Real-Time Communications

Topics for Research and Methods of Collaboration

Carol Davids
Illinois Institute of Technology
School of Applied Technology
201 East Loop Road
Wheaton, IL
+1 630-682-6024
davids@iit.edu

Gaston Ormazabal
Columbia University
Dept. of Computer Science
520 West 120th Street
New York, N.Y. 10027
+1-212-939-7137
gso@cs.columbia.edu

Radu State
University of Luxembourg
Interdisciplinary Centre for Security
Reliability and Trust
4, Rue Alphonse Weicker,
L-2721 Luxembourg
(+352) 46 66 44 5647
radu.state@uni.lul

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ABSTRACT

In this article we describe the discussion and conclusions of the "Roundtable on Real-Time Communications Research: What to Study and How to Collaborate" held at the Illinois Institute of Technology's Real-Time Communications Conference and Expo, co-located with the IPTComm Conference, October 15–17, 2013.

Categories and Subject Descriptors

A.0 [General Literature]: General - *Conference Proceedings;* A.1 [General Literature]: Introductory and Survey*;* H.5.3 [Information Interfaces and Presentation]: *Web-based interaction*

Keywords

Real Time Communications; RTC; IPTComm; research; telecommunications; collaboration; WebRTC; web; software defined networks; SDN; mobility; heterogeneous networks; cloud communications

1. Introduction

The field called Real-Time Communications (RTC) defines methods for delivering interactive voice, video and data on demand in real time, providing the functions of both data communications and telecommunications in new contexts and platforms, of which mobile is becoming the predominant mode. Protocols including the Session Initiation Protocol (SIP) [9] and the Hypertext Transfer Protocol (HTTP)[3] and encoding languages including JavaScript are frequently used to implement these services whose antecedents once relied upon dedicated circuits to ensure the timely delivery of the synchronous data emitted by codecs. Today, much of the creative energy in the field of RTC is focused on the development of real-time applications that support social, educational and business services. What are the topics for research and the methods for collaboration that will support and advance development of RTC systems, solutions and operations and that may also point the way to a new stage of development?

A panel of researchers from industry and academia addressed these questions at a roundtable discussion last October, as part of the Illinois Institute of Technology 9th Annual Real-Time Communications Conference [5] and the 6th IPTComm Conference [6], which were co-located at the IIT Main Campus in Chicago, Illinois. The panelists were Gregory Bond of AT&T Research, Ronald Marx of the Fraunhofer Institute for Secure Information Technology SIT, Henning Schulzrinne and Gaston Ormazabal of Columbia University and Radu State of the University of Luxembourg. Carol Davids of IIT moderated the panel and Andrew Rollins of Nokia Solutions and Networks (NSN) created the minutes based upon which this editorial note was written. The panel addressed two basic questions – "What to study" and "How to collaborate." Over thirty participants contributed to the discussion. The notes that follow summarize and in some cases expand on the observations and concerns that were raised.

2. Overview

2.1 Evolution of Real-Time Communications

The telecommunications industry is experiencing a rapid transition from a circuit-switched network to a packet-switched, IP-based network, previously at the wire-line level and most recently in the wireless arena with the advent of LTE [7]. This revolutionary transition has opened up research areas in the general field of IP telecommunications that were basically nonexistent only five years ago. While its original goal was person-to-person audio communications or voice, on today's networks voice is considered to be the spice. Peer-to-Peer, Machine-to-Machine, Vehicle-to-Vehicle and Browser-to-Browser applications are now using a large share of network resources. The panel identified the following broad areas for research: Which layer of the data communications model to use to implement communications functions; How to implement security over heterogeneous networks; What impact will Software Defined Networks (SDN) have on RTC applications and services; and, How to evolve our operating systems and hardware platforms to optimize their use by applications and services based on RTC principles.

2.2 Types of Research

Four types of research were identified: ***Prototyping*** involves the design and implementation of a Proof of Concept application which demonstrates the possibility and sometimes the feasibility of implementing a function, application or service using a particular technology, protocol or architecture; ***Evaluation or 'keeping people honest'*** consists in the identification and application of the metrics against which the relative merits of one system over others can be determined. This type of research may also include the actual implementation of a system that will deliver a particular service to a user community and its subsequent evaluation; ***Identification of Real Problems*** requires a critical examination of the things that are blocking progress toward a technical or commercial goal and an analysis of where best to invest our research resources. This type of research is initially based on sparse, non-systematic and anecdotal data. A group may make a large investment in resources to resolve a problem that will not greatly impact the financial or technical 'bottom line.' ***Performance and Scalability Measurements and Solutions*** enable verification that a new service or application can withstand the rigors of deployment in a global as well as an enterprise, environment, where global solutions must scale to millions of connections while enterprise solutions may scale to thousands. It was observed that existing infrastructure technology is inadequate for large-scale RTC and solutions need to be developed. In this type of research we need to identify the metrics, define minimum requirements, and develop the infrastructure that can enable us to achieve them. We will return to the distinction between global and enterprise in the section on Networks, Applications and Services below.

3. Areas and Topics for Research

3.1 Where to implement functions

On analog circuit-switched telecommunication networks, the network and the application were all carried at layer one, on the wire or in the channel. The traditional telecommunications provider sold a service with a single application – voice – that might come with a set of additional features for which the subscriber paid extra. On today's networks, the wire or channel carries multiple applications across a mesh of different data-links, virtual circuits, channels, streams, and administrative domains, all of which have distinct - and often minimal - central controls. Seamless handoffs between different network technologies can be implemented at layer two using Software Defined Networks (SDN) techniques, layer three, using the OMNE method [1] or at the application layer. In some cases, we implement connections at layer four; in others we implement them at layer five. In some cases we implement the application using session-layer protocols as a tool kit, in others we write scripts that run in the browser and use HTTP as a new transport layer. Studies of security, performance and reliability for these different approaches can help determine which might be the best option, under a variety of constraints. Today we distinguish between the 'network' and the 'applications and services' that it carries. User-centric control may be the predominant mode in the future, with new challenges that will need to be addressed and researched.

In related research, a Physical Layer Control Function that provides Dynamic Spectrum Access (DSA) functionality to enable access to additional wireless spectrum, based upon location, network conditions, and application-specific requirements is becoming an important topic for investigation given the scarcity of available long-range spectrum for wireless communications. The goal is to efficiently use the available wireless spectrum based upon the location of a mobile node using DSA solutions through opportunistic access to the licensed bands (e.g., TV Whitespaces) without interfering with the existing users. DSA also enables on-demand high bandwidth for mobile users. Mobile nodes can opportunistically perform (1) spectrum sensing, and (2) spectrum management with corresponding Base Station (BTS) by using cognitive radio methods or by querying a remote geospatial spectrum database [4].

3.2 Security over heterogeneous networks

Networks today are not controlled by a single entity and do not adhere to uniform security policies. A new framework and paradigm to address the security needs of applications running on heterogeneous networks that use multiple technologies and multiple domains is needed. Research can focus in particular on mobile networks and cloud technologies. Mobile communications are typically vulnerable to interception and analysis by third parties. Since the new mobile architectures require management of connections across heterogeneous networks, the most significant challenge is to maintain identity, confidentiality and integrity in a non-uniform security environment. A mobile device, for example, may transition from a secure LTE network to a public Wi-Fi access point that may not support adequate protection mechanisms, and consequently render communications vulnerable to attacks. The identification, categorization, and prioritization of applicable network threats will help define and enforce correspondingly uniform security controls to mitigate them. In this connection, non-repudiation as an optional feature in multimedia communication [11] was identified as additional topic for research. Furthermore, SDN can be beneficial for managing heterogeneous networks since it can close vulnerabilities faster than traditional network architectures. Issues for research include defense mechanisms and counter-measures implemented on top of SDN, as well as the communication security of SDN components. Cloud communications bring further requirements related to the dissolution of the security perimeter. Each entity has to be treated as an object, with its own security requirements.

3.3 Cloud Communication Services, Software Defined Networks and Big Data

Network operators are using data generated within the network itself to support software defined networks (SDN) and Traffic Engineering in real time. SDN's can provide Selective Traffic monitoring as well as high velocity monitoring and billing. To study the impacts of these dynamically changing networks on RTC applications and services we need new research on data collection (probes), storage, and analysis (Big Data). Data coming from the network can have many flavors.

Application layer data related to video and audio streaming can be used to optimize content distribution networks and optimize their placement. Using analytics platforms will enable the adaptation and optimization of the network topology in real time. This topology can be both physical and logical. At a physical layer, SDN can serve to reconfigure a network topology. At a logical layer, server replication and content delivery network (CDN) placement can optimize the service. Some research challenges will need to be addressed. Firstly, a network analytics platform will need to rely on timely and relevant data. This data can use simple packet-based statistics, or ones specific to a particular application, such as Real-time Transport Protocol (RTP.) Secondly, the analytics platform should be able to predict short-term future service degradations, and initiate preventive actions and thus drive an evolution from reactive network management towards a pro-active and predictive management. Research on prediction approaches for multimedia delivery platforms is needed, as well as linking the prediction with a control-loop management framework, where actions can be taken, their impact assessed and an additional set of control actions generated. The third research challenge is related to optimization of network services with respect to available resources, traffic conditions or service level policing.

Optimization strategies such as those proposed by the Application Layer Traffic Optimization Servers (ALTO) IETF working group are among the works in progress. Validation and deployment approaches for dynamic clouds, including OpenStack and

OpenVSwitch indicate a direction for future work as well. The special challenges associated with operating cellular SDN Networks need to be explored. The research priorities proposed include: Analytics approaches; Northbound interfaces for SDN; Eastbound and Westbound interface to integrate with legacy equipment.

3.4 Hardware and Software Platforms

RTC applications and services need to run on all hardware platforms. The increased demand for power on the part of mobile devices points to a need to optimize their power consumption as well as the design of their batteries. We need to develop algorithms to determine when the mobile device should request heavy-duty processing from the cloud. Hardware platforms are becoming an important attack vector as defenses against software based attacks become mature and strong. The Stuxnet [2] attack infiltrated the embedded processor firmware used in critical infrastructure and industrial process control systems. Research labs have reported backdoors in chips used in weapons control systems, nuclear power plants, and public transport monitoring systems. Research into modifications to traditional System on a Chip (SoC) design flows can enable effective protection against maliciously inserted rogue functionality during design and fabrication, requiring a joint circuit-architecture-level design approach to help in preventing or detecting Trojan attacks at the hardware level.

3.5 Applications, Services, Networks and Operations

Enabling RTC to meet the needs of communities as well as individuals means developing not only the applications but also the network architectures, operations, and support systems that will allow the applications to deliver services that function reliably and consistently. These latter will enable the applications to become IP-based services. Traditionally, circuit switched networks refer to 'services' whereas IP- and Web-based networks use the term 'applications.' Under the circuit switched paradigm, a government or government-regulated monopoly controlled the network and the only application running on that network was voice: 'Operations and Maintenance' systems, 'Carrier Grade' services, 'Quality of Service' were all terms used to describe functions necessary to deliver the service we call voice. The industry was concerned with the quality of the end-user experience, but this itself was controlled by the quality of the network. In this context the 'Quality of Service' described the quality of the end-user experience.

Under the packet-switched paradigm of the Internet, there are more variables, and more factors that can impact the end-user experience. The network is specifically not adapted for synchronous data such as is emitted by codecs. The network carries many different types of applications. It is a mesh of networks that are administered by different organizations with different operations and maintenance standards, different implementations of application-level servers and clients that have not been tested for interoperability, and different security policies and practices. One reflection of this more complex reality is our use of the term 'End-User Experience' rather than 'Quality of Service.' Researchers should continue to create a new terminology to describe the goals for RTC.

Open-source-based technologies and frameworks have many advantages for both sustainable business development and as powerful catalyzers for joint research between academia and industry. Cloud services in particular are changing the way we use the Internet. Applications and services will need to leverage cloud-like deployment infrastructures. Moreover, traditionally network-based "appliance-based" services, such as media transcoding and mixing, are being migrated to virtual, cloud-based functions, necessitating cloud infrastructure supporting low latency and low jitter.

Traditional telecom providers will need to shift towards a flexible and elastic provisioning mode. New metrics to define and evaluate the efficiency of these systems can be developed. Today we have multiple operating systems and multiple browsers. We can work to enable interoperable applications and services in this pluralistic environment. We can also try to extrapolate into the future to define different paths that technology can take and evaluate their relative advantages.

Emergency Services is an important testing ground for RTC. The public has adopted text messaging, smart phones , video calls, and Voice over IP services for its communications needs and expects to be able to contact emergency service providers using these means. To meet this expectation, government [10], standards organizations [8], and the research community have worked together to develop and test an IP-backbone network, whose architecture and functional elements support the special requirements of this lifeline service. This 'Emergency Services IP backbone Network' (ESInet) enables users from both the PSTN and the Internet to reach the appropriate Public Services Answering Point (PSAP). Much work still needs to be done to develop fail-over solutions, load balancing, policy routing and operations specific to a social service, which must be available all the time, and under all conditions.

Finally, economics and finance as well as government policies will play an important role in shaping the directions that technology will take. Research can be done to demonstrate the feasibility and comparative efficiency of different methods, protocols and architectures to provide new as well as existing functions. We will need to develop some new metrics for the comparisons, including clear definitions of what we mean by efficiency. We will need to include factors that may not have been considered in the past, such as environmental impacts, security, and support for people with disabilities.

4. Collaboration

The distributed character of the networks, and the applications and services that use them, implies a need for a new paradigm for the research community as well. In contrast to the old telecom research community, the current community is fragmented, studying various aspects of the challenges posed by the diverse collection of networks, applications and services, but not integrating these into systems that inter-operate and co-operate to produce a scalable service or solution. Lacking a separate forum for publication of RTC research, we seek publication and community in the established societies and reviews. Some RTC research is classified as Computer Science (CS) and some as Network focused and in the purview of Electrical Engineering (EE).

With respect to the CS focused research, students and faculty build applications in isolation from the communities that will use them and the infrastructure that will carry them. Writing proof of concept code on virtual machines requires only a narrow range of skills and experience. Developing the actual test beds and systems that will demonstrate the scalability, security and performance of the applications requires much more. Yet the skills needed to do this are often not developed in the research community. In the early days, the CS students and faculty actually built and operated the University networks, giving them the hands-on experience and operational involvement that is lacking today. Research that is related to IP networks faces a different problem. Since many of the challenges that faced early deployments of IP networks have been resolved, the interest in and funding for research in this area is relatively low. Several participants in the discussion recounted experiences in which their network-oriented RTC research was misunderstood by established research publications and societies. Some reviewers did not recognize the protocols used for RTC and others deemed the problems addressed by RTC to be out of scope.

5. Conclusions

Panelists and participants decided to stay in contact through a mailing list, and will communicate throughout the year to continue to clarify both research goals and methods for collaboration. The IPTComm annual conference plays a useful role in this context since Technical Program Committee Members are themselves active in the field of Real-Time Communications over IP networks. Additional interaction between universities and industrial research laboratories will be implemented through this mailing list and additional efforts will be made to provide academic institutions with a firmer grounding on "real life" problems of industry, and their largest customers, including government and enterprise.

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7. REFERENCES

[1] A. Singh, G. Ormazábal, H. Schulzrinne, Y. Zou, P. Thermos and S. Addepalli. Unified Heterogeneous Networking Design. IPTComm 2013, Chicago, USA. IPTComm ACM Proceedings, Oct. 2013.

[2] B. Neild, Does Stuxnet Herald the Age of Cyber Warfare?, 2010. [Online]. Available: http://www.globalpost.com/dispatch/asia/101016/stuxnet-cyber-warfare-computer-science.

[3] HTTP: IETF [RFC2616] Fielding, R.,Gettys, J. Mogul, J., Frystyk, H., Masinter, L., Leach, P. and T. Berners-Lee, "Hypertext Transfer Protocol – HTTP/1.1", RFC 2616, June 1999

[4] I. F. Akyildiz, W. Lee, M. C. Vuran, and S. Mohanty, NeXt Generation/ Dynamic Spectrum Access/ Cognitive Radio Wireless Networks: A Survey, Computer Networks Journal, Vol. 50, 2006, pp. 2127-2159.

[5] IIT Real Time Communications Conference and Expo: http://www.rtc-conference.com

[6] IPTComm: http://iptcomm.org

[7] LTE: 3GPP TS 36.300: E-UTRA and E-UTRAN Overall Description; Stage 2: http://www.etsi.org/deliver/etsi_ts/136300_136399/136300/08.04.00_60/ts_136300v080400p.pdf

[8] National Emergency Numbers Association: The i3 Standard: http://www.nena.org/?page=i3_Stage3

[9] SIP: IETF [RFC3261] Rosenberg, J. Schulzrinne, H., Camarillo, G., Johnston, A., Peterson, J., Sparks, R., Handley, M. and E. Schooler, "SIP: Session Initiation Protocol", RFC 3261, June 2002.

[10] US Department of Transportation: Research and Innovative Technology Administration: Next Generation 9-1-1: http://www.its.dot.gov/ng911/index.htm

[11] R. Marx, N. Kuntze, and H. Lauer. Bringing VoIP Signatures to Mobile Devices. In Proceedings of the Conference on Principles, Systems and Applications of IP Telecommunications (IPTComm), Illinois Institute of Technology, Chicago, USA, October 2013. ACM.