Open Source for Networking: Tools and Applications


Ying-Dar Lin


Ren-Hung Hwang


Grenville Armitage


Vincenzo Eramo

Welcome to our 2nd special issue on Open Source for Networking. Our March 2014 issue [1] focused on open source implementations of key networking protocols and protocol stacks. Now we move our attention to tools and applications in data networking that have been developed and released under the open source model.

Whether you are doing protocol research, prototyping & development or network operations, it is crucial to have good insight into, and control over, the behavior of your systems. This may involve instrumentation of existing systems, or building precisely controllable emulation and simulation environments. Although specialized (and closed) development, monitoring and evaluation tools have been commercially available for many years, we are living in an era where many powerful techniques and tools (both software and hardware) are being released under open source licenses.

Open source tools give our networking community significant benefits. We can directly inspect how such tools work, and modify them as required if our own circumstances do not quite match those of the tool's author(s). By inspection we can verify the heuristics and assumptions utilized by any tools we rely on to report the dynamic behaviors of our networked services and equipment. As most open source licenses encourage a collegial environment of idea-sharing, local enhancements are often fed back to enhance each tool's utility for the broader networking community.

As we noted in [1], open source tools and applications allow educators world-wide to better illustrate theory using live, running examples that may be inspected and modified by their students. The beauty of open source tools is that almost anyone can become student, educator and contributor.

In this Issue

In this September issue, the first two papers are devoted to illustrate the advantages and the drawbacks of open source hardware platforms using Field Programmable Gate Array (FPGA). The next three papers describe some tools aiming at facilitating experimentation in wireless networking research by simplifying the task of implementing, deploying and testing networking protocols. The sixth paper presents open source packages for network simulations. Last two papers introduce some open source software frameworks for the support of virtualization environment. Brief summaries of the accepted articles are listed below.

Open Source Hardware Platform

"OSNT: Open Source Network Tester" by Antichi *et al.* presents the Open Source Network Tester (OSNT), a low cost and fully open source traffic generator and capture system. The prototype is implemented on the NetFPGA-10G and supports 4?10Gbps traffic generation across all packet sizes and traffic capture up to 2?10Gbps with naıve host software. The authors show how such a test is able to achieve full line-rate, provide sufficiently accurate timestamping and be flexible enough to allow new protocol tests to be added to the system. "Bridging the Gap Between Hardware and Software Open-Source Network Developments" by Forconesi *et al.* illustrates how the main drawback in using Field Programmable Gate Array (FPGA) based platform as the NetFPGA is the need of developing network applications by using Hardware Description Language (HDL) that can lead to high development time. The authors show how a reduction of the development time is possible when the whole application is developed with High-Level Languages (HLL), typically C/C++, and a translation into hardware is performed with the aid of a High-Level Synthesis tool. A HDL and HLL development comparison of a network application is also carried out.

Open Source Experimentation Tools in Wireless Networking Research

"Open-field Emulation of Cooperative Relaying in LTE-A Downlink Using the GNU Radio Platform" by Atungire *et al.* proposes the usage of open-source GNU radio tools to build a full-Software-Defined Radio (SDR) implementation of cooperative relaying for an Long Term Evolution-Advanced (LTE-A) downlink connection. The authors provide experimental results to study the effectiveness of the cooperative relaying in LTE-A-like scenarios. "GNURadio and 802.11: Performance evaluation and limitations" by Vilches at al. evaluates the performance of an 802.11 software-based transmitter and receiver implementation on top of the GNU Radio platform highlighting its capabilities and limitations. The authors analyze the Bit

Error Rate and the Packet Error Rate measurements on a reference scenario. "The FINS Framework: An Open-Source, Userspace Networking Subsystem for Linux" by Thompson at al. introduces the Flexible InterNetworking Stack (FINS) Framework, an open source userspace networking subsystem designed and built for Linux-based systems. FINS makes wireless networking research easier by moving networking functionality into userspace and building a platform for mobile devices. The authors perform some performance measurements to verify if the FINS framework is capable of supporting some common applications.

Open Source Network Simulation Tool

"Open-source Suites for the Underwater Networking Community: WOSS and DESERT Underwater" by Casari *et al.* presents two open-source frameworks, World Ocean Simulation System (WOSS) and Design, Simulate, Emulate and Realize Test-beds (DESERT) Underwater, that respectively address how to bring realistic channel impulse responses into underwater network simulators, and how to allow an efficient transition from simulations to underwater networking experiments. The authors mention their experience and how their software has been tested in collaboration with major institutions and modern manufactures in the field.

Open Source Software Frameworks for the support of Virtualization Environment

"A Flexible Quagga-Based Virtual Network With FIB Aggregation" by Abraham *et al.* describes an extension of the open source VirtualBox to build a virtual network consisting of many virtual routers each running an instance of Quagga and fed with real-time routing data. Through this system the authors are able to monitor the virtual routers' Forwarding Information Base (FIB) size and CPU usage, to demonstrate the effectiveness of a proposed FIB aggregation mechanism under a realistic network environment. "Optimal Deployment of Open-Source Application Servers providing Multimedia Services" by Femminella *et al.* introduce how to make use of Java Call Control (JCC) Application Programing Interfaces (API) for managing Session Initiation Protocol (SIP) sessions and Media Gateway Control Protocol (MGCP) connections. Then inspired by the results of an extensive experimental campaign, the authors consider resource allocation and configuration management of application servers in a virtualized environment, so as to extract useful configuration and deployment information. In addition, they also use these results to define an effective model to predict the achievable throughput of service platforms in calls per seconds.

References

[1] Y.-D. Lin *et al.*, "Guest Editorial: Open Source for Networking: Protocol Stacks," *IEEE Network*, vol.28, no.2, pp.2,5, Mar.–Apr. 2014.

Biographies

YING-DAR LIN [F'13] (ydlin@cs.nctu.edu.tw) is a professor of computer science at National Chiao Tung University (NCTU), Taiwan. He received his Ph.D. in computer science from the University of California, Los Angeles (UCLA) in 1993. He served as the CEO of Telecom Technology Center during 2010–2011 and a visiting scholar at Cisco Systems in San Jose, California, during 2007–2008. Since 2002, he has been the founder and director of the Network Benchmarking Lab (NBL, www.nbl.org.tw), which reviews network products with real traffic. He also cofounded L7 Networks Inc. in 2002, which was later acquired by D-Link Corp. He founded, in 2011, the Embedded Benchmarking Lab (www.ebl.org.tw) to extend into the review of handheld devices. His research interests include design, analysis, implementation, and benchmarking of network protocols and algorithms, quality of services, network security, deep packet inspection, and embedded hardware/software co-design. His work on multihop cellular was the first along this line, and has been cited over 600 times and standardized into IEEE 802.11s, IEEE 802.15.5, IEEE 802.16j, and 3GPP LTE-Advanced. His IEEE Fellowship was in recognition of his contributions to multihop cellular communications and deep packet inspection; he is also an IEEE Distinguished Lecturer, 2014–2015. He is currently on the editorial boards of *IEEE Transactions on Computers*, *IEEE Computer*, *IEEE Network*, *IEEE Communications Magazine* (Network Testing Series), *IEEE Wireless Communications*, *IEEE Communications Surveys and Tutorials*, *IEEE Communications Letters*, *Computer Communications*, *Computer Networks*, and *IEICE Transactions on Information and Systems*. He published a textbook, *Computer Networks: An Open Source Approach* (McGraw-Hill, 2011; www.mhhe.com/lin). It is the first textbook that interleaves open source implementation examples with protocol design descriptions to bridge the gap between design and implementation.

REN-HUNG HWANG [SM] received his Ph.D. degree in computer science from the University of Massachusetts, Amherst, in 1993. He joined the Department of Computer Science and Information Engineering, National Chung Cheng University, Chia-Yi, Taiwan, in 1993, where he is now the Dean of the College of Engineering and distinguished professor of the Department of Computer Science and Information Engineering. He is currently on the editorial boards of the *Journal of Information Science and Engineering* and *The Scientific World Journal* (Computer Science area). He is also a co-author of the textbook *Computer Networks: An Open Source Approach* (McGraw-Hill, 2011). He received the IEEE Outstanding Paper Award from IEEE IC/ATC/ICA3PP 2012. He was Guest Editor of *IET Communications*' Special Issue on WiMAX Integrated Communications and Program Chair of International Symposium on Pervasive Systems, Algorithms, and Networks '09.

GRENVILLE ARMITAGE [M] received his B.Eng. degree (Hons.) in electrical engineering and Ph.D. degree in electronic engineering from the University of Melbourne, Australia, in 1988 and 1994, respectively. Between 1994 and 1997 he worked in New Jersey at Bellcore as a senior scientist in the Applied Research Division's Internetworking Research Group. From 1997 to 2001 he worked as a member of technical staff in Bell Labs, Lucent Technologies (in both New Jersey and California), and in 1998 was also product marketing director in Lucent Technologies' then Data Networking business unit. He is currently a professor of telecommunications engineering and eirector of the Centre for Advanced Internet Architectures, Swinburne University of Technology, Melbourne. He authored *Quality of Service In IP Networks: Foundations for a Multi-Service Internet* (Macmillan, 2000) and coauthored *Networking and Online Games — Understanding and Engineering Multiplayer Internet Games* (Wiley, 2006). He is a member of the Scientific Advisory Board for the EC-funded Reducing Internet Transport Latency (RITE) project, and on the editorial boards of *IEEE Communications Surveys and Tutorials* and *ACM Transactions on Multimedia Computing Communications and Applications*. He is a member of the ACM.

VINCENZO ERAMO received his Laurea degree in electronics engineering in 1995 and his Dottorato di Ricerca (Ph.D. degree) in information and communications engineering in 2001, both from the University of Roma La Sapienza. From June 1996 to December 1996 he was a researcher at the Scuola Superiore Reiss Romoli. In 1997, he joined the Fondazione Ugo Bordoni as a researcher in the Telecommunication Network Planning group. From November 2002 to October 2005 he was an assistant professor, and from November 2006 to June 2010 was an aggregate professor in the Infocom Department of the University of Rome La Sapienza. Currently he is an aggregate professor in the Department of Engineering of Information, Electronics and Telecommunications. He collaborated with the Alcatel Lucent Research Center in Murray Hill, New Jersey from 1 January 2001 to 31 December 2001. His research activities have been carried out in the framework of national and international projects. In particular, he was scientific coordinator for the University of Roma La Sapienza in Experimental University Router Open (EURO), Building Open Router Architecture Based on Router Aggregation (BORA-BORA), and Software Routers to Improve Next-Generation Internet (SFINGI), three national projects financed by the Minister for University and Research (MUR) in 2002–2004, 2005–2006, and 2011–2013, respectively, focused on the performance evaluation of software routers. He was scientific coordinator for the University of Roma La Sapienza of E-PhotoONe+ and BONE, two Networks of Excellence focusing on the study of optical networks and financed by the European Commission]s Framework Programmes 6 and 7 in 2006 to 2007 and 2008 to 2011, respectively. He has been an Associate Editor of *IEEE Transactions on Computers* since July 2011, Associate Editor of *Dataset Papers in Science* (Hindawi) since November 2011, and an Associate Editor of *Photonic Network Communications* (Springer) since September 2013. He is organizing as Guest Editor two Special Issues (SI): Innovative Techniques for Power Consumption Saving in Telecommunication Networks, *Journal of Electrical and Computer Engineering* (February 2014) and Elastic Optical Networks organized by *Photonic Network Communications*. He has served as Chair of some international conferences (IEEE ICC 2003, EuroIMSA 2005, and IEEE ICC 2011). His research areas are queuing theory, resource dimensioning techniques in telecommunication networks, all-optical networks, and Internet switching architectures. His current research interests are focused on the definition and performance evaluation of routing techniques and technologies to reduce power consumption in telecommunication networks.