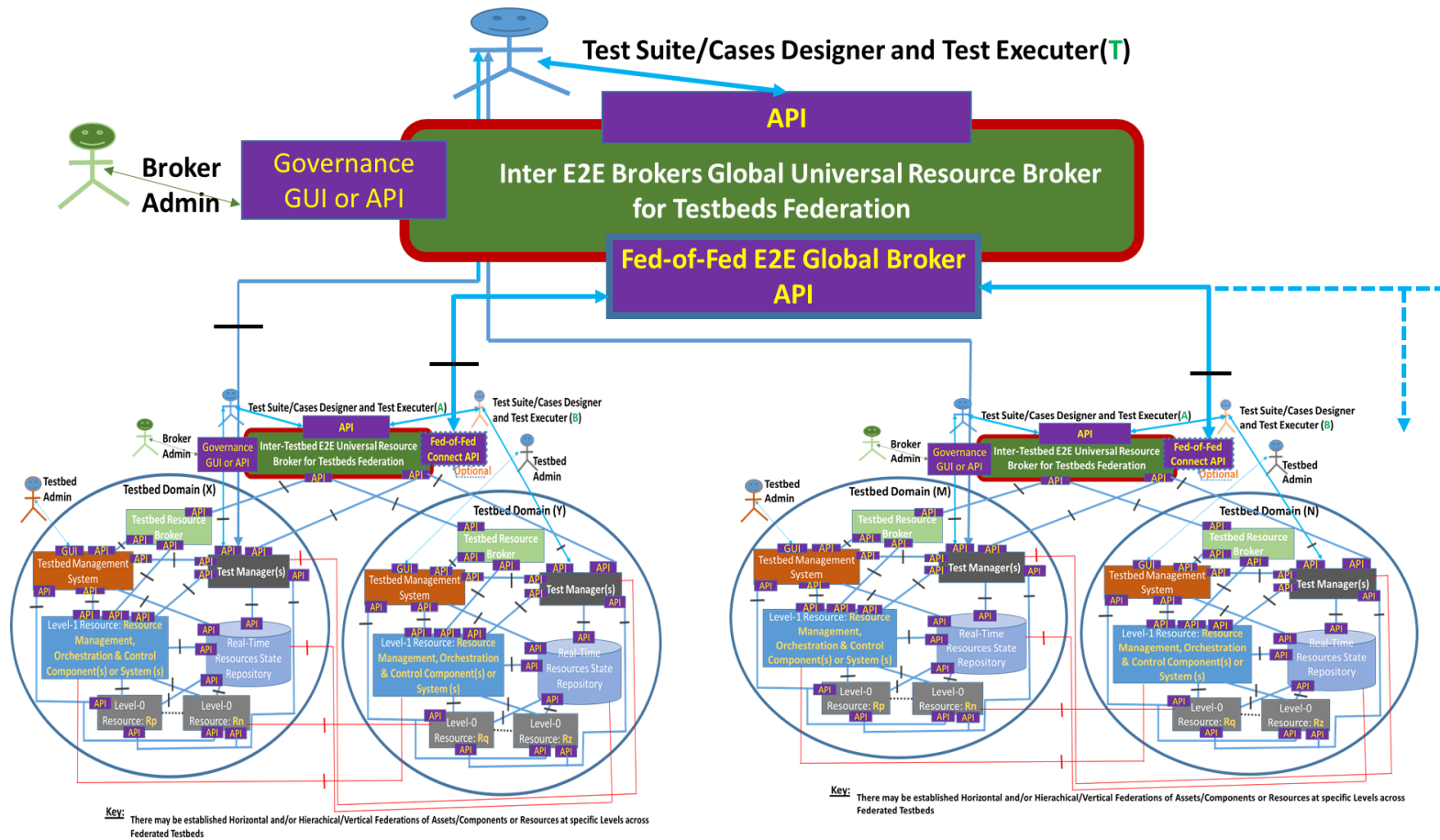
Roles of Various Stakeholders to the Emerging Ecosystem around the Testbeds Federation Reference Model

Looking at the following aspects for Consideration:

1. Stakeholders that need to be engaged to play specific in the emerging Ecosystem around the Testbeds Federation Reference Model, its APIs and its instantiations using various Testbeds that get federated

2. Summary of the objectives of the Workshop with regard to stakeholders engagement around the Testbeds Federation Reference Model and associated Ecosystem to emerge

Stakeholders to be engaged:

- **SDOs/Fora, Research Communities/Researchers on 5G and Beyond, Industry Users of Testbeds, Testbeds Suppliers for 5G Testbeds and other Testbeds, CSPs & Enterprises, Infrastructure Vendors/Suppliers for ICT and Verticals, ISVs, Open Source & Open Hardware Projects, Regulators, Owners of Existing Testbeds and Platforms for 5G& Beyond, and any other interested parties**

Roles of Various Stakeholders to the Emerging Ecosystem around the Testbeds Federation Reference Model (Cntd….)

Examples of Potential Roles of certain Stakeholders (Objectives on why engaging the various stakeholders at this first joint SDOs/Fora Workshop):

- **SDOs/Fora:** Can potentially share the burden on APIs standardization and on roadmaps in a harmonized and collaborative way

- **ALL Stakeholders**: Help contribute to capturing requirements to be fulfilled by the Testbeds Federations APIs

- **Testbeds Suppliers, CSPs, Enterprises, Infrastructure Vendors, ISVs**: Help contribute to derivation of potential new Business Models for Testbeds Suppliers that derive from the Testbeds Federations Reference Model

- **5G& Beyond Research/R&D Communities**: Bring experiences to the discussions of the Reference Model and APIs Specifications and contribute what may have been achieved already in this area of Testbeds Federations—with respect to existing API implementations by research communities and by the Industry as well

- **Owners of Existing Testbeds and Platforms for 5G& Beyond**: Embark on transformation or evolution of existing Testbeds (Industry and Potential Research Testbeds as well) and Federation APIs to meet the requirements of the Testbeds Federation Model being standardized. Make Efforts on the instantiations of the Reference Model in building Industry-Grade new Testbeds and/or Transformations of existing Testbeds

- **Open Source & Open Hardware Projects**: Help contribute to the Building of Open Networking Platforms (ONPs) Testbeds that conform to the Testbeds Federation Reference Model and its associated APIs. Also make efforts on the instantiations of the Reference Model in Building Industry-Grade New Testbeds and/or Transformations of Existing Testbeds

1. SDOs such as ETSI TC INT AFI WG and NGMN advocate for Disaggregated GANA KP Platforms for specific network segments/domains, due to the call by CSPs for Disaggregated Networks, Control Planes & Data Planes and Software Platforms for AMC

2. Intra-CSP Federations of GANA KP Platforms across Network Segments and Inter-CSPs GANA KP Platforms Federations inherently and correspondingly require Federated Testbeds to Test the Cross-Domain AMC Operations

3. When applied to testbeds, GANA allows asset exposure and Testbed-as-a-Service (TaaS) modelling and with federation provides significant advantages for (especially) CSP stakeholders

4. The Standardized Testbeds Federation Reference Model for aligning and streamlining various stakeholder architectures strengthens the eco-system and value-chain for increased collaboration and leveraging of Testbeds for 5G & Beyond among stakeholders (CSPs, vendors, testbed-operators, open-source and „disruptive players")

5. Network disaggregation drives need for test automation & federation

6. 5G Network layer testing automation is progressing well

7. 5G Application layer (NetApp) integration is challenging

8. Telco operators mindset needs to shift towards taking control of QA

9. Telco industry has not adopted standards for test automation and federation yet

10. Specifically, goals for certification programs should be carefully reviewed to be successful

11. Suggestion: Increase peer review and industry buy-in for important standardization efforts

12. Suggestion: Lead and improve focus on technology-specific QA goals (quality awareness)

Q/A (1/6)

- **How to harmonize testbeds across SDOs when their own document database does not have an open standardized API?**
  – Harmonization goes through the Testbeds Federations reference model being developed by ITU and ETSI and presented at this Workshop.

- **How is the automation in the reference Model for testbeds handled?**
  – It is handled by discovery. The capabilities are automatically build by testbed domain and then are published in E2E universal broker for testbeds. Other automation is in the testbed management system which does the interconnection (horizontal federation) with other testbeds

Q/A (2/6)

- **There have been federation of Internet testbeds, such as GENI, for scability and heterogeneousness. But what's the purpose of a federation of 5G testbeds? Is there going to be an Internet of 5G?**

    – Management systems should be autonomous and disaggregated

- **How to define end-to-end in 5G ? It is defined in a single provider 5G system or among interconnected 5G system.**

    – 5G started, as a non-stand alone, only in the radio part was 5G, the core was 4G. The big players are moving to a standalone 5G, where the core in completely based on 5G where can be build the slices, the connections E2E and can build their relationships. With the stand alone 5G can applied each use case.

- **Are Platforms like FABRIC going to be open for Users in Europe and other regions?**

    – It will be available for research purposes but would probably require some sort of bilateral agreement(s) between parties

Q/A (3/6)

- **Can the platforms validate the KPIs?**

    The vertical KPI are a very large and complex topic. It is planned to create a set of recommendations for common applications. To get a clear picture is planned to execute interoperability and conformance tests or tests between technologies.

    It was created a KPI model for different application KPIs. The work is ongoing in ETSI TC INT. They are several layers of KPI and the final goal is to measure the real customer performance.

    They are also requirements from 3GPP SA1 and from the industry. These requirements should be translated in capability in 5G networks to be able to measure and monitor to fulfill the requirements of this verticals.

    The relevant topic is proposed to become a subject of a new Work Item.

Q/A (4/6)

- **The performance is not only determined by 5G systems. It is also related, or even largely determined by the public network the data travels?**
  - Yes, the performance is indeed determined by the server providing the service and the position of the server compared to 5G Core (Server over Internet). MEC in this sense can help.

- **Who finances the establishment of the Platform that FNIC IEEE talks about?**
  - Financed by IEEE

Q/A (5/6)

- **Vertical application KPIs is a very large and vertical domain-dependent topic without considering the large variety of scenarios in a given vertical. It is not clear on how it can be expected that the platform can validate application KPIs. In the same perspective, it is not clear on how the platform can then allow the selection of the best underlying technologies.**

  - Create some recommendations for common applications. Vertical expectations are supposed to be added.

  - Probably the taxonomy of these KPIs need to be developed.

  - ETSI plans to develop KPI model which might be used for different set of verticals.

  - There is a need to build repository of KPIs.

  - Definitely, application KPIs is a wide topic and the community is working on. Certainly, a goal could be to identify basic repository for general usage.

Q/A (6/6)

- **With regards to validation of the trustworthiness of the AI-enabled test system itself. What is the robustness of the test system which has to test the network itself?**
  - There is a need to define metrics for AI-based test systems that can be independent of assessed technology. Certification of AI applications may be one of the ways forward.

- **As in many multi-stakeholder platform projects, various aspects will need to be clearly defined and agreed among all expected stakeholders incl. - apart from funding - governance, accessibility, transparency, sustainability, assets management, contributions handling, decision process, win-win conditions for stakeholders.**
  - Standardization of APIs and reference model in SDOs is very important and is the best way forward.

Call for standardization (1/2)

1. There is a need the value creation blueprint which allows all stakeholders to join such ecosystem that is therefore to emerge around the Testbeds Federations Reference Model being standardized by ITU-T and ETSI, its APIs and its instantiations

2. APIs of TMForum that pertain to Products/Services Selling and Uptake that capture generic aspects of relevance to the new idea of "Testbed as Service" might be adopted by ITU and ETSI in elaborating APIs for the Testbeds Federations Reference Model.

3. SDOs should not go to the marketing.

4. The commercial requirements need to be identified, and the "Testbeds-as a Service" is good example.

5. Security attributes are used as a kind of reputation of the application

6. ITU-T SG17 is encouraged to collaborate with IEEE INGR Security Group on the possibility to join forces in working on the Required Security Framework (as a standard) associated with the Testbeds Federations Reference Model and its APIs (as security requirements that should be considered in Testbeds Federation).

Call for standardization (2/2)

7. Standardization of APIs for the Reference Model should also consider SDKs to provide guidance on how the APIs can be flexibly implemented

8. The improvement of interoperability testbeds is needed. All industrial and research solutions needs to be considered in the efforts around the Testbeds Federation Reference Model.

9. Some regulations should be put in place. JASON is used for connection 5G core at the moment. Attributes need to be defined.

10. SDO should be open. Make it easy for operators. Test once – implement multiple times.

11. Sharing information would be a good benefit to continue dialog.

12. SDOs and stakeholders are encouraged to work jointly to understand all needs.

13. ETSI TC INT and IEEE INGR Testbeds WG need to discuss together on the proposal on the need for ontologies in the case of Testing of Vertical Applications in 5G pertaining to the various KPIs as potentially a new work item is needed.

14. Possibility to launch ITU-T Focus Group is being recommended to engage various Stakeholders to contribute (ITU-T SG11 is parent group)

Industry Requirement & Proposal for a Multi SDO/Fora "Standards Driven" Open Networking Platform (ONP) Environment for Standards Driven Innovation, Multi-SDO Standards Harmonization, and Validation of Pre-Deployment Technology Use Cases

1. The proposal on ONPs was very much appreciated by the SDOs/Fora that participated, as the proposal shares a lot in common with the vision of TIP, IEEE FNIC, O-RAN and other Industry-Grade Testbeds oriented initiatives. This is because an ONP(s) is to be considered as a Playground (Proving Ground) for trying out Pre-Deployment Real Use Cases based on Industry Harmonized and Cross-SDO/Fora interworking standards (so as to implement Cross-SDO Industry Harmonization of Multi-SDO/Fora Standards). The various stakeholders intensified for the ONP Ecosystem would benefit a lot from such Open Platforms

2. TIP, FNIC and all the SDOs/Fora who attended agreed to follow up on this Proposal for Building ONPs as driven by Multi-SDO/Fora Standards Fusion and the Testbeds Federation Reference Model. There will be follow up meetings on this important proposal.