MONITORING AND TROUBLESHOOTING MULTI-DOMAIN NETWORKS USING MEASUREMENT FEDERATIONS


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In both the scientific and corporate worlds, users, resources, and data are often physically distributed, making networks increasingly important for all operations. Enormous progress has been made in increasing the capacity and accessibility of networking infrastructures, which in turn has fostered wider adoption of cloud and grid environments. Unfortunately, these advances have not directly translated into improved performance for all applications and users; instead, network performance problems become even more subtle and detrimental as the capacity of the network increases, and troubleshooting them on multi-domain network paths is highly challenging. These problems may be as benign as congestion from other network users, or as serious as packet loss caused by one or more intermediate domain infrastructure(s) and architectural flaws.

Troubleshooting performance problems on multi-domain networks requires a great deal of effort and expertise, as well as measurement policy agreements that mutually benefit domains within measurement federations. Novel approaches are needed to foster wider adoption of explicit measurement federations involving cooperating agents in collaborating vendor organizations as well as user communities. These approaches may also be suitable for implicit measurement federations seen in content delivery networks involving service providers that cooperate to reduce operating costs, while providing satisfactory end-user experience. Building on current measurement federation related standards development efforts can benefit the interoperability and sustainability of measurement federations.

In addition, sophisticated tools are required to monitor multi-domain networks, and to detect, localize, and diagnose performance problems in real time. As networks increase in capacity, and new paradigms such as software defined networking emerge to aid in traffic management, performance monitoring tools must be scalable and capable of detecting performance issues in a timely manner. The monitoring and diagnostic tools must comply with measurement federation policies and aid network operators in troubleshooting perceived abnormalities, as well as help network middleware and intelligent applications to work around problems, ultimately minimizing the impact on end users.

This Feature Topic aspires to cover novel techniques and standardization efforts in the area of monitoring and troubleshooting of multi-domain networks using measurement federations. Fortunately, the response to the call for papers was very positive, and we received 18 submissions. Many of the received submissions were quite strong in terms of fit for the Feature Topic and substantive content. After a rigorous review process by a team of reviewers, we selected eight articles for publication. Due to Feature Topic article number limitations, we have decided to partition the selected articles. Four articles that are complete in all terms of review criteria appear in this issue, and the remaining four papers that need revised effort for completion will appear in the May 2014 issue.

The first article, "Pythia: Detection, Localization, and Diagnosis of Performance Problems" by Kanuparthy *et al.*, describes the Pythia system developed by the authors to perform root cause analysis and localization of performance problems in wide area networks. The problems targeted include common link failures and route changes, as well as router misconfiguration, intermittent congestion, and underprovisioned buffers. Pythia by design can be deployed within perfSONAR deployments, and allows network operators to define performance problem signatures to help with more effective analysis and localization. Results from a Pythia deployment within perfSONAR monitors for over 250 inter-domain paths are presented in the article to show detection, localization, and diagnosis effectiveness.

The second article, "Secure Federated Monitoring of Heterogeneous Networks" by Brennan *et al.*, focuses on issues related to explicit management of relations within heterogeneous monitoring federations with the help of a federated IPTV monitoring use case. Trusted communication paths between federation members and semantic capability models are used to secure the explicit management in a decentralized manner. An interesting "semantic uplift" approach within a data annotation service is proposed in the article to help non-expert users gain more context when analyzing measurement data in multi-domain monitoring federations.

The third article, "On the Composition of Performance Metrics in Multi-Domain Networks" by Dourado *et al.*, argues that the availability of numerous forms of performance measurement data along an end-to-end path is just the first of many steps needed to arrive at the ultimate goal of automated network awareness. Techniques are required to combine disparate metric types, to better understand the underlying behavior of traffic patterns and possible flaws. The authors describe their software, which follows Internet Engineering Task Force (IETF) recommendations on metric composition, and demonstrate that their methodology is capable of correlating data delivered via perfSONAR frameworks on national research and academic network footprints.

In the last article, "Collaborative Network Outage Troubleshooting with Secure Multiparty Computation" by Djatmiko *et al.*, a diagnostic approach to network problems is presented using NetFlow measurements from different networks. Obviously, the main issue in any such effort would be the privacy concerns that are always associated with NetFlow data. The authors propose a surprising yet effective solution based on Multi-Party Computation (MPC). This cryptographic tool allows ISPs to aggregate private data without revealing any sensitive information. The article demonstrates the potential of this approach using a case study that is interesting in itself, where their MPC scheme is used to analyze the impact of Hurricane Sandy on Internet connectivity in terms of scope and severity.

BIOGRAPHIES

PRASAD CALYAM (calyamp@missouri.edu) is an assistant professor in the Department of Computer Science at the University of Missouri-Columbia. He received his Ph.D. degree from the Department of Electrical and Computer Engineering at The Ohio State University in 2007. His research and development areas of interest include distributed and cloud computing, computer networking, networked-multimedia applications, and cyber security.

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LOKI JÖRGENSON (ljorgenson@ACM.org) is chief technology officer for Lionsgate Technologies, a mobile technology startup in Vancouver, British Columbia, Canada. Over the last 20 years, he has established a successful record of innovation and commercialization related to network performance monitoring. He has acted as chief scientist for Apparent Networks (now Appneta) and INETCO Systems, where he directed research and commercialization efforts in transaction and application performance monitoring systems for VoIP, video, transaction, and virtualization environments. He has authored 12 patents for related technologies.

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