European Commission

mPlane main achievements and exploitation prospects

At A Glance: mPlane

an Intelligent Measurement Plane for Future Network and Application Management

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Main Objectives

The Internet is the principal pillar of the Information Society. Decentralized and diverse, the Internet is resilient and universal. However, its distributed nature leads to operational brittleness and difficulty in identifying and tracking the root causes of performance and availability issues. The first step to improve this situation is measurement: illuminating the currently obscure dynamics of the Internet. To address this, mPlane has the main objective of *building the Internet's measurement plane, alongside the Internet's data and control planes*.

mPlane: building the Internet's measurement plane

To achieve its main objective, mPlane consists of: i) a *Distributed Measurement Infrastructure* that performs active, passive and hybrid measurements, operates at a wide variety of scales and dynamically supports new functionality; ii) a *Repository and Analysis layer* that collects, stores, and analyses the collected data via parallel processing and data mining; and iii) an *Intelligent Reasoner* that iteratively drills down into the cause of an evidence, determining the conditions leading to given issues, and supporting the understanding of problem origins.

By enabling pervasive measurement throughout the Internet, *mPlane benefits everyone*: *ISPs* get a fine-grained picture of the network status, empowering effective management and operation. *Application providers* gain powerful tools for handling performance issues of their application. *Regulators and end-users* can verify adherence to SLAs, even when these involve many parties. *Customers of all kinds* can objectively compare network performance, improving competition in the market.

mPlane is significantly advancing the state of the art in Internet measurement, from innovative probe technology to intelligent algorithms for distributed data analysis. The development of the Reasoner is a key result that will allow structured, iterative, automated analysis. An emphasis on open, standard interfaces will speed adoption and increase the impact of the project.

Mplane Consortium is made up of 16 organizations chosen for their complementary skills and competences: 3 large Manufacturers, 3 large Telecom Operators, 2 Research Centres, 2 SMEs, 6 University Research Groups.

Challenges and Technical Approach

One of the main challenges of mPlane is the integration of new programmable probes with legacy probes all sharing a common standardized interface in order to realize a large-scale, distributed measurement layer. Besides this, the key challenge for the partners relies on understanding and engineering a complete solution, which is able to deal with big, heterogeneous, and multi-source monitoring data to actually provide operational value out of them.

We face three main difficulties associated to such system which also outline our main technical approach towards the "mPlane": (i) handle the overwhelming amount of data generated by pervasive measurements at the Internet scale; (ii) process/aggregate/pre-digest such data so as to allow a more detailed and complex analysis; and (iii) provide valuable insights and proper answers out of the aggregation of data coming from very different and heterogeneous vantage points, specially in the complex scenario represented by today's Internet.

The Figure 1 summarizes the mPlane architecture ad defined in [1]. An mPlane infrastructure consists of a set of components spanning over multiple domains, whose overall workflow is (i) *flexible*, supporting continuous background as well as on-demand and iterative measurement; (ii) *compatible*, through the integration of existing measurement tools and platforms; and (iii) *widely interoperable*, through the application of standards to the export formats and protocols as well as to the metrics supported by the platform themselves. In mPlane, *everything is a component*, and the architecture is largely defined by the protocol among the components.

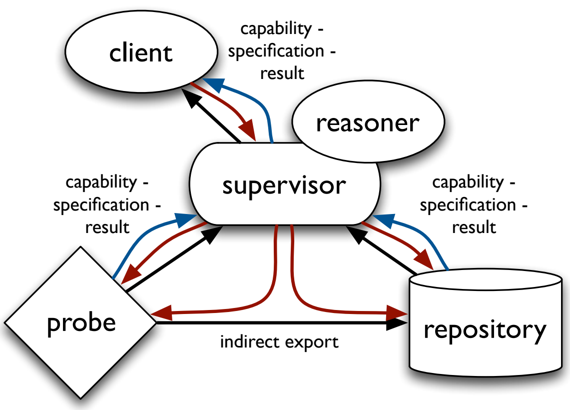

Figure 1: The mPlane Architecture

Components are the building blocks that perform passive, active and hybrid measurements, and that store and analyze the resulting data. Components can be roughly divided into **probes** and **repositories**. Probes perform raw measurements, and may pre-process them. Repositories store, correlate, and analyze the measurements provided by multiple probes. These components are coordinated by a **supervisor**, which handles the mechanics of distributed measurement (e.g., component discovery, capabilities management, access control, etc.) as well as final analysis, correlation, and compilation of results from multiple repositories and probes.

A key feature of most troubleshooting workflows is **iterative measurement**: the results of one measurement eliminate possible causes of an issue and point to others, triggering the next measurement to perform. Iterative measurement is especially useful for root cause analysis applications. However, not all measurement workflows are iterative, and iterative measurements often require comparison to background information generated by continuous or periodic measurements. The data and control flow within the architecture must therefore support both an inherently cyclic workflow in the "foreground", as well as the management of a large set of continuous/periodic measurement in the "background", whether autonomously performed by probes or directed by supervisors. **Flexible interfaces** facilitate the flow of control messages to trigger new measurements and get the data in return, supporting both synchronous and asynchronous operation modes.

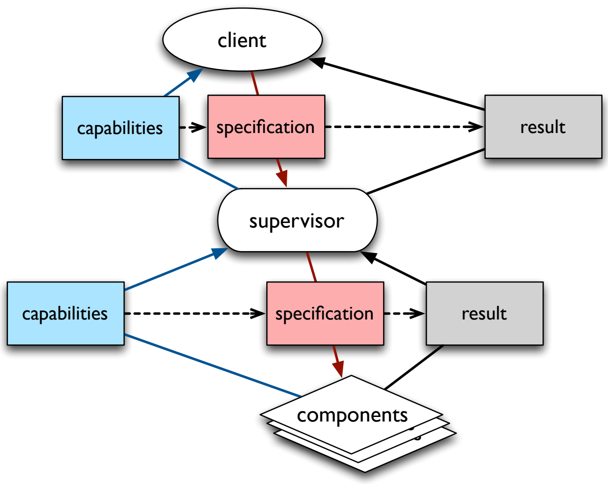

Figure 2: the mPlane workflow

As shown in Fig. 2, interaction in mPlane begins from a set of component capabilities. From the bottom (blue path), a supervisor collects the capabilities of the components it supervises, and presents capabilities to its clients (e.g., representing measurements it can perform or queries it can answer with its components). From the top (red path), a client selects some set of capabilities and sends a *specification* to the supervisor, i.e., a description of which measurement to perform, how, where, and when. The supervisor authenticates the client, checks its authorization to perform the measurements called for in the specification, and sends corresponding specifications to the appropriate components. Results (black path) can be returned instantaneously, in which case they are presented over the same channel, or retrieved later. Each result contains all the parameters of the specification used to generate it, so that it is self-contained. This simplifies management in large-scale deployments, while reducing the amount of state that each component has to store while waiting for one of its specification to return.

This iterative analysis, supported and automated by an **intelligent reasoner**, is sorely missing in present measurement systems, and is one key element of the mPlane. Its design will advance the state of art by providing intelligent algorithms for distributed data analysis.

Key results

The key results can be summarized as follows: (i) the definition of the mPlane Reference Architecture, which allows to instantiate a large-scale monitoring and analysis system in a standard way; (ii) two independent implementations of the Reference Architecture are now available. They allow anyone working in the field to develop mPlane-complaint modules that can be easily integrated thanks to the mPlane protocol and architecture; (iii) a set of software tools that support the mPlane Reference Architecture are available. They allow anyone to perform active and passive measurements at different granularities, layers of the network stack (L1 to L7 and the user itself), and vantage points; (iv) a set of large-scale storage and processing systems are also being released. They are based on both standard SQL and novel Big Data approaches, which are capable of managing big monitoring data for traffic analysis purposes, considering both off-line and on-line processing; and (v) a set of advanced analytic algorithms and a main orchestrator for the overall analysis of the mPlane measurements is under construction; they are capable of tackling very different types of real and highly relevant use cases.

In more detail, during the course of the project, partners have successfully pursued the implementation of high-speed (i.e., beyond 10Gbps) software for passive traffic monitoring and analysis, as well as high-speed Internet-scale active probing that cooperate using the mPlane protocols. These are not a minor contribution, as the improvement is sometimes of orders of magnitude with respect to the state of the art.

Scientific results gathered both in terms of novel methodologies (e.g., anycast geolocation, efficient algorithms for revealing middleboxes align a path, and lightweight algorithms to estimate, rate or rank end-to-end paths in large-scale distribution systems) or insights (e.g., on bufferbloat, on a bad interplay between low-priority congestion control and active queue management/scheduling disciplines) were published in top venues in the field (including ACM SIGCOMM IMC, ACM CoNext, IEEE Infocom, Passive and Active Measurement, etc.) and received distinctions (e.g., 4 best paper award). The list of all publications is available on the project website [2]

During the second year, mPlane partners collaborated to the organize a second Ph.D. course on "Traffic Monitoring and Analysis", held in London during April 2014 [3]. mPlane participants have also contributed to the success of a Dagsthul seminar [4] on building a "Global Measurement Framework".

All software produced by the consortium has been made available as public software, and can be accessed from the mPlane website at [5]. Documentation is also available, and more tools and examples are being made available.

Experimental activities are progressing, with the first complete demonstration of an mPlane complaint setup being already available. It shows how probes and repositories can cooperate and be controlled from the supervisor, allowing a simple iterative approach where further measurements can be triggered to drill down the analysis in case some anomalies are detected.

Exploitation prospects

In terms of long term impact, the key results of the project are: i) the definition of a standard-ready protocol specification for the integration of heterogeneous measurement tools and data sources into a coherent measurement plane, ii) the open-source release of a reference implementations of this protocol and iii) the release of high-quality, open-source software for both active and passive measurements.

In terms of the industrial exploitation of mPlane results, we can cite three concrete success stories where mPlane partners have already started to collaborate with their business units in order to transfer the foreground IPR generated in the first two years of the project: i) one partner is currently applying the developed techniques and the obtained results on the automatic detection and diagnosis of network anomalies in collaboration with a trans-national EU ISP and a main EU vendor; ii) another partner is applying the techniques and methods developed during the project to optimize video delivery service and to detect QoS in their network and iii) a third partner has already deployed a monitoring solutions for service assurance at customer premises and is currently discussing commercial arrangements.

References

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[4] https://www.ict-mplane.eu/public/news/dagsthul-seminar

[5] mPlane software: http://www.ict-mplane.eu/public/software