

OneLab: Tools for Future Internet Research

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I. INTRODUCTION

Experimental research is an essential building block of scientific work. Experiments help to prove a theory, investigate particular effects, and to test new methods under real conditions before applying them in infrastructure and production environments.

Making observations is fundamental for experimental research. Like other scientific discipline, network research requires observation tools to capture experiment outcome and log experiment conditions. The need for flexible and standardized tools to support scientists and their experiments gets even more critical in large scale and federated environments with mixed technologies, shared resources and different authorities that need to cooperate. Besides the federation with other networks and heterogeneous technologies, Future Internet research requires also the integration of disruptive environments that do not follow classical Internet design principles. This causes additional challenges for providing observation tools in new environments.

II. THE PERFECT EXPERIMENT?

The spectrum of experimental research ranges from well controlled tests in closed lab environments to large scale experiments in real environments. Ideal experiments should fulfill a set of requirements. They should be:

- **Controllable:** It is desired to be able to fully control the parameters which are of interest for the investigation and to fix everything else (environment conditions, parameter settings)
- **Repeatable:** Experimental settings should be fixed and all variable experiment conditions should be documented in a way that other scientist can repeat the experiment to check results or as reference for own investigations.
- **Comparable:** It should be possible to compare results with others.

Especially for experiments in real environments these requirements are hard to achieve. Even with perfect documentation some conditions cannot be replicated in order to repeat experiments under exactly the same conditions. In a shared environment where resources are used by multiple experimenters simultaneously, experiments may interfere with each other. And some environmental conditions, physical effects, weather, etc. that may influence the experiment cannot be controlled at all.

But isn't this exactly what we want? Isn't the real thrill of experimental research coming exactly from those unpredictable changing conditions? Furthermore, shouldn't we keep the doors open for unexpected side effects that may provide the key to a real breakthrough?

With large scale heterogeneous experimental facilities federated and connected via the Internet we provide an environment that allows experiments to run under real network conditions. The key for successful experimental research in such environments is the provisioning of sophisticated tool to observe, supervise and document conditions and results.

Besides providing support for experimenters, supervision is also required for the operation of experimental facilities. It helps to control the compliance of experiments to the different policies of federated facilities and to prevent damage to other experiments or the experimental platform itself.

III. THE ROLE OF STANDARDS

It is crucial to agree on standard measurement methods and result data formats to be able to compare the outcome of different experiments and to share data with other scientists.

This is especially true in federated heterogeneous environments where different technologies have to be supported and the instrumentation may differ. Accuracy statements are needed to assess the potential errors if methods with different precision are used or data selection is needed to reduce and control resource consumption. Furthermore, standardized input and output formats simplify the development of tools (e.g., for data analysis) and allows the provisioning of reference data. Standards for anonymization or aggregation can help to preserve privacy and encourage data sharing.

IV. THE ONELAB APPROACH

OneLab has a strong focus on the provisioning of research tools for Future Internet research. Experimenters can get conditions and results based on sophisticated active and passive measurements. Approaches for benchmarking in only partially controllable environments are investigated. Recent standards for measurement methods, data export and storage are utilized and exploited. Project results and new requirements are brought back into the standardization process. Furthermore, OneLab integrates facilities for disruptive Future Internet research, like testbeds for delay-tolerant networks (DTN), pocket switched networks and autonomic networking into PlanetLab Europe and also provides research tools for such environments.