FIREWORKS

SEVENTH FRAMEWORK PROGRAMME

Requirements and Needs for Testbeds

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1 Introduction

The Future Internet Research and Experimentation - FIRE - Initiative is addressing this need, creating a multidisciplinary research environment for investigating and experimentally validating highly innovative and revolutionary ideas for new networking and service paradigms. FIRE is promoting the concept of experimentally-driven research, combining visionary academic research with the wide-scale testing and experimentation that is required for industry. FIRE works to create a dynamic, sustainable, large scale European Experimental Facility, which is constructed by gradually connecting and federating existing and upcoming testbeds for Future Internet technologies.

There is an increasing demand from both academic and industrial communities to bridge the gap between visionary research and large-scale experimentation, through experimentally-driven advanced research consisting of 'iterative' cycles of research, design and experimentation of new networking and service architectures and paradigms addressing all levels, including horizontal research on issues such as system complexity and security. FIRE embraces this cycle and close connection between experimenters and the facilities for those experiments. Researchers define the needs for the facilities to support their research, hence providing the blueprint for the facility builders. Experimentation cannot happen without observation, monitoring. One vision of the Future Internet is that its each element is equipped with a monitoring device and hence the network measures itself, processes the data and reacts to changes - a self-optimising network!

Each FIRE project is a case of its own, with its key users being involved in the facility development, having established its own research challenge, proposed solution and validation methodology. For example, in order to perform a realistic performance evaluation of machine learning algorithms two factors are critical for success. First, realistic training data is needed to train the machine learning algorithms. Second, the best way to evaluate the performance of a particular machine learning algorithm is to compare it with other algorithms. This requires that different algorithms need to be deployed in identical but representative test setups. Moreover, each algorithm needs to be executed multiple times to produce repeatable (and thus statistically representative) results in the same experimental conditions.

Some principles can be extracted and generic needs for testbeds in networks and systems architecture domain identified. Recently carried out FIRE Portfolio analysis (FIREworks deliverable D2.6) identifies well needs for FIRE facilities and their federation.

This deliverable has collected those requirements and needs for testbeds from various sources: FIRE projects, several workshops held during FIREworks lifetime 04/2008 - 09/2010 and the above mentioned FIRE Portfolio analysis.

2 Experimenter needs

Experimenter wants to: 1) proof a theory, 2) investigate a phenomenon, or 3) compare own approach to others. Experiments need to be controllable, repeatable and comparable, in as close to real-life conditions as possible. This means that the observation tools should be accurate and standardized. The experimentation environment should also accommodate as wide and accurate observation scope as possible, as an unexpected side effect is often the real discovery. General experimenting challenges are uncontrollable parameters (weather, physical effects,…), resource limitations for data capturing and privacy issues for data sharing. Hence the experimenter has the following needs:

1. Provide possibility to control experiment and conditions
    - Provide ability to bring environment in a specific state
    - Provide wide range of changeable parameters
    - Provide ability to fix variables, which are not part of the investigation

2. Provide observation tools
    - Capture and store results and conditions
    - Provide standardized measurement tools
    - Ensure reliable observations
    - Provide accuracy statements

3. Provide reference data
    - Reference settings
    - Reference traffic
    - Assessment metrics

Furthermore, Future Internet research has some specific features. It consists of broad range of approaches: 1) evolutionary vs. revolutionary, 2) different layers (optical, network, services), 3) different key objectives (manageability, security, mobility, etc.), 4) different networks, 5) different basis technology, 6) different structures (dynamic/static, operator-driven/free). These all set further challenges to accommodate experiments on large-scale. Due to the lack of assessment metrics, there are no standardized ways to compare approaches, in particular for features such as autonomicity, decision quality, adaptability, etc. Ironically, the design of new network architectures should be amenable to modeling and measurement in ways that today's Internet is not.

Future Internet experiments are typically carried out in large-scale shared testbeds. Then specific challenges apply while multiple experimenters use the same infrastructure. The testbed should be able to prevent interference between experiments, distribute resources effectively and fairly and provide access control. In commercial environment some more specific challenges occur concerning security (e.g. prevent competitors from getting results first), sharing resources (anonymization, etc.), and accounting for testbed usage.

3 Needed from FIRE facilities

FIRE Portfolio analysis identified the following needs for FIRE facilities. An effective testbed should be used by both experts in the technology which it exposes and those who just want to integrate that technology with higher or lower levels in an application stack. It must be robust enough for reliable, reproducible tests by the first category of users as well as for durable prototypes needed to expose new functions to end users.

A diagram (Fig. 2) captures the set of issues which must be dealt with by a single testbed or (by recursion) by a federation of testbeds. This also provides a simple way of categorizing the issues that must be addressed to support real external users:

- "User facing clearinghouse " is the way a facility is discovered, how you can be authenticated as a user and how the access to the facility can be defined. This is not only a list of facilities it is also the ability to create an understanding in what way a facility may be used.
- "Terms & conditions" includes the cost to use a facility, the acceptable use policy, frequency and duration of use.
- "Security & Privacy" defines both the ability to protect the IPR of the experimenter and the facility provider. It also includes methods to protect privacy of a traffic data.
- "Operational & Research Monitoring" are the functions to start, stop and meter experiments and other operational aspects of experiment control.
- "Define, simulate and control experiments" is the process of creating and supporting the experimental development process.
- "User support to grow the market for test beds" is the process to make public what facilities are available and when, announce federated facilities and promote use of facilities for other user groups.
- "Deployment of resources" is the process of creating the virtual test bed for an experiment where both physical and software resources will be bound to an experiment.

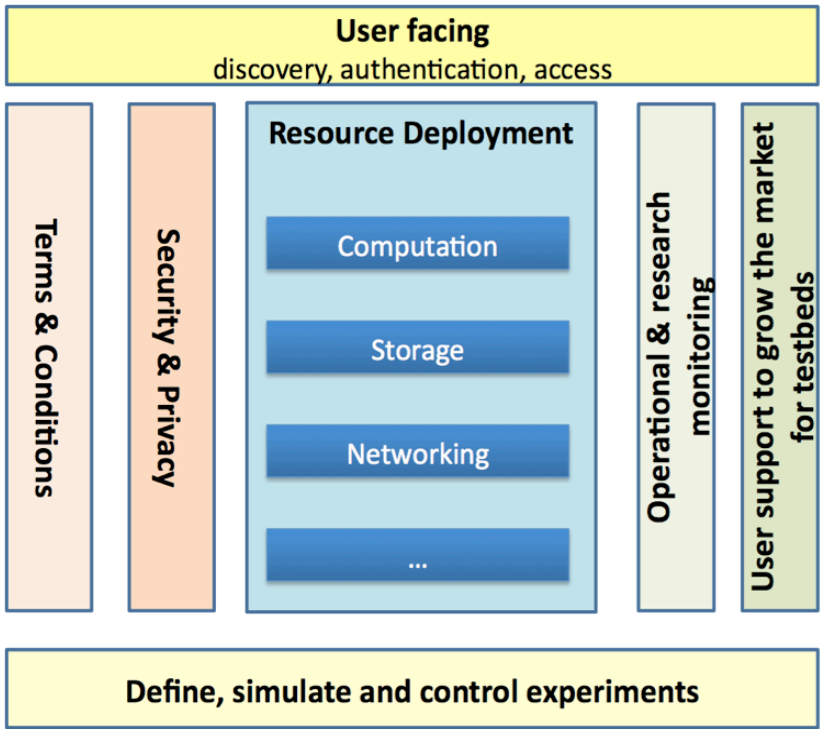

Figure 2 – FIRE experimenter requirements on facilities

Note that this does not mean that it is necessary that all test beds investigate all these features; they should however take advantage of the work, which is done in other test beds and/or in common so that all features are available in their test bed. These functions are required for a successful FIRE federated facility.

Furthermore, the following requirements for the FIRE Facility evolution were expressed.

- A common portal is a required tool to improve usage. It necessary to find intermediate stages when defining and implementing shared tools (due to heterogeneity of resources).

- Sharing/interconnecting data, not only resources, is crucial since it will enable sharing of data across experiments. Benchmarking and repeatability of experiments is key to experiments of high quality and scientific impact. This will put requirements on format, storage, and access to experimental input data and results. It also will require comparable methods for measurement. Data archiving will become increasingly important as user projects evolve. Standards and shared tools in this area should be organized once the shape of the experiments performed under the open calls is visible. Overall, such efforts should be coordinated by FIREstation, better being addressed by a dedicated effort with clear goals and milestones to measure progress.

- Sustainability of each FIRE experimental facility shall be studied in the context of a sustainable FIRE federated facility.

- A vision of end-to end support for the FIRE users need to be integrated into the requirements of Calls 7 and 8. Put the FIRE customer at the center of these efforts, with measurements of usage and value to the end-user (both developers and true end-users).

- Optical networking and equipment found at the edge (e g hand held terminals) are still underrepresented in the FIRE portfolio. Also the application efforts address computational resources but not storage (possibly “in the network”) of the large amounts of data consumed or generated.

- There has been progress in top-down federation in FIRE projects, while SFA (Slice-Federated-Architecture in FIRE + GENI) has shown potential for scalability in bottom-up federation. FIRE should address the integration of these two approaches.

- The selection on use of facilities when heterogeneous federation is required has to be a decision based on implementation cost and goals/interest of the involved individual facilities. As a result, the combinations (projects, use cases, and users) leading to the most exciting advances are and will be rare. These must be cultivated.

- Experiments in heterogeneous federation must be encouraged and probably become a strong requirement in future calls. As a consequence, there is a need to establish metrics for facility usage that establish strong barriers against unnecessary re-implementation of facilities and tools that already exist. These metrics need to be a major foundation for any experimental research project.

- It is necessary to clarify how the open calls are to be coordinated. FIRE Office and the IP projects must each have influence on which projects are chosen. The procedures for the open calls shold be formalized and explained to the IPs, to align the selection process with the overarching vision of a federated experimental facility.

- FIRE Office should take the lead in identifying appropriate levels of user support and ensuring that the best practices are shared across the FIRE portfolio.