



mPlane

an Intelligent Measurement Plane for Future Network and Application Management

ICT FP7-318627

Dissemination, Exploitation And Standardization Final Report

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Abstract:

This deliverable describes the dissemination activities and standardization achievements of mPlane during the third year. The document provides detailed dissemination activities undertaken by the project, with the publication of a total of over 110 research papers to journals and various conferences and workshops since the start of the project. Furthermore, the document provides mPlane's standardization efforts, the establishment of links to various working groups and a tutorial to the international delegates. Finally, the document provides a detail report on the software open source release and covers the exploitation activities from all the partners.

Keywords: dissemination, publications, standardization, exploitation, open-source software

Disclaimer

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1 Introduction

This document describes the overall dissemination achievements of mPlane during the Final year of the project. The details of the dissemination during the first and second year are described in deliverable D7.2 and D7.3 respectively.

The mPlane project has put great effort into disseminating project results to the community, and has been successful at it. The broad active dissemination efforts have resulted in publications and demonstrations at scientific conferences, standardization bodies, workshops organized in collaboration with leading conferences, and talks given to numerous audiences. mPlane members have become chairs of two IETF working groups (IETF IP Performance Metrics and IETF RTP Media Congestion Avoidance Techniques), and contributed to drafting the mPlane Protocol Specification for the IETF Network Working Group. As well as contributing to numerous standardization activities, the mPlane consortium have published more the 40 papers in peer reviewed conferences and journals during years three and four.

To disseminate the results of the project wider, mPlane members have strived to collaborate with other EU projects and further. We have introduced the project, and presented results and tools to EU projects METRICS and LEONE, as well as giving invited talks at various institutes in Europe and beyond. mPlane has striven to organize events at relevant and high profile conferences. mPlane organized the industrial workshop in conjunction with TMA 2015 in April 2015, and the final project workshop which was attended by more than 30 people in conjunction with the CoNext conference in December 2015.

Finally, the mPlane consortium has continued to update and add the list the of software released by project. Furthermore, the consortium has focused on producing demos with the software libraries developed. These have been used to disseminate the project's both internally within the organizations of the project members, as well to wider audience.

Considering exploitation, partners have devised a detailed and concrete exploitation plans, which are presented at the of this document. Those range from new products being based on mPlane tools, to new collaborations among partners and other companies and institutions, from new courses being offered to students at Universities, to new projects continuing the development of mPlane software and solutions.

2 Dissemination and Standardization activities planned

Here, we briefly summarize the overall dissemination and standardization plan of the project:

- Project press release, factsheet and presentation;
- Project website;
- Research papers (aiming at disseminating research results);
- Talks and presentations focused on specific project objectives and tasks;
- Standardization contributions;
- Participation in concertation and Future Internet Assembly (FIA) activities;
- Open source release;
- Exploitation activities.

Table 2.1 shows the plans for dissemination and education activities, while Table 2.2 outlines the standardization activities planned within the mPlane project.

Objective	Approach	Outcome	Specific Actions	Key Performance Indicator
Awareness creation: involving the public	On-line dissemination with public information and news related to the topics.	Reaching a worldwide audience and communities of interest	Project website, including software repositories and collection of tools; brochures and posters.	Website up and running from month two until the end of the project; newsletter issued three times a year and at least three press releases.
R&D community dissemination	Publish the project results in suitable events	Reaching the R&D community involved in related areas of research	Participate in European and international conferences presenting project results and exchanging of know-how	At least ten top-tier conference publications, five journal publications; organization of one IEEE special issue on mPlane-related topics.
Scientific dissemination and Education	Lectures and continued dissemination of project results for under- and post-graduates as well for the scientific community.	Reaching the scientific community, researchers and both under- and post-graduate students	Organize seminars and PhD schools, also with hands-on experiences.	One post-graduate school lasting for one week; one series of Dagstuhl seminars; at least one undergraduate project work.
Industrial dissemination	Venues of different target groups to exchange experiences and advances with respect to the state of the art in the field related to mPlane	Reaching Industry, Regulatory Agencies, Policy makers and interest groups	Organize workshops and ah-hoc meetings.	At least one industrial workshop and one workshop with Regulatory Agencies and policy makers; at least two presentations at operator events.

Table 2.1: Plans for dissemination and Education activities within the mPlane project.

Standards Body	Specific Group Targeted	Details of Contribution
IETF	IPFIX (IP Flow Information Export) - OPS Area	Extensions to the IPFIX protocol to take into account application-layer parameters, and passive and active performance measurements.
	IPPM (IP Performance Metrics) - TSV Area	Extensions to the IPPM framework metrics, possibility to extend IPPM to passive measurements.
	NETCONF (Network Configuration) - OPS Area	Extensions of the NETCONF protocol to take into account measurement probe coordination.
IRTF	NMRG (Network Management Research Group)	Contribute mPlane control interfaces to configure probes. Possibility to generate enough interest to spin-off a working/research group (through a BOF)
	NCRG (Network Complexity Research Group)	Proposals based on mPlane technology that help operators to regain control over their complex networks.
ETSI	Technical Committee Speech Processing, Transmission and Quality Aspects (TC STQ)	Extensions of "User related QoS parameters definitions and measurements" (ETSI EG 202 507-4) to capacity greater than e.g., 20Mbps.
ITU-T	Study Group 12 on Performance and Quality of Service (QoS)	Contribute mPlane metrics definitions and mapping of metrics to user-perceived quality.

Table 2.2: Plans for standardization activities within the mPlane project.

3 Dissemination activities

mPlane has striven to disseminate the activity and results of the consortium to a wide audience. Here, we briefly summarize the overall dissemination and standardization plan of the project:

3.1 Project press release and newsletters

To create a wider awareness of the project, we have update the project pages regularly (see www.ict-mplane.eu), and published press releases suitable for the wider audience. Below are a list of the significant press releases during year 3 and 4.

1. “Perché la Rete non funziona?”, Il Sole 24 Ore. 12/2014: SSB published a project press release on, one of the most important Italian business newspapers. Details can be found here. (http://www.system24.ilsole24ore.com/static/minisiti/2014/bside/081214_NO_programmi_progetti/Pagine/4.pdf).
2. “NEC develops new high speed solution for Internet performance monitoring”, press release, 01/2015. NEC published a press release for its advancements in high speed network monitoring.

Aside from the about official project releases, various mPlane works have attracted considerable community and press attention.

1. “Characterizing IPv4 Anycast Adoption and Deployment”, ACM CoNEXT, Heidelberg, DE, ACM, 12/2015. This work has won the IRTF award for Applied Networking Research Prize 2016 (ANRP 2016), see <https://irtf.org/anrp>.
2. “Enabling Internet-Wide Deployment of Explicit Congestion Notification”, Proceedings of the 2015 Passive and Active Measurement Conference, New York, Mar, 2015. This was cited by Apple at WWDC 2015 when it announced that ECN will be turned on by default for client applications, see (<https://developer.apple.com/videos/play/wwdc2015-719/>).
3. “The Cost of the “S” HTTPS”, ACM Conference on emerging Networking EXperimen and Technologies (CoNEXT), 12/2014. This work has been appeared in the popular Slashdot tech. site and widely commented on with in the community, see (<http://yro.slashdot.org/story/14/12/04/1513255/the-cost-of-the-s-in-https#comments> and <http://www.zdnet.com/article/reseachers-quantify-the-s-in-https/>).
4. “Cloud Storage Service Benchmarking Methodologies and Experimentations”, 3rd IEEE International Conference on Cloud Networking (IEEE CloudNet 2014), Luxembourg IEEE, 10/2014. This work has been appeared in the popular Slashdot tech. site and widely commented on with in the community, see (<http://hardware.slashdot.org/story/13/11/23/0056250/cloud-storage-comparison-benchmarking-from-afar>).

3.2 Research papers

The project partners have been very active in publishing a large number of scientific papers in international conferences and journals to inform the research community about the results achieved in the project.

The list below summarizes the research papers published during the third year in different conferences and workshops. Notably, some of the papers also received distinctions and awards for the presented work (highlights in bold font). Joint collaboration among partners of the project has generated a total of eight published papers.

The full list, together with the papers, is also made publicly available through the project website at <https://www.ict-mplane.eu/publications>.

3.3 Journal paper publications

The list below summarizes the research papers published during the third year in different journals:

1. Casas P. et. al. Unveiling Network and Service Performance Degradation in the Wild with mPlane. IEEE Communications Magazine - Network Testing Series, March 2016.
2. Bocchi E. et. al. Personal Cloud Storage Benchmarks and Comparison. Cloud Computing, IEEE Transactions on, vol. PP, pp. 1-1, 2016.
3. Rufini A. et. al. Multilevel Bandwidth Measurements and Capacity Exploitation in Gigabit Passive Optical Networks. Communications, IET, Dec-14 2014. IEEE New York, NY Volume:8, Issue: 18, pp 3357 - 3365 10.1049/iet-com.2014.0165.
4. Bermudez I. et. al. A Distributed Architecture for the Monitoring of Clouds and CDNs: Applications to Amazon AWS. Network and Service Management, IEEE Transactions on, Dec-14 2014. IEEE New York, NY Volume:11, Issue: 4, pp 516 - 529 10.1109/TNSM.2014.2362357.
5. Casas P. et. al. When YouTube Does not Work - Analysis of QoE-Relevant Degradation in Google CDN Traffic. Network and Service Management, IEEE Transactions on, Dec-14 2014. IEEE New York, NY Volume:11, Issue: 4, pp 441-457 10.1109/TNSM.2014.2377691.

3.4 Conference paper publications

The list below summarizes the research papers published during the third year in different conferences:

1. Vanaubel Y. et. al. A Brief History of MPLS Usage in IPv6. Passive and Active Measurement Conference (PAM), Mar-16 2016. Springer Heraklion, Greece.
2. Cicalese D. et. al. Characterizing IPv4 Anycast Adoption and Deployment. CoNEXT 2015 The 11th International Conference on emerging Networking EXperiments and Technologies, Dec-15 2015. ACM Heidelberg, Germany TBD.

3. Wassermann S. et. al. Towards DisNETPerf: a Distributed Internet Paths Performance Analyzer. The 11th International Conference on emerging Networking EXperiments and Technologies - CoNEXT 2015, Dec-15 2015. ACM Heidelberg, Germany TBD.
4. Faath M. et. al. A GLIMPSE of the Internet's Fabric. 9th EAI International Conference on Performance Evaluation Methodologies and Tools (ValueTools), Dec-15 2015. EAI/ACM Berlin, Germany TBD.
5. Liao Y. et. al. A Lightweight Network Proximity Service Based On Neighborhood Models. 22nd IEEE Symposium on Communications and Vehicular Technology in the Benelux (SCVT), Nov-15 2015. IEEE Luxembourg 1 - 6 10.1109/SCVT.2015.7374218.
6. Casas P. et. al. Taming QoE in Cellular Networks: from Subjective Lab Studies to Measurements in the Field. Network and Service Management (CNSM), 2015 11th International Conference on, Nov-15 2015. IEEE Barcelona, Spain 237 - 245 10.1109/CNSM.2015.7367364.
7. Faath M. et. al. Measurements with the Masses. Proceedings of the first IRTF/ISOC Workshop on Research and Applications of Internet Measurements (RAIM), Oct-15 2015. ACM Yokohama, Japan TBD.
8. Trammell B. et. al. Observing Internet Path Transparency to Support Protocol Engineering. Proceedings of the first IRTF/ISOC Workshop on Research and Applications of Internet Measurements (RAIM), Oct-15 2015. ACM Yokohama, Japan TBD.
9. Casas P. et. al. Taming QoE in Cellular Networks: from Subjective Lab Studies to Measurements in the Field. Proceedings of the first IRTF/ISOC Workshop on Research and Applications of Internet Measurements (RAIM), Oct-15 2015. ACM Yokohama, Japan TBD.
10. Faath M. et. al. A Cautious Look at Using Internet Standards-to-be in Research Work. 2015 IEEE Conference on Standards for Communications and Networking (CSCN15), Oct-15 2015. IEEE Tokyo, Japan TBD.
11. Vanaubel Y. et. al. MPLS Under the Microscope: Revealing Actual Transit Path Diversity. the 2015 ACM Conference on Internet Measurement Conference (IMC), Oct-15 2015. ACM Tokyo, Japan 49-62 10.1145/2815675.2815687.
12. Trammell B. et. al. A New Transport Encapsulation for Middlebox Cooperation. Proceedings of the 2015 IEEE Conference on Standards for Communications and Networking, Oct-15 2015. IEEE Tokyo, Japan TBD.
13. Bocchi E. et. al. Personal Cloud Storage: Usage, Performance and Impact of Terminals. 4th IEEE International Conference on Cloud Networking (IEEE CloudNet 2015), Oct-15 2015. IEEE Niagara Falls, Canada 106 - 111 10.1109/CloudNet.2015.7335291.
14. Papadimitriou D. et. al. Robust cooperative monitoring problem. Reliable Networks Design and Modeling (RNDM), 2015 7th International Workshop on, Oct-15 2015. IEEE Munich, Germany 186 - 193 10.1109/RNDM.2015.7325228.
15. Kutzkov K. et. al. Weighted Similarity Estimation in Data Streams. CIKM '15 Proceedings of the 24th ACM International on Conference on Information and Knowledge Management, Oct-15 2015. ACM Melbourne, Australia 1051-1060 10.1145/2806416.2806515.

16. Naylor D. et. al. multi-context TLS (mcTLS): Enabling Secure In-Network Functionality in TLS. SIGCOMM '15, the 2015 ACM Conference on Special Interest Group on Data Communication, Oct-15 2015. ACM London, UK 199-212 10.1145/2785956.2787482.
17. Seufert M. et. al. On the Monitoring of YouTube QoE in Cellular Networks from End-devices. S3 '15 Proceedings of the 2015 Workshop on Wireless of the Students, by the Students, & for the Students, Sep-15 2015. ACM Paris, France 23-23 10.1145/2801694.2802142.
18. Wamser F. et. al. Understanding YouTube QoE in Cellular Networks with YoMoApp - a QoE Monitoring Tool for YouTube Mobile. MobiCom '15 Proceedings of the 21st Annual International Conference on Mobile Computing and Networking, Sep-15 2015. ACM Paris, France 263-265 10.1145/2789168.2795176.
19. Fiadino P. et. al. RCATool - A Framework for Detecting and Diagnosing Anomalies in Cellular Networks. Teletraffic Congress (ITC 27), 2015 27th International, Sep-15 2015. IEEE Ghent, Belgium 194 - 202 10.1109/ITC.2015.30.
20. Hours H. et. al. A Study of the Impact of DNS Resolvers on Performance Using a Causal Approach. Teletraffic Congress (ITC 27), 2015 27th International, Sep-15 2015. IEEE Ghent, Belgium 10 - 18 10.1109/ITC.2015.9.
21. Fiadino P. et. al. Challenging Entropy-based Anomaly Detection and Diagnosis in Cellular Networks. SIGCOMM '15, the 2015 ACM Conference on Special Interest Group on Data Communication, Aug-15 2015. ACM London, UK 87-88 10.1145/2785956.2790011.
22. Casas P. et. al. Exploring QoE in Cellular Networks: How Much Bandwidth do you Need for Popular Smartphone Apps?. 5th ACM SIGCOMM Workshop on All Things Cellular: Operations, Applications and Challenges, Aug-15 2015. ACM London, UK 13-18 10.1145/2785971.2785978.
23. Casas P. et. al. On the Analysis of QoE in Cellular Networks: from Subjective Tests to Large-scale Traffic Measurements. 6th International Workshop on Traffic Analysis and Characterization (TRAC), Aug-15 2015. IEEE Dubrovnik, Croatia 37 - 42 10.1109/IWCMC.2015.7289054.
24. Fiadino P. et. al. Towards Automatic Detection and Diagnosis of Internet Service Anomalies via DNS Traffic Analysis. 6th International Workshop on Traffic Analysis and Characterization (TRAC), Aug-15 2015. IEEE Dubrovnik, Croatia 373 - 378 10.1109/IWCMC.2015.7289112.
25. Callegari C. et. al. Troubleshooting Web Sessions with CUSUM. 6th International Workshop on Traffic Analysis and Characterization (TRAC), Aug-15 2015. IEEE Dubrovnik, Croatia 385 - 390 10.1109/IWCMC.2015.7289114.
26. Seufert M. et. al. YouTube QoE on Mobile Devices: Subjective Analysis of Classical vs. Adaptive Video Streaming. 6th International Workshop on Traffic Analysis and Characterization (TRAC), Aug-15 2015. IEEE Dubrovnik, Croatia 43 - 48 10.1109/IWCMC.2015.7289055.
27. Bocchi E. et. al. Impact of Carrier-Grade NAT on Web Browsing. 6th International Workshop on Traffic Analysis and Characterization (TRAC), Aug-15 2015. IEEE Dobrovnik, Croatia 532 - 537 10.1109/IWCMC.2015.7289140.
28. Casas P. et. al. QoMOSN - On the Analysis of Traffic and Quality of Experience in Mobile Online Social Networks. Networks and Communications (EuCNC), 2015 European Conference on, Jul-15 2015. IEEE Paris, France 471 - 475 10.1109/EuCNC.2015.7194120.

29. Wamser F. et. al. YoMoApp: a Tool for Analyzing QoE of YouTube HTTP Adaptive Streaming in Mobile Networks. Networks and Communications (EuCNC), 2015 European Conference on, Jul-15 2015. IEEE Paris, France 239 - 243 10.1109/EuCNC.2015.7194076.
30. Papadimitriou D. et. al. Lagrangian relaxation for the time-dependent combined network design and routing problem. Communications (ICC), 2015 IEEE International Conference on, Jun-15 2015. IEEE London, UK 6030 - 6036 10.1109/ICC.2015.7249283.
31. Bär A. et. al. MTRAC - Discovering M2M Devices in Cellular Networks from Coarse-grained Measurements. IEEE International Conference on Communications (ICC), Jun-15 2015. IEEE London, UK 667 - 672 10.1109/ICC.2015.7248398.
32. Papadimitriou D. et. al. Distributed monitoring problem. 7th International Network Optimization Conference, INOC, May-15 2015. Warsaw, Poland TBD.
33. Fiadino P. et. al. Online Social Networks anatomy: On the analysis of Facebook and WhatsApp in cellular networks. IFIP Networking Conference (IFIP Networking), 2015, May-15 2015. IFIP Toulouse, France TBD 10.1109/IFIPNetworking.2015.7145326.
34. Bär A. et. al. Cache Oblivious Scheduling of Shared Workloads. 31st IEEE International Conference on Data Engineering (ICDE), May-15 2015. IEEE Seoul, Korea 855 - 866 10.1109/ICDE.2015.7113339.
35. Cicalese D. et. al. Anycast census and geolocation. 7th Workshop on Active Internet Measurements (AIMS 2015), Apr-15 2015. San Diego, CA.
36. Cicalese D. et. al. A Fistful of Pings: Accurate and Lightweight Anycast Enumeration and Geolocation. Computer Communications (INFOCOM), 2015 IEEE Conference on, Apr-15 2015. IEEE Hong Kong, China 2776 - 2784 10.1109/INFOCOM.2015.7218670.
37. Cicalese D. et. al. A Lightweight Anycast Enumeration and Geolocation. Computer Communications Workshops (INFOCOM WKSHPS), 2015 IEEE Conference on, Apr-15 2015. IEEE Hong Kong, China 1 - 2 10.1109/INFOCOMW.2015.7179313.
38. Edeline K. et. al. Towards a Middlebox Policy Taxonomy: Path Impairments. Computer Communications Workshops (INFOCOM WKSHPS), 2015 IEEE Conference on, Apr-15 2015. IEEE Hong Kong, China 402 - 407 10.1109/INFOCOMW.2015.7179418.
39. Thirion V. et. al. Tracking Middleboxes in the Mobile World with TraceboxAndroid. 7th International Workshop on Traffic Monitoring and Analysis (TMA), Apr-15 2015. Springer Barcelona, Spain 79-91 10.1007/978-3-319-17172-2_6.
40. Fiadino P. et. al. Vivisecting WhatsApp in Cellular Networks: Servers, Flows, and Quality of Experience. 7th International Workshop on Traffic Monitoring and Analysis (TMA), Apr-15 2015. Springer Barcelona, Spain 49-63 10.1007/978-3-319-17172-2_4.
41. Espinet F. et. al. Zen and the art of network troubleshooting: a hands on experimental study. 7th International Workshop on Traffic Monitoring and Analysis (TMA), Apr-15 2015. Springer Barcelona, Spain 31-45 10.1007/978-3-319-17172-2_3.
42. Bocchi E. et. al. Personal Cloud Storage Benchmarks and Comparison. Cloud Computing, IEEE Transactions on, Apr-15 2015. IEEE 99 10.1109/TCC.2015.2427191.

43. Trammell B. et. al. Enabling Internet-Wide Deployment of Explicit Congestion Notification. Passive and Active Measurement Conference (PAM), Mar-15 2015. Springer New York, NY 193-205 10.1007/978-3-319-15509-8_15.
44. Leontiadis I. et. al. From Cells to Streets: Estimating Mobile Paths with Cellular-Side Data. CoNEXT '14 Proceedings of the 10th ACM International on Conference on emerging Networking Experiments and Technologies, Dec-14 2014. ACM Sydney, Australia 121-132 10.1145/2674005.2674982.
45. Naylor D. et. al. The Cost of the 'S' in HTTPS. CoNEXT '14 Proceedings of the 10th ACM International on Conference on emerging Networking Experiments and Technologies, Dec-14 2014. ACM Sydney, Australia 133-140 10.1145/2674005.2674991.
46. Schiavone M. et. al. Diagnosing Device-Specific Anomalies in Cellular Networks. CoNEXT Student Workshop '14 Proceedings of the 2014 CoNEXT on Student Workshop, Dec-14 2014. ACM Sydney, Australia 18-20 10.1145/2680821.2680831.
47. Bär A. et. al. Large-Scale Network Traffic Monitoring with DBStream, a System for Rolling Big Data Analysis. International Conference on Big Data, IEEE BigData, Nov-14 2014. IEEE Washington D.C., USA 165 - 170 10.1109/BigData.2014.7004227.
48. Casas P. et. al. On the Analysis of QoE-based Performance Degradation in YouTube Traffic. Network and Service Management (CNSM), 2014 10th International Conference on, Nov-14 2014. IEEE Rio de Janeiro, Brazil 1 - 9 10.1109/CNSM.2014.7014135.
49. Casas P. et. al. YouTube in the Move: Understanding the Performance of YouTube in Cellular Networks. Wireless Days (WD), 2014 IFIP (Best Paper Runner Up Award), Nov-14 2014. IEEE Rio de Janeiro, Brazil 1 - 6 10.1109/WD.2014.7020798.
50. Tego E. et. al. Quality of Service Management based on Software Defined Networking Approach in wide GbE Networks. Euro Med Telco Conference (EMTC), 2014, Nov-14 2014. IEEE Naples, Italy 1 - 5 10.1109/EMTC.2014.6996660.

3.5 Talks, project presentations, seminars

This section summarizes the talks, presentations and seminars that were held during the third year of the project by all the partners. All presentations slides are also available at <http://www.ict-mplane.eu/public/talks>. Beyond the reported talks, each partner made sure to introduce and mention the scope of the project at every occasion they introduced the institution (commercially or academic circles) and the activities.

1. Marco Mellia. Troubleshooting with active and passive speed test. The ITU Regional Initiative for Europe, Bologna, November 2015.
2. Dario Rossi. Where are the anycasters? RIPE 71, Plenary, Bucharest, November 2015.
3. Dario Rossi. Where Are the Anycasters, reloaded? RIPE 71, MAT WG, Bucharest, November 2015.
4. Dario Rossi. Impact of Carrier Grade NAT on Web Browsing. RIPE 71, MAT WG, Bucharest, November 2015.

5. Brian Trammell. Internet Path Transparency Research and the mPlane Platform. RIPE 71, MAT WG, Bucharest, November 2015.
6. B. Donnet. Invited talk at RIPE 71, Bucharest, November 2015. MPLS Under the Microscope: Revealing Actual Transit Path Diversity, 2015.
7. Brian Trammell. Platforms and Tools for Internet Measurement: Current and Future Developments. Keynote address at RAIM, Yokohama, November 2015.
8. B. Donnet. MPLS Under the Microscope: Revealing Actual Transit Path Diversity. Invited talk at RAIM, Yokohama, November 2015.
9. R. Winter. Measurements with the Masses. Invited talk at RAIM, Yokohama, November 2015.
10. Marco Mellia. Traffic, Performance and Big Data. Panel presenter at ITC'15, Gent, September 2015.
11. Marco Mellia. Crowdsourcing for measurements. Panel presenter at the ACM SIGCOMM Workshop on Crowdsourcing and crowdsharing of Big (Internet) Data (C2B(I)D), London, August 2015.
12. Brian Trammell. ECN Beyond the Web: Measurements from the BitTorrent DHT. Internet Congestion Control Research Group, IETF 93, Prague, July 2015.
13. Stefano Traverso. WeBrowse: a Passive Content Curation System. Invited talk at the Innovation Workshop at Telecom Italia Labs, July 2015.
14. Korian Edeline. Tracking Middleboxes with Tracebox. Talk at the IETF93 (HOPS), July 2015
15. Dario Rossi. The mPlane distributed measurement infrastructure: overview, insights & hindsight. Invited talk at the Journée du Conseil Scientifique de l'Afnic (JCSA2015), 2015.
16. Francesco Matera. All Optical Access Platforms for Fiber to the Home Networks. FIAT LUX Conference, Rome. June 2015.
17. Marco Mellia. The Web: Source of Big Data with a Measurement Perspective. Invited talk at the 7th Annual IMDEA Networks Workshop: Big Data and Cloud Computing. Madrid, 2015
18. Brian Trammell. mPlane: An Intelligent Measurement Plane for the Internet. Invited talk at Open Systems AG, Zurich, June 2015.
19. Benoit Donnet. Dig into MPLS: Transit Tunnel Diversity. Invited talk at the AIMS Workshop, San Diego (USA), April 2015.
20. Marco Mellia. Network Neutrality and Measurements. Invited talk at the SMART workshop, Barcellona, April 22nd.
21. Francesco Matera. MPLANE for network monitoring and management. AGCOM forum, April 22nd.
22. Brian Trammell. Enabling Internet-Wide Deployment of Explicit Congestion Notification. Internet Congestion Control Research Group, IETF 92, Dallas, USA, March 2015.
23. Marco Mellia. The Cost of the S in HTTPS and a Malware Picture in the Internet. Invited talk at the Metrics industrial Workshop, Heidelberg, February 2015

24. G. P. Mattellini, A. Sannino. Network measurements and analytics for service management frameworks. Invited talk at the Metrics industrial Workshop, Heidelberg, February 2015
25. B. Donnet. MPLS Under the Microscope: Revealing Actual Transit Path Diversity. Invited talk at University Roma 3, January 2015.
26. Korian Edeline. On a Middlebox Classification. IAB Workshop on Stack Evolution in a Middle-box Internet (SEMI), Zurich, January 2015.
27. Marco Mellia. Is There a Case for Mobile Phone Content Pre-staging? Invited talk at LINC seminar, Paris, December 2014.
28. Marco Mellia. Cost of the S in HTTPS. Invited talk at the Orange Lab seminar, Paris, December 2014.
29. Marco Mellia. Cost of the S in HTTPS. Invited talk at the ARE SystemX, Paris, December 2015.
30. Alessandro D'Alconzo. Overview and Results of the mPlane Project. Invited talk at the IFIP TC6 2014/2 Strategic Review Meeting in Dagstuhl, November 2014.

3.6 mPlane organized workshops and summer schools

Finally, mPlane has organized the following workshops, and special issue journals, to disseminate the results of the project to wider audience. Details and feedback received are provided in D6.3.

1. "mPlane Final workshop" 12/2015, in conjunction with the CoNEXT conference, see <https://www.ict-mplane.eu/public/mplane-workshop-platform-measuring-internet>.
2. "mPlane Industrial Workshop", 4/2015, in conjunction with the TMA conference, see <https://www.ict-mplane.eu/public/mplane-industrial-workshop>.
3. "Elsevier Communication Networks Special issue on Machine learning, data mining and Big Data frameworks for network monitoring and troubleshooting", 10/2015, see <http://www.journals.elsevier.com/computer-networks/call-for-papers/>.
4. "IEEE JSAC Special issue on Measuring and Troubleshooting the Internet", 11/2015, see <http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6985755>

4 Standardization activities

This Section describes the standardization achievements of the mPlane project during the third year. The standardization strategy taken is outlined and the concrete activities in the IETF, IRTF and ITU are described.

4.1 IETF activities in Year 3

4.1.1 IETF working groups

IETF IPPM Working Group – Brian Trammell from ETH co-chairs the IP Performance Metrics (IPPM) working group; as an IPPM chair, he is overseeing metric development for large-scale network measurements. Current work in IPPM to define a set of core metrics for basic network performance metrics will complete after the project. These core metrics are intended for use with the LMAP working group.

IETF IE-DOCTORS group of experts – Brian Trammell from ETH is a member of the IE-DOCTORS group of experts responsible for the maintenance of the IPFIX Information Element Registry, on which work on the mPlane Element Registry is based.

IETF LMAP Working Group – The Large-Scale Measurement of Broadband Performance (LMAP) working group consensus has diverged significantly in the past couple of years from the more flexible architecture envisioned by mPlane, making close interoperability between LMAP and mPlane entities less practical than originally hoped. However, discussions at the LMAP meeting at IETF 93 in Prague have led to further work on standardizing the mPlane protocol itself, separate from LMAP.

4.1.2 IETF meetings

Partners participated in the following IETF meetings during the period:

IETF 91 Honolulu, USA – Rolf Winter (FHA) participated in the LMAP working group.

IETF 92 Dallas, USA – Brian Trammell (ETH) chaired the IPPM Working Group. Brian Trammell proposed and Mirja Kuehlewind (ETH) co-chaired the Substrate Protocol for User Datagrams (SPUD) Birds of a Feather session, discussing mechanisms for transport stack evolution that, among other things, could be used to build measurement protocols inline into traffic flows. Work is ongoing in the scope of the IP Stack Evolution Program, led by Brian Trammell. He also attended sessions of interest to mPlane, especially with respect to passive measurements of transport performance and path transparency: TAPS, TCPM, and RMCAT, and the HOPS side meeting. Rolf Winter (FHA) participated in the LMAP working group.

IETF 93 Prague, Czech Republic – Brian Trammell (ETH) chaired the IPPM Working Group. Brian Trammell and Mirja Kuehlewind (ETH) co-chaired the HOPS proposed RG meeting (see below); Korian Edeline (ULG) presented Tracebox at this meeting. Brian Trammell also attended sessions of interest to mPlane, especially with respect to passive measurements of

transport performance and path transparency: TAPS, TCPM, and RMCAT. Rolf Winter (FHA) participated in the LMAP working group and the HOPS proposed RG meeting.

IETF 94 Yokohama, Japan – Brian Trammell (ETH) delivered a keynote address at the co-located Research and Applications of Internet Measurement (RAIM) workshop, focusing on the present and future of network measurement platforms; Pedro Casas (FTW) and Rolf Winter (FHA) also delivered a lightning talk at this workshop. Brian Trammell also delivered an address at the IETF combined plenary meeting on measurement as a first-class service of the protocol stack, mentioning efforts to standardize mPlane. Brian Trammell and Mirja Kuehlewind (ETH) co-chaired the HOPS proposed RG meeting. Brian Trammell chaired the IPPM Working Group. He also attended sessions of interest to mPlane, especially with respect to passive measurements of transport performance and path transparency: TAPS, TCPM, and RMCAT. Rolf Winter (FHA) participated in the LMAP working group. Michael Faath (FHA) conducted a measurement experiment on the IETF meeting network. The results of this work are currently under submission and have led to publishing an Internet draft (see below).

4.1.3 Drafts in progress

The following contributions are currently in progress.

1. “Services provided by IETF transport protocols and congestion control mechanisms” (draft-ietf-taps-transport-08)
co-edited by ETH, was largely completed during the third year of the project. This document surveys the set of IETF transport protocols as part of an effort to define common services, which could then be provided through an interface independent of the underlying protocol mechanisms. mPlane interest in this work is primarily with respect toward the promotion and definition of measurement as a first-class, explicit service provided by the stack, future work within the TAPS working group.
2. “The mPlane Protocol Specification” (draft-trammell-mplane-protocol-00)
edited by ETH, based on D1.4 with minor enhancements made to the protocol during SDK and use case development, is an initial effort to standardize the core mPlane protocol. This document was discussed in the LMAP working group meeting at IETF 93 in Prague, and ongoing discussions with a mobile operator and equipment vendor have shown some interest beyond the consortium in standardization of the protocol. ETH will carry this effort forward beyond the project, targeting either single RFC publication or the formation of a working group to standardize flexible measurement control and reporting protocols based on mPlane.
3. “A Mechanism for ECN Path Probing and Fallback” (draft-kuehlewind-tcpm-ecn-fallback-01)
Following ongoing studies of ECN path transparency in the Internet using the mPlane-enabled PathSpider tool, and the decision by Apple to deploy client-side default ECN in developer betas of Mac OS X and iOS, based in part on these studies, this (expired) draft is in the process of being revised and resurrected to provide guidance of an ECN probing and fall-back mechanism in case ECN has been successfully negotiated between two connection endpoints, but might not be usable on the path.
4. “Considerations for IP broadcast and multicast protocol designers” (draft-winfaa-broadcast-consider-01)

A number of application-layer protocols make use of IP broadcasts or multicast messages for functions such as local service discovery or name resolution. Some of these functions can only be implemented efficiently using such mechanisms. When using broadcasts or multicast messages, a passive observer in the same broadcast domain can trivially record these messages and analyze their content. Therefore, broadcast/multicast protocol designers need to take special care when designing their protocols.

4.2 IRTF activities in Year 3

ETH led a research group (RG) creation effort in the IRTF, the How Ossified is the Protocol Stack (HOPS) proposed RG, for coordination of measurements of Internet path transparency. This proposed research group met at IETF 93 in Prague and IETF 94 in Yokohama. Discussions at these two meetings have led to the revision of this RG's proposed charter to more widely cover the intersection of Internet measurement and Internet protocol engineering. The result, the Measurement and Analysis for Protocols (MAD) proposed RG, will continue to meet until chartered as an RG; Mirja Kuehlewind from ETH co-chairs the MAD proposed RG.

ETH presented ongoing work in ECN path transparency research at the Internet Congestion Control Research Group (ICCRG) meetings at IETF 92 in Dallas and IETF 93 in Prague.

4.3 ITU-T activities in Year 3

On 25-26 november FUB organized in Pontecchio Marconi (BO), the Regional Workshop for Europe "New Issues in Quality of Service Measuring and Monitoring" together with the Telecommunication Development Bureau (BDT) of ITU-T, the Italian Ministero dello Sviluppo Economico and in cooperation with the Italian Autorità per le Garanzie nelle Comunicazioni (AGCOM).

The meeting is in the framework of the European politics about broadband and in agreement with the tasks of the World Telecommunication Development Conference (WTDC-14) of ITU.

In such a workshop several representatives of ITU and EU illustrated some initiatives about the adoption of the QoS methods and measurements, while enterprises and research institutes showed some prospective of technical and normative guidelines on the base of future next generation network implementations. MPLANE had a relevant role in such a workshop with the talk "Understanding QoS measurements: experience from the mPlane European Project" presented by M. Mellia. Details can be found in <http://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Events/2015/11%20QoS/151123%20QoS%20Meeting%20-%20Bologna%20draft%20agenda.pdf>

5 Record of Participation in concertation and future Internet assembly activities

The project is aware of a number of concertation activities that the EC regularly organizes to coordinate the research results across projects. The mPlane project participated in the following concertation and future Internet assembly activities:

- The European Conference on Networks and Communications (EuCNC 2015). Details can be found at the following link <http://www.ict-mplane.eu/public/eucnc-2015-exhibition>. Video of the some of the mPlane tools exhibited can be found at the following link <https://www.youtube.com/channel/UCHGS6U1UKvGZTyt5DemmPaw>.
- Participation to the Stakeholders Consultation Workshop - Network Technologies Work Programme 2016-2017
- Contribution to the writing of the Future Internet Cluster position paper on Work Programme 2016-2017
- Participation at the ITU Regional Initiative for Europe, Bologna, November 2015, on the troubleshooting with active and passive measurement and definition of SLA verification policies in the next generation networks.

6 Open source release

mPlane has been developing quite a number of tools for the analysis and measurement of the Internet infrastructure. The project has released most of those tools as open source to the community and partners are actively involved in the development of them. Note the material below is available in an easy to navigate page at <http://www.ict-mplane.eu/public/software>, and detailed descriptions are available in D2.3, D3.4, D4.4, D5.4 and D6.2.

mPlane architecture, reference implementation and SDK

- RI - Reference Implementation / Software Development Kit (SDK): <https://www.ict-mplane.eu/node/314>
- Initial Core Registry: <https://www.ict-mplane.eu/node/389/>
- mPlane node.js implementation: <https://github.com/finvernizzi/mplane>

Probes Final release of the following tools has been included in D2.3. Note that the versions on the webpages listed below are always to be considered the most up to date.

Passive probes

- Blockmon node, a modular system for flexible, high-performance traffic: <https://www.ict-mplane.eu/public/blockmon-node>
- DATI, a flexible, high performance passive monitoring platform: <https://www.ict-mplane.eu/node/340>
- MobileProbe, a tool for monitoring smartphone performance for Android devices: <https://www.ict-mplane.eu/node/328>
- Tstat, a passive monitoring tool: <https://www.ict-mplane.eu/node/316>

Active probes

- Anycast, a tool to detect, enumerate and geolocate anycast probes: <https://www.ict-mplane.eu/public/anycast>
- ECN-Spider, a tool to test ECN readiness and connectivity failure linked to ECN negotiation attempts: <https://www.ict-mplane.eu/node/448>
- Fastping, a fast ICMP scanner for TopHat: <https://www.ict-mplane.eu/node/323>
- GLIMPSE, an end host-based network measurement tool: <https://www.ict-mplane.eu/node/324>
- mSLAcert, a tool for measurement of multi layer throughput and other active data for Service layer level agreement certification: <http://www.ict-mplane.eu/node/331>
- OTT probe, an active video content download performance evaluation tool: <https://www.ict-mplane.eu/public/ott-probe>

- Scamper, a sophisticated active probing tool: <https://www.ict-mplane.eu/public/scamper>
- Tracebox, a tool for topology discovery: <https://www.ict-mplane.eu/node/321>

Hybrid probes

- Firelog, a hybrid probe for diagnosing Web browsing QoE: <https://www.ict-mplane.eu/node/327>

Repository tools Final release of the following tools has been included in D3.4. Note that the versions on the webpages listed below are always to be considered the most upto date.

Query Engines

- Blockmon Controller, the controller for the distributed stream-processing platform Blockmon: <https://www.ict-mplane.eu/public/blockmon-controller>
- DBStream, a flexible and easy to use Data Stream Warehouse: <https://www.ict-mplane.eu/node/444>
- EZRepo, an mPlane-compliant repository with measurement data preprocessing for root cause analysis: <https://www.ict-mplane.eu/public/EZRepo>
- MATH, Mplane Authorized Transfer via HTTP, a tool to export bulk data in the form of logs from a mPlane probe (e.g., Tstat) and to import it into DBStream: <https://www.ict-mplane.eu/public/mplane-authorized-transfer-http-math>
- mPlane interfaces for Tstat, a set of mPlane protocol-based tools to import logs and RRDs generated by Tstat: <https://www.ict-mplane.eu/public/repository-mplane-interfaces-tstat>
- MongoDB, a proxy interface to use MongoDB as repository: <http://www.ict-mplane.eu/public/mongo-db>
- repoSim, a ns2 based simulator to fine-tune the mPlane repository performance: <https://www.ict-mplane.eu/node/356>

Schedulers

- Hadoop Fair Sojourn Protocol, a scheduler for Apache Hadoop: <https://www.ict-mplane.eu/node/318>
- Schedule, a tool for cache-oblivious scheduling of shared workloads: <https://www.ict-mplane.eu/public/schedule>

Repository tools Final release of the following tools has been included in D4.4. Note that the versions on the webpages listed below are always to be considered the most upto date.

Reasoners

- nodejs Reasoner (link is external): basic mplane reasoner, written in nodejs: <https://github.com/finvernizzi/reasoner>

- Reasoner for Content Popularity Estimation: <https://www.ict-mplane.eu/public/reasoner-content-popularity-estimation>
- Reasoner for Content Curation: <https://www.ict-mplane.eu/public/reasoner-content-curation-use-case>
- Reasoner for Web browsing QoE: <https://www.ict-mplane.eu/public/webqoe-reasoner>
- Mobile Network RCA Reasoner: <https://www.ict-mplane.eu/public/mobile-network-rca-reasoner>
- mpAD_Reasoner: Reasoner for Anomaly Detection and RCA: <https://www.ict-mplane.eu/public/mpadreasoner-anomaly-detection-and-diagnosis>
- Reasoner for SLA Verification and Troubleshooting: <https://www.ict-mplane.eu/public/sla-verification-and-troubleshooting>
- RC1: Reasoner for Multimedia Content Delivery Analysis: <https://www.ict-mplane.eu/public/rc1-reasoner>
- GLIMPSE Traceroute Reasoner: <https://www.ict-mplane.eu/public/glimpse-traceroute-reasoner>

Analysis modules

- WeBrowse Content Curation Modules are the set of analysis modules that process http logs and infer interesting web pages to promote. A limited version (due to IPR): <https://www.ict-mplane.eu/public/webbrowse-modules>
- Mobile Network RCA modules: <https://www.ict-mplane.eu/public/tid-reasoner>
- Spark Jobs for Web QoE Analysis: <https://www.ict-mplane.eu/public/spark-jobs-processing-raw-data>
- ADTool: on-line anomaly detection module, running on top of DBStream: <https://www.ict-mplane.eu/public/adtool>
- Entropy: anomaly detection module, running on top of DBStream: <https://www.ict-mplane.eu/public/entropy-based-anomaly-detection-module>
- DisNETPerf: locating the nearest measurement probe to a remote (and not controlled) server: <https://www.ict-mplane.eu/public/distnetperf>
- LPR: MPLS tunnels classification: <https://www.ict-mplane.eu/public/lpr>
- Middlebox Taxonomy: classifying middleboxes according to their path impairment: <https://www.ict-mplane.eu/public/middlebox-taxonomy>
- IGP Weight Simulator: inferring IGP weigh of an ISP based on collected traces: <https://www.ict-mplane.eu/public/igp-weight-inference>
- iGreedy: analysis module capable of anycast detection, enumeration and geolocation based on distributed latency measurements: <https://www.ict-mplane.eu/public/igreedy-anycast-enumeration-and-geolocation-module>
- SEARUM: Hadoop MapReduce implementation of Association Rule Mining technique: <https://www.ict-mplane.eu/public/searum>

Integrated Prototype virtual appliance As a result of integration activities, a virtual appliance containing working active and passive probes ready to interoperate with mPlane elements has been released. Detailed information can be find at <https://www.ict-mplane.eu/public/mplane-probes-virtual-appliance>.

7 Exploitation activities

mPlane explores new areas for monitoring applications by research and prototyping. However, the outcome of mPlane is also intended to be used by each partner to advance in their particular area. This section is describing the usage of results stemming from the mPlane project.

7.1 Usage of Results

7.1.1 POLITO

First of all, POLITO is actively using the mPlane platform as a tool for the following teaching activities: Network Measurements Laboratory, Networking Laboratory, BigData Laboratory and Master.

Mostly related to the academic context, thanks to mPlane and its probes, POLITO is attracting a number of potential industrial partnerships. In particular, Talaia Solutions (<http://talaiasolutions.com>), Ennova (<http://www.ennova.it>), Vodafone Italia (<http://www.vodafone.it/>) and Cisco Systems (www.cisco.com) have already expressed their interest in employing mPlane for their activities, and POLITO is working with them to exploit mPlane results and tools in their product-line. Proof of concepts are being studied at the time of writing.

In addition to above specific tasks, POLITO intends to leverage the knowledge and the tools produced within the mPlane project in wide set of activities:

- POLITO has already started the integration of its Tstat probes in the mPlane ecosystem. The Tstat probe installed at the egress network link of Politecnico di Torino network is already fully mPlane-compliant and all probes installed within FW's network will be integrated soon.
- POLITO has contributed to the adoption of mPlane as the standard protocol for measurement collection in the testbed of the European Project MONROE (<https://www.monroe-project.eu>). In fact, all the 300 probes deployed within MONROE's testbed are mPlane-compliant.
- POLITO will cooperate with CAIDA (<http://www.caida.org/home/>) to provide BGPStream an proxy to make it compatible with the mPlane ecosystem.
- POLITO is also concentrating its efforts on integrating the Hadoop/Spark cluster made available by the BigData@Polito project (<http://bigdata.polito.it>) as an mPlane repository.

POLITO plans to improve WeBrowse (<http://webbrowse.polito.it>), the service born from the collaboration with ALBLF under the mPlane umbrella, and deployed in the campus network of Politecnico di Torino. Moreover, POLITO intends to offer WeBrowse as a value-added service for the users of Politecnico di Torino, and to deploy WeBrowse in other networks.

POLITO commits to keep working on Tstat tool, continuing its development as open source tool, and to collaborate with the research community and with industrial partners to develop new methodologies to be integrated in Tstat.

At last, POLITO is currently working on a spin-off that, based on mPlane experience and unsupervised reasoning algorithms, will offer privacy preserving solution for end-users. The spin-off will use data extracted from mPlane-Tstat passive probe to generate data which will be processed in

the mPlane-hadoop based repository to automatically discover leakage of private information and violation of end-user privacy.

This is in line with the original exploitation plan as described in Section 3.2.4 of the DoW.

7.1.2 FUB

Relating to its role as independent institution supporting the Italian Regulatory Authority (AGCOM) to monitor the quality of wired and wireless Internet accesses through the country, FUB periodically reported its mPlane outcomes to the Italian ISP community, with particular details for the mPlane architecture and about the role of mSLAcert for SLA verification and certification.

Just in December 2015 some e-mails were circulated among AGCOM, FUB and ISP about the possibility to implement a new measurement architecture (www.misurainternet.it) based on mPlane protocol. Such a topic is going to be investigated along 2016.

Furthermore, just starting from the experimental investigations carried out in WP2 and WP5 regarding the use a new procedure to estimate the channel capacity based either on UDP or TCP multi-session, FUB has introduced a new agent for high bandwidth x delay product accesses, based on TCP multi-session approach (for more details please refer to F. Matera, et al "Multilevel Bandwidth Measurements and Capacity Exploitation in Gigabit Passive Optical Networks" IET Communications, 2014). Such a new agent is now under field test.

In November 2015 FUB made a presentation to HP and ORACLE giving an overview on mPlane activities and pointing out the importance of mPlane for Software Defined Network and Network Function Virtualization. mPlane has been also presented at GARR, the Italian network for research and education, and future meeting should be taken about the adoption of the mPlane network monitoring procedures in the High Speed GARR network.

Currently FUB is adopting the mPlane architecture for network investigation in its test bed, with particular interest for the cooperation between the mSLAcert active probes and TSTAT. Furthermore FUB intends to leverage the knowledge and experience acquired within mPlane for future projects and activities concerning the introduction of the mPlane architecture for 5G, Software Defined Networks and Network Function Virtualization approaches

7.1.3 SSB

SSB will leverage the knowledge and experience acquired within mPlane in future projects concerning high performance big data management and large scale distributed applications security.

From an industrial point of view SSB is exploiting the mPlane philosophy and know how in these projects:

- FID is a financial data delivery platform developed within the project MC3 for Intesa Sanpaolo, one of the most influential Italian banks. It is a distributed platform adopted by financial trading institutions to manage and deliver real time big data streaming coming from financial markets. SSB is exploiting the mPlane distributed architecture to provide QoS monitoring features within the new platform that will be released before the end of this year.
- Furthermore, SSB took part in a new ERDF funded call for proposal issued by Piedmont Region called "Smart Factory Technological Platform", that supports the industrial research and

the technology innovation that will be used in the factories of the future. SSB, together with other venues, is working on the DISLOCA proposal (Dynamic Integrated Shopfloor LOGistics for Advanced Manufacturing Industry 4.0), that has as primary objective the realization of an IoT platform for the autonomous management of the factory logistics, aimed to the optimization of the resources. In this proposal, SSB is exploiting the know-how acquired in mPlane to create a Reference Implementation of a cloud-based software platform that will be used to acquire, aggregate and homogenize data, and for the dynamic storage of the data flows.

From a research point of view, SSB will continue the collaboration with some mPlane partners, especially with POLITO, for the development and improvement of open source probes such as tStat to be integrated into the mPlane infrastructure.

7.1.4 TI

Telecom Italia is validating a solution for controlling via an mPlane Supervisor the DATI probes currently installed in its production network. These probes are currently managed individually, while the use of mPlane could represent a single control point for configuring and managing all probe instances. This would simplify the possibility to increase the number of probes in the network without overwhelming operations staff. If the solution will work for DATI probes, it could be extended to manage also different probes already installed.

TI is also verifying the use of a centralized repository (currently the DB is integrated within the DATI probe) and to use the mPlane protocol to include it in the overall mPlane-based measurement architecture.

A parallel activity is evaluating the possibility to leverage the reasoner algorithms developed in the project in order to exploit the data collected by DATI probes to assist operations staff during troubleshooting events, specifically targeting a few internal use cases that would benefit from an automated approach. This is in line with the original exploitation plan as described in Section 3.2.4 of the DoW.

7.1.5 ALBLF

The content curation use case that ALBLF proposed in mPlane, and on which it collaborated with Polito, has led to the birth of a concrete new content curation system, called WeBrowse, currently deployed in the Polito network (webrowse.polito.it). During the mPlane project, ALBLF built intellectual property around this novel approach for information discovery, as well as some aspects of the system, and intends to valorize it. One of the patents has been already granted.

Finally, ALBLF believes that WeBrowse offers a new perspective for sharing information between people in the same community of a place such as coworkers in corporate networks and students in campuses. In such environments, people often share common interests but fail to engage in actively sharing content. WeBrowse solves this problem since it does not require user engagement. More concretely, the next step is future deployments of WeBrowse in such realistic environments. Indeed, WeBrowse will be officially launched early June in the French research institute INRIA. Advanced discussions are currently being carried out to test WeBrowse in our corporate network.

7.1.6 EURECOM

The work carried during the development of the Firelog probe and the OpenStack repository will serve as the basis for future students projects at Eurocom, to further investigate possible enhancements of the complete platform and to provide data for algorithm and machine learning courses, in order to refine, expand and enhance the diagnosis algorithm.

Furthermore, Eurocom has set up a collaboration with Orange to study the impact of virtualization on performance. To do so, we have exploited both the repository and the hfsp scheduler deployed in mPlane.

7.1.7 ENST

The exploitation plan of ENST comprises two main directions: research and education. In particular, as far as the research is concerned:

- ENST research work started during the mPlane projects now continues under the sponsorship of a Google Faculty Research Award received by Dario Rossi.
- ENST is collaborating with CAIDA to complement BGPStream control-plane information with the active data-plane measurement with the Fastping and iGreedy softwares developed through the mPlane project.
- ENST is collaborating with Cisco on telemetry to reduce the timescale of available measurements, as part of a newly created Chair (<http://newnet.telecom-parisitech.fr>).
- ENST is maintaining the map of anycast IPv4 census (<http://www.telecom-parisitech.fr/~drossi/index.php?n=Dataset.Ancast>) running monthly censuses from PlanetLab and RIPE, and is collaborating with RIPE to integrate it into OpenIPMap (<https://marmot.ripe.net/openipmap/>).

In addition, knowledge generated by mPlane is already disseminated in courses of the MSc engineering curricula at ENST (for instance, in the RES203 Internet application course), both in terms of classical courses, as well as in the form of student projects (for instance, in the INF570 course).

7.1.8 NEC

NEC actively utilizes mPlane technologies across several areas. Commercially several components developed with mPlane have been adopted by NEC subsidiary NetCracker (<http://www.netcracker.com/>) and, inline with the product specifications, deployed within NEC's Traffic Management System (TMS, <http://www.nec.com/en/global/solutions/nsp/tms/>). NEC makes use of the BlockMon probe's high-speed packet capture and filtering capabilities. The captured traffic supports numerous functions within the appliance, including applications monitoring and troubleshooting. Furthermore, we make use of various application-relevant functionalists from the reasoner, such as the content popularity prediction and content caching, so as to improve the performance of the appliance, and support the scalable handling of load.

At the prototype level, NEC has extended the capabilities of the reasoner by developing new algorithms which build on the high-throughput data collection capabilities of mPlane probes. We have focused on scalability and built new methods to support new applications such as stream based recommender systems, and anomaly detection ¹. Furthermore, we are exploring the trial of the technologies developed (such as stream based anomaly detection methods for trouble shooting networks) with operators.

In the research context, mPlane technology has been utilized by NEC within other EU projects such as the European Project TYPES (<http://www.types-project.eu>) in order to prototype privacy enhancing technologies.

In summary mPlane technologies is being applied to commercial, prototype and research output within NEC. This is in line with the original exploitation plan as described in Section 3.2.4 of the DoW.

7.1.9 TID

TID is currently using the mobile probe architecture to provide analytics to the business intelligence units about the Quality of Experience. Web logs and TCP logs are used from production networks. Moreover, there are efforts to bring the machine learning component to production in one contrary related to detecting video QoE and predicting satisfaction. Finally, network KPIs (measurements) are now considered to predict Video QoE, using mPlane know-how. Finally, we plan to further explore the machine learning components to build models that can further help us to detect the performance of applications even in encrypted traffic based on generic TCP and hardware statistics and multiple vantage points.

7.1.10 FTW

As FTW's operations are ending by the end of the mPlane project (31.12.15), the foreseen post-project exploitation plans would not be realized within the framework of FTW. However, we have indeed exploited the intermediate results of the mPlane project in the last years, particularly in the following FTW-related activities:

- FTW has applied the know-how and technology developed within the first 2 years of the project into several of its industry-related projects. In particular, we have been using the anomaly detection and diagnosis modules developed within mPlane for the COMET Darwin 4 project, and the QoE-related analysis modules and conceived KPIs in the COMET ACE 3 project. COMET projects correspond to research projects performed with industry partners (in this case Telekom Austria Group, NSN, Vodafone), within the framework of the FFG COMET program.
- Being DBStream a partially funded by mPlane technology and a major outcome of the project, FTW has applied this mPlane repository in the execution of many of its industry related projects, where big network monitoring data has to be analyzed on the fly and stored for historical analysis.

¹c.f Konstantin Kutzkov, Mohamed Ahmed, Sofia Nikitaki Weighted similarity estimation in data streams 24th ACM International Conference on Information and Knowledge Management (CIKM), 2015.

In addition to above specific tasks, and mostly related to the research context, some of the researchers involved in the mPlane project (in particular Dr. Pedro Casas and Dr. Alessandro D'Alconzo) are using the mPlane technology in further research collaborations (including institutions such as TU Wien, Politecnico di Torino, CAIDA, Northwestern University, NII Tokyo, etc.) within recently funded research projects: the EU project MONROE, and the FFG Austrian project BigDAMA.

7.1.11 FHA

The GLIMPSE measurement platform will be developed and used by FHA even after the mPlane project. To maintain the source code, track issues and allow students to write measurements, find bugs and further improve GLIMPSE the probe's source code is available on GitHub with an open source license. FHA is continuously working on experiments and publications based on the data and experience gained with this platform, partially with the help of semester projects with students of the university.

Multiple probes are deployed on end-user devices to perform active network measurements. FHA works on the release of GLIMPSE in the Google Play Store to make it available to a wider audience. This includes a rework of the user interface as well as the public representation of the project including advertisement material.

Additionally, FHA has applied for the First MONROE Open Call for Experiments and Extensions to make GLIMPSE part of the MONROE testbed. This would bring another tool using mPlane besides TSTAT into the MONROE project and ensure that the developed mPlane architecture and protocol is still actively used and if necessary improved.

The three students (one PhD student and two Bachelor of Science) primarily responsible for the development of GLIMPSE are working on a startup which is partially based on GLIMPSE. They have applied for the EXIST Business Start-up Grant to receive funding for the development of a business plan.

7.1.12 ULg

As a University, ULg will leverage the knowledge and experience acquired within mPlane in advanced networking courses. In particular, researches done on measuring MPLS networks and on middleboxes discovery are included in a "Network and Monitoring Measurements" course given to Master Students (this corresponds to roughly half of the course).

In addition, researches started within the mPlane project will be continued. First, ULg is still extensively working on middleboxes detection (through improvement to tracebox) and middleboxes modeling. Discovering and understanding MPLS networks is also a key topic. Measurement techniques developed during the mPlane project are currently used to build partnership with industrial, such as CISCO. Also, learning techniques developed during the mPlane project are used now for reverse path inference in the context of network troubleshooting. This work is done in collaboration with AIT researchers (previously at FTW) and Potilo.

Furthermore, ULg is involved in a new research project about middleboxes and new transport protocol. The project (MAMI) has started in January 2016 and leverages middleboxes researches initiated within mPlane. The mPlane measurement framework is also used to collect data. Finally, ULg has been recently involved in the writing of a Belgian research proposal about middleboxes. This

research proposal is done in collaboration with other Belgian universities and local industries.

7.1.13 ETH

ETH's exploitation plan for mPlane is twofold: using the platform for teaching at the masters' level, and leveraging and extending the platform and software development kit for future research projects. As for teaching, two thesis projects involving integration of tools into mPlane for path transparency measurement have already been completed, and further such projects are pending.

The primary exploitation of the products of mPlane will take place within the scope of the Horizon 2020 Measurement and Architecture for a Middleboxed Internet project (MAMI; grant agreement number 688421), which runs from January 2016 through June 2018. ETH is the coordinator of MAMI, and leads the measurement work package, which has as its task quantifying and localizing *path impairments* within the Internet, caused primarily by middleboxes, that reduce the deployability of new transport protocols and transport protocol features.

First, the mPlane Software Development Kit will be built out to improve scalability and integrability of probes. Second, these improvements will be leveraged to extend the ECNSpider/PathSpider tool set, development of which started within mPlane, into a more generic tool for large-scale, on-demand as well as continuous measurement of path impairments on diverse Internet paths from diverse vantage points. Third, an mPlane capability interface will be added for certain queries to the MAMI Path Transparency Observatory, a centralized, public repository of information about path impairments, allowing path impairment information collected therein to be used by other mPlane tools online. ETH is a key partner in MAMI for all these activities. Fourth, given the applicability of mPlane to MAMI's measurement goals and MAMI's desire to build its measurements on open standards, ETH will lead efforts within the MAMI project to standardize the mPlane protocol.

In addition, certain measurements for the analysis of packet data for differential treatment of traffic based on protocol and other flow characteristics within the observatory use the QoF flow meter, developed by ETH within mPlane.

7.1.14 NETVISOR

In the past few months, NETvisor has developed an OTT monitoring solution which is based on several mPlane components: it incorporates a module that was originally developed as the OTT probe in the mPlane reference implementation, and also a data acquisition and evaluation mechanism, the principle of which is based on mPlane's. Some major changes/improvements have been incorporated to make the communication protocol more efficient, both from the resource and also from the computational point of view.

NETvisor has defined a concrete road map to exploit these Mplane results by extending its existing operational support solutions with Mplane-derived technologies. These include the following technologies which are already available as products and are in operation at several customers.

- IP Explorer, an IP network discovery and visualization tool. We intend to reuse MPlane developed Anycast detection and fastping capabilities to improve network discovery features.
- PerformanceVisor, a performance monitoring system, which has been extended with the capability to act as an indirect export target for probes compliant with the mPlane protocol.

- iTVSense, NETvisor's above mentioned product for digital video service assurance. As described it already incorporates the OTT monitoring probe algorithms which were developed in the Mplane project. This way, our coverage for IPTV and DVB is extended with capabilities to monitor advanced, over-the-top media delivery methods as well.

The products listed above already have deployments at various telecommunication operators and other network service providers, regulators, and other companies involved in digital video transmission in Europe and across the world. With the upcoming updates for these customers, the additional Mplane-related features are automatically deployed. We are also confident that the extra functionality will make our sales efforts at further operators even more successful. The first customer to use thee in a live service environment is Magyar Telekom, which use this as a the primary monitoring system for their live OTT service of 60 channels.

NETvisor's OSS products mentioned above improve service quality in terms of provisioning speed, availability, problem detection and repair time, and thus indirectly contribute to better and faster communication services for citizens and other customers.

7.1.15 A-LBELL

The use of machine learning, data mining, and reasoning techniques is progressively becoming one of the major pillars of evolution of the networking domain towards cognitive infrastructures. In this context, A-LBELL work has been dedicated to the reasoner and will exploit the results produced in order to progressively build a cognitive - optimization plane that will capable to operate the functionality provided by the network infrastructure/elements; this represents an unprecedented paradigm shift compared to the protocol-oriented control and management of network devices/engines. More precisely, the development of i) multi-instance regression algorithm to process noisy monitoring data that finds regression regularizers without cross validation (analyzer) ii) decision procedure for optimally placing and configuring passive monitoring probes (at various locations in the network, e.g., edge or aggregation points) according to some goals determined offline, and iii) data-driven methods for automatically building uncertainty sets using novel non-linear least squares curve fitting algorithm when solving robust formulation of mixed-integer optimization problems do find direct applicability.

Finally, the Flemish Smart City initiative aims at developing an urban connectivity layer as critical component linking infrastructure and services to innovative ICT applications. In this context, results/tools of the mPlane project find applicability in the resource, performance but also service monitoring of urban IoT networks exploiting heterogeneous low power technologies (802.11ah, 802.15.4, etc.).

7.1.16 FASTWEB

The mPlane protocol demonstrated to be very flexible and useful to control and instantiate measures form heterogeneous devices. FASTWEB plans to evaluate if the protocol could be engineered to be exploited as coordinator for all the active measurements in the network, considering also aspects such as scalability, high availability and internal rules compliance.

Furthermore, since the consortium has been very active in contributing to the development of several (open source) components, FASTWEB plans also to use some of those.

Especially for the passive measurements, Tstat demonstrated to be more than a prototype and it has been installed in FASTWEB production network. FASTWEB plans to continue to utilize this probe and possibly extend the passive monitoring also to other portion of the network, integrating the solution with FASTWEB Operating Support Systems (OSS).

FASTWEB positions the customer at the core of its business, therefore is always in search of improving the tools that enlighten the customer behavior and experience. FASTWEB finds the output of the mPlane project helpful to understand the customer behavior (Passive content curation and Estimating content and service popularity for network optimization use cases) and take actions accordingly. Passive content curation use case, which is implemented in FASTWEB network, provides insights of the visited websites by the customers and FASTWEB considers this output as an important input for its marketing purposes.

The proportion of video traffic of Internet is increasing day by day and is being forecast to be around 70% ² within five years of time. This increasing interest on video forces FASTWEB and the other operators to focus on the availability and quality of the video services. Active measurements for multimedia content delivery use case is installed in FASTWEB; the output of the use case (Video quality, service availability) is quite useful to understand the customer experience. FASTWEB plans to continue experiment more of this use case, its algorithms and mPlane protocol.

FASTWEB intends to continue the collaboration with the consortium partners also beyond the mPlane project. For instance, FASTWEB is collaborating with POLITO for the deployment of mPlane complaint Tstat probes within the network.

²<http://www.cisco.com/c/en/us/solutions/service-provider/visual-networking-index-vni/index.html>