
ADVANCING STANDARDS AND TOOLS FOR INFORMATION EXCHANGE AND DISPLAY:
ENABLING DELIVERY OF BUILDING INTELLIGENCE TO FIRST RESPONDERS

Proposal Submitted to the 2010 NIST Extramural Fire Research Grants Program
Category D. Engineered Fire Safety

Point of contact: Dr. Steven Ray, Carnegie Mellon University Silicon Valley
Steve.r.ray@sv.cmu.edu

“The goal is to enable a future where first responders can arrive at a building already knowing the magnitude and location and hazards (including both emerging hazards such as fire and smoke, as well as fixed hazards such as stored chemicals or explosives), quickly perform an on-scene size-up, and deploy resources appropriate to the risks, enhanced by real-time alerts showing conditions and assets within the context of the building and site.”

– Holmberg, Raymond, Averill, ‘Delivering Building Intelligence to First Responders’, 2009.

A Proposal To
NIST Building and Fire Research Laboratory

Submitted by
Carnegie Mellon Silicon Valley
and the
Golden Gate Safety Network
January 2010

SUMMARY PROJECT DESCRIPTION

TECHNICAL AREA: CATEGORY D – ENGINEERED FIRE SAFETY

PRIMARY OBJECTIVE

To advance standards and tools for information exchange and display, to enable delivery of building intelligence to first responders, by implementing the recommendations of the NIST Building Information Exchange with First Responders (**BIEFR**) Building Emergency Response 2008 workshop.

PROBLEM DESCRIPTION

The lack of information about a building, and about the location and condition of first responders inside a building, has repeatedly surfaced as a priority need by incident commanders and the first responders themselves. It was identified at the 2008 workshop mentioned above, that a fundamental requirement of BIEFR would be an open and portable format for floor plan maps, to provide backgrounds for the display of alarms and alerts, safety elements including exits and stairs, hazardous materials, and the firefighters themselves. This proposal is designed to address the exchange of open floor plans and related information, as well as prototyping demonstration software and advancing standardization efforts for this information.

SUMMARY OF TECHNICAL APPROACH

The proposal describes the following set of tasks to be performed over three years:

- Documentation of lessons learned since the 2008 BIEFR workshop
- Development of exemplar software demonstrating the use of the Open Floor Plan Display/eXchange specification
- Advance the standardization effort for real-time building information for emergency responders
- Hold a workshop to accelerate and improve adoption of the standards
- Develop a set of network protocols and a security architecture for securely exchange building information during disasters
- Harmonize the above standards with relevant other standards activities including NIEM, APCO, NBIMS & OASIS
- Prototype a Standard Access Point (SAP) for connection to a building simulation system

MAJOR MILESTONES

- 2010 – Delivery of working group documentation
- 2011 – Delivery and demonstration of Open Floor Plan Display software
- 2011 – Delivery of ontology and serial representation of the information content and format of building information pertaining to emergency response
- 2011 – Workshop and workshop report on advancement and adoption of relevant standards
- 2012 – Network protocols and a security architecture specification for secure, real-time building system data exchange
- 2013 – Demonstration of building alert data exchange using CAP messages encapsulated within NIEM
- 2013 – Demonstration of an implemented Standard Access Point

STATEMENT OF SIGNIFICANCE

The results of this work will directly support the basic BFRL objective of providing the technical base for reducing the nation's fire losses. This claim is substantiated by the fact that this proposal is derived directly from the recommendations arising from the 2008 BIEFR workshop convened by NIST. The technical work will flow directly from development, through demonstration, and finally to standardization through the appropriate standards bodies. The prototype open source implementations coupled with open standards will enable rapid commercialization by private companies and thus provide affordable tracking and display solutions to the nation's firefighters. These outcomes are directly aligned with NIST's mission to provide measurements and standards for U.S. industry, and with the goal of NIST BFRL to improve the performance and safety of constructed facilities. The impact of this work will be measured by reduced property losses due to fire as well as fewer lives lost.

TWO SENTENCE SUMMARY:

One of the most elusive problems for first responders is reliable and accurate situational awareness during emergency operations. This research will provide the means to quickly and easily exchange vital information about a building and the location of emergency responders within the building using easily understood floor plans represented in an open standard format.

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– Holmberg, Raymond, Averill, ‘Delivering Building Intelligence to First Responders’, 2009.

This proposal describes ongoing work to advance standards and tools for information exchange and display to enable delivery of building intelligence to first responders. This activity was catalyzed by NIST/BFRL when it convened the NIST Building Information Exchange with First Responders (**BIEFR**) Building Emergency Response 2008 workshop, and brought together a diverse set of researchers and practitioners representing both the first responder community and the building information standards community. The conclusions from the workshop included the need for an open means of exchanging floor plan information, and are captured in the attached letters from NIST and bSa (Building Smart Alliance).

We propose to advance an open exchange system to support information handling for emergency response in buildings. Components of the system include basic building geometry, consensus-based semantics, and standards-compliant exchange structures. The extended project team represented by this statement of work includes Carnegie Mellon University Silicon Valley, the SFC MapLab and members of the Golden Gate Safety Network (**GGSN**), the National Institute of Justice (**NIJ**), the National Institute of Standards and Technology (**NIST**), the Organization for the Advancement of Structured Information Standards (**OASIS**), and the **Ontolog Forum**. We are currently strengthening collaborations with the building Smart alliance (**bSa**), Open Geospatial Consortium (**OGC**), and the National Information Exchange Model (**NIEM**).

We will continue to coordinate with other **BIEFR** teams, including Scott Parker’s Integrated Justice Information Systems (**IJIS**) Data Elements Resolution Effort. Our objective is to bring together the work of all the organizations listed above to produce a relevant publication and realistic demonstration for adoption and use by any public safety organization. Liaison with **bSa** and **OGC** will engage a broader range of industry participation. Cannon Design, an architecture engineering firm, has expressed an interest in undertaking case studies. Our higher aim is to install at least one working Base Building Server (**BBS**) in at least one operational **Healthcare**, **Educational**, or **Justice System** facility; and to undertake a Proof of Concept integration of OFPD (Open Floor Plan Display) into the typical building permit and inspection process for at least one building under construction. Data delivery will be geared to web services and open standards. The goal is to create one working solution able to meet the complex needs of diverse organizations, using secure interoperable open networks. We will use the

Carnegie Mellon Disaster Management Initiative¹ testing and demonstration laboratory to foster advancement of standards through testing and public-access to tools.

Current Status

The work is proceeding through the undertaking of a number of pilot projects and Use Case Studies. The existing prototype systems and software are concept demonstrations or related to contract services. This work may be tailored for an open BIEFR system.

Current Project Need

The project is primarily operating through volunteer efforts, but cannot make substantial progress without funding support. A nominal level of \$100K is requested to produce a deliverable and sustain work until longer term funding sources are identified. Work options for funding levels beyond this amount are also listed below.

Work Plan

This work plan is aligned directly with the “Steps Forward” detailed in Holmberg, Raymond & Averill in ‘Delivering Building Intelligence to First Responders,’ 2009.

Task 1 – Working Group Documentation

- a. Leverage progress made through NIST and industry collaboration within the NEMA SB30 standardization process.
- b. Liaison with the IJIS Institute, APCO, bSa, OGC, OASIS and other organizations with key stake-holder or subject-matter/standards expertise.

Deliverable: Documentation of NIST BIEFR working groups’ and liaison organizations’ lessons-learned (from base level funding and in cooperation w/ NIST personnel)

Task 2 – Software Development

- a. Establish an exemplar implementation of emergency response software tools that are freely available to public safety agencies including further development of Open Floor Plan Display/ eXchange (OFPD/X) software as a standards-based toolset.
- b. Develop building information data-entry templates, building information visualization components and building data connectivity interfaces

Deliverable: Open tools, documentation of the tools and a web server to disseminate the tools

Task 3 – Standards Development

- a. Forward a set of standards that allows an authorized remote client to access real-time building system data via a compliant interface connection to the building.

Interface standards include:

- A data model to represent the building elements and dynamic information
- Message syntax
- Mapping of real-time data to a floor plan in the remote unit

¹ See <http://www.cmu.edu/silicon-valley/dmi/index.html>

Deliverables: Ontology and serial representation of the information content and format of building information pertaining to emergency response.

Year 2 and 3 Tasks

Assuming satisfaction with the accomplishments of the first year, we propose the following two option year activities. Details and amendments to these tasks will be provided before the start of each year's tasks.

Year 2:

Task 1 – Workshop

Forward a consensus standard that addresses the content and format of building information presented to responders.

At the completion of the segment of work outlined in this proposal, hold a workshop for advancement and adoption of the standards.

Deliverable: Workshop and workshop report

Task 2 – Standard Protocols

Forward a set of network protocols and a security architecture that allows an authorized remote client to access real-time building system data via a compliant interface connection to the building. Prototype software tools that exercise these protocols.

Deliverables: Protocols and policies for system connection and data access

Year 3:

Task 1 – Building Alerts

Address the automated building alert data transfer from building to PSAP with the CAP message format encapsulated within NIEM, specifically the development of an Information Exchange Package Documentation (IEPD) in collaboration with the IJIS Institute that has extensive experience with IEPD Development.

This effort has begun already with work initiated in APCO, in cooperation with CSAA. The APCO External Alerts Alarm Exchange effort links central station alarm systems via automated messages to the PSAP and has been tested in the Richmond, VA area.

Deliverable: Demonstration of building alert data transfer

Task 2 – Implementation and Integration of a Standard Access Point (SAP)

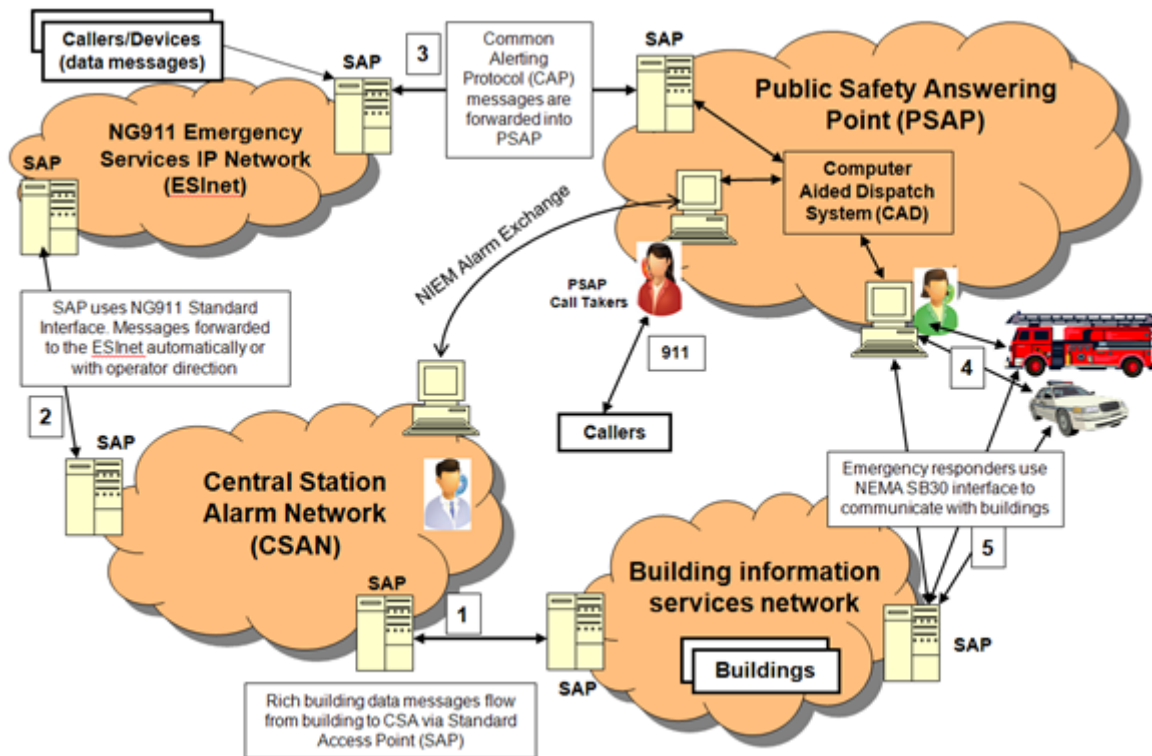
Implement the SAP to allow authorized external partners to access building alerts and real-time sensor data.

Prototype SAP with connection to a building simulation system. The Cisco Mediator device is being evaluated as a possible SAP that incorporates open standards and is commercially available.

Integrate OFPD/X system with SAP

Perform systems integration required to provide a full working implementation

Test the effectiveness of the tools and system through training and exercises in a controlled environment such as through collaboration with CM Disaster Management Initiative and CM Lab



The proposed work focuses on the data structure, semantic and syntactic, and system tools to facilitate steps 1 and 5 of the figure above. Although the other three information exchange steps will not be developed within the base budget proposed, all work will take into consideration the requirements of all the exchange steps in order to support a cohesive response in a fully developed system-of-systems.

Program Organization

The work will be performed by a team of researchers from Carnegie Mellon University, plus several independent researchers who participated in the 2008 NIST BIEFR workshop. These independent researchers will be supported through a subcontract from Carnegie Mellon, and are identified in the budget breakdown.

Students' Participation

The proposal sets aside a small amount of funding to support some time for one or more graduate students to contribute to the work. This funding will be leveraged by other means within the University such as class project assignments and/or research practicum assignments, in order to stretch the funding as far as possible.

Related Programs

The work of the proposing team is currently unfunded, but a related proposal has been submitted to FEMA under the Assistance to Firefighters program. The more ambitious FEMA proposal, should it get funded, will address the creation of a technology and information exchange testbed at Carnegie Mellon dedicated to disaster management, as part of a larger Disaster Management Initiative that is being presently designed, in partnership with NASA-Ames, commercial partners and emergency response practitioners. The current proposal to NIST and the FEMA proposal are synergistic in their approach and promise to yield leveraged results to both sponsors, to the benefit of the nation's first responders.

Standards Alignment Goals

- W3: Scalable Vector Graphics (**SVG**), JavaScript, Asynchronous JavaScript and XML (**AJAX**)
- NBIMS: OmniClass, Tables 11 through 14 Facility and Space Types
- NBIMS: Construction Operations Building Information Exchange (**COBIE**) - sensor locations captured once, able to meet NG9-1-1 metadata requirements
- NBIMS: Industry Foundation Classes (**IFC**) ISO 16739
- NBIMS: International Framework for Dictionaries (**IFD**) ISO 12006
- NIEM: National Information Exchange Model (**NIEM**) Information Exchange Package Documentation (**IEPD**)
- OASIS: Emergency Data Exchange Language (**EDXL**) Distribution Element (**EDXL-DE**), Resource Messaging (**EDXL-RM**), Hospital Availability (**EDXL-HAVE**), and Common Alerting Protocol (**CAP**)

Biographies of Contracted Personnel

Mr. David Coggeshall is a 40 year veteran of custom software development in commercial and public benefit applications.. As the principal consultant for San Francisco Communications, he is a founder of the Golden Gate Safety Network, an informal consortium of public and private safety organizations. For the last eight years he has led the development of open systems demonstration prototypes for information sharing methods for emergency first responders. His work encompasses Common Operating Picture, Open Floor Plans, GPS Resource Tracking, and Exercise Control systems for large multi-agency incidents. Support has been provided to over 25 training exercises, workshops, and public events. All of this work has been based on Open Standards so that that the results can be provided to public safety agencies at no cost.

Ms. Michelle Raymond is an independent contractor in Emergency Response, Firefighter Decision Support and Knowledge Representation. Ms. Raymond was a Research Scientist for 14 years at Honeywell Labs in Minneapolis, Minnesota. In 2004, she and two team members received one of eleven Honeywell International Technical Achievement Awards for bringing a research concept to product-on-the-market within two years. The product, called "First Vision", is a facility-model visualization and decision-support tool for fire responders. Michelle is trained in National Incident Management System/Incident Command System (NIMS/ICS), National Information Exchange Model (NIEM) and qualified to train Community Emergency Response Teams (CERT) and develop/review exercises. Ms. Raymond was co-editor of the OASIS EDXL-DE specification, a standard in the EDXL family of standards. Michelle was a primary contributor to the National Electrical Manufacturing Association (NEMA) SB 30-2005 Standard, "Fire Service Annunciator and Interface," which is part of the NFPA-72 code, and chaired the NEMA SB 30/NIST joint committee to develop the interface standards for information exchange between building systems and fire service displays external to the fire panels.

Ms. Deborah MacPherson brings over 20 years of experience in research and specifications for the built environment, especially public buildings. Her role includes writing technical specifications and assisting project teams with product selection, submittal review, construction procedures and best practices. She is currently developing a vocabulary and workflow for Revit-eSPECS software exchanges, focusing on medical equipment.

She is an active participant in the Construction Specification Institute and building Smart alliance. Before joining Cannon Design, Deborah worked with high rise residential, office, and mixed use development. Her background is museum design including the International Spy Museum, Science City at Union Station, and Shanghai Scienceland. Current specification projects: Fort Saint John Hospital, BC Place Stadium Redevelopment, Human Performance Wing at Wright Patterson Air Force Base. Current research projects include OmniClass Facility and Space Types, Properties, Activities and Process, and the Open Floor Plan project.

Mr. Rex Brooks is President of Starbourne Communications Design and works on creating information technology standards as part of industry-wide teams. He aims to improve individual information quality and control in digital information technology. Mr. Brooks currently serves on several Information Standards and Research bodies including the Organization for the Advancement of Structured Information Standards (OASIS) on the Emergency Management Technical Committee (EM TC), and the Service Oriented Architecture Reference Model TC. These activities contribute to improving interoperability of vocabularies and data models within and across disciplines. He graduated from the University of California Berkeley

Steven R. Ray

Carnegie Mellon Silicon Valley
NASA Research Park, MS 23-11
Moffett Field, CA 94035

Email: steve.r.ray@sv.cmu.edu
Phone: (650) 587-3780

PROFESSIONAL EXPERIENCE:

Carnegie Mellon University Silicon Valley **2009-present**

Distinguished Research Fellow:

Working on systems integration and interoperability standards, particularly in the domains of the smart electrical grid, electronic business, emergency response, supply chains, and manufacturing.

National Institute of Standards and Technology **1997 - 2009**

Chief, Manufacturing Systems Integration Division:

Led a division of roughly 60 staff including 30 visiting researchers addressing technical interoperability challenges, standards and testing related to manufacturing systems, healthcare, homeland security, and the electrical grid; responsible for a budget of \$10-13M. Identified priority industrial interoperability standards needs, successfully developed and secured funding for national initiatives in key industrial sectors, and championed the use of semantic technologies for standards. Worked in close collaboration with other government agencies including DHS, DOD, DOE, NSF. Activities within the division have included leadership positions in standards bodies including the Secretariat of ISO TC184/SC4 (the largest subcommittee in ISO) which is responsible for the "STEP" product data standard (ISO 10303) that has documented savings to manufacturers of \$200M/year (2002), projecting to \$1B/year.

National Institute of Standards and Technology **1993 - 1997**

Group Leader, Manufacturing Collaboration Technologies:

Led a group that addressed integration issues related to manufacturing process planning, exchange and communication standards, integration architectures, and collaborative engineering technologies. Initiated the creation of a flagship ontology standard for process – PSL (Process Specification Language, ISO 18629). Established a new program (TIMA - Technologies for the Integration of Manufacturing Applications) within NIST's Advanced Technology Program.

National Institute of Standards and Technology **1985 - 1993**

Process Planning, Factory Automation Systems Division:

Participated as a member of a research team, then as Team Leader, directing research on process planning within an integrated automated manufacturing environment. Developed ALPS (A Language for Process Specification). Served as Chair of the IGES/PDES Organization. Earned two NIST Bronze Medals.

National Bureau of Standards **1981 - 1985**

Research Staff, Chemical Process Metrology Division:

Pursued independent research on the development of high speed laser tomography and spectroscopy for chemically reacting fluid flows. Began appointment as a National Research Council Postdoctoral Research Fellow.

SECURITY CLEARANCE: Secret

EDUCATION:

Princeton University, Princeton, New Jersey
Ph.D., Mechanical & Aerospace Engineering, 1981

Princeton University, Princeton, New Jersey
M.A., Mechanical & Aerospace Engineering, 1979

Bristol University, Bristol, England
B.Sc. (honors), Physics, 1977

OTHER PROFESSIONAL ACTIVITIES:

Wireless Communications Alliance, SmartGrid Special Interest Group, Founding Co-chair	2009-present
National Center for Ontological Research, Founding member, Chair – Ontology Evaluation	2005-present
Editorial Board, International Journal of Product Lifecycle Management	2005-present
Ontolog Forum	2004-present
Strategic Advisory Council, Institute for Systems Research, University of Maryland	2001-present
U.S. Delegation, Intelligent Manufacturing Systems Initiative	2003-2009
PDES, Inc. Board	2001-2008
US PRO Board	2001-2007
Technical Advisory Board, Semiconductor Research Corporation	1998-2001
Technical Advisory Board, Advanced Technology Program CIIMPLEX project	1997-2000
Accreditation Board for Engineering and Technology	1996-present
Networking and Information Technology R&D Program (NITRD) Agency representative	1996-2003
NIST Centennial Committee	1996-2001
Guest Editor - Journal of Systems Engineering	1995
Mentor - Japan/US Fellowship Program	~1994
Program in Manufacturing Advisory Board, University of Michigan	1994
CIKM Program Committee	1994
NSF Presidential Young Investigator Panelist	~1994
Speaker and organizer at Elementary Schools, National Engineers Week	1993-1996
Connection Resource Bank	1993
NRC Postdoctoral Research Advisor	1992-present

Patrick Tague

Carnegie Mellon Silicon Valley
NASA Research Park, Building 23 (MS 23-11)
Moffett Field, CA 94035-1000

(650) 335-2827 (w), (206) 890-4692 (c)
patrick.tague@sv.cmu.edu
<http://sv.cmu.edu/>

Research Interests

My research interests are in the area of network security for wireless networks, focusing on modeling and evaluating vulnerabilities in wireless ad-hoc and sensor networks and designing robust networking protocols for ad-hoc networks, wireless embedded systems, cognitive radio networks, and cyber-physical systems.

Education

PhD Electrical Engineering, University of Washington, WA, USA 08/2009
Identifying, Modeling, and Mitigating Attacks in Wireless Ad-Hoc and Sensor Networks

MS Electrical Engineering, University of Washington, WA, USA 01/2007
Modeling Adaptive Node Capture Attacks in Multi-hop Wireless Networks

Bachelor of Computer Engineering (cum laude), University of Minnesota, MN, USA 08/2003

BS Mathematics, University of Minnesota, MN, USA 08/2003

Employment History

Assistant Research Professor, Carnegie Mellon Silicon Valley 08/2009 – current

Research Assistant, Network Security Lab, University of Washington 06/2004 – 07/2009

Instructor, Electrical Engineering, University of Washington 01/2008 – 03/2008
Course: Computer-Communication Networks I (EE 565)

Teaching Assistant, Electrical Engineering, University of Washington 09/2003 – 06/2004
Courses: Fundamentals of Electrical Engineering (EE 215), Digital Circuits and Systems (EE 271), Introduction to Computer-Communication Networks (EE 461)

Teaching Assistant/Instructor, ITCEP, University of Minnesota 10/1999 – 08/2003

Publications

Published/Accepted Journal Papers

Patrick Tague and Radha Poovendran, Modeling Adaptive Node Capture Attacks in Multi-hop Wireless Networks, *Ad Hoc Networks*, vol. 5, no. 6, pp. 801-814, August 2007.

Patrick Tague and Radha Poovendran, A Canonical Seed Assignment Model for Key Predistribution in Wireless Sensor Networks, *ACM Transactions on Sensor Networks*, vol. 3, no. 4, p. 19, October 2007.

Patrick Tague, David Slater, Jason Rogers, and Radha Poovendran, Evaluating the Vulnerability of Network Traffic Using Joint Security and Routing Analysis, *IEEE Transactions on Dependable and Secure Computing*, vol. 6, no. 2, Apr-Jun 2009.

David Slater, Radha Poovendran, **Patrick Tague**, and Brian J. Matt, Tradeoffs Between Jamming Resilience and Communication Efficiency in Key Establishment, *ACM Mobile Computing and Communications Review*, April 2009.

Patrick Tague, Mingyan Li, and Radha Poovendran, Mitigation of Control Channel Jamming under Node Capture Attacks, *IEEE Transactions on Mobile Computing*, available January 2009.

Journal Papers under Review

Patrick Tague, Sidharth Nabar, James A. Ritcey, and Radha Poovendran, Jamming-Aware Traffic Allocation for Multiple-Path Routing Using Portfolio Selection, submitted to *IEEE/ACM Transactions on Networking*.

Patrick Tague, David Slater, Guevara Noubir, and Radha Poovendran, Quantifying the Impact of Efficient Cross-Layer Jamming Attacks via Network Traffic Flows, submitted to *IEEE/ACM Transactions on Networking*.

Published Conference Papers

Patrick Tague, Jooyoung Lee, and Radha Poovendran, A Set-Covering Approach for Modeling Attacks on Key Predistribution in Wireless Sensor Networks, *3rd International Conference on Intelligent Sensing and Information Processing (ICISIP'05-Bangalore)*, December 2005.

Patrick Tague and Radha Poovendran, A General Probabilistic Model for Improving Key Assignment in Wireless Networks, *4th International Symposium on Modeling and Optimization in Mobile, Ad-hoc, and Wireless Networks (WiOpt'06)*, April 2006.

Patrick Tague, Mingyan Li, and Radha Poovendran, Probabilistic Mitigation of Control Channel Jamming via Random Key Distribution, *18th Annual International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC'07)*, September 2007, **Best student paper**.

Patrick Tague, David Slater, Guevara Noubir, and Radha Poovendran, Linear Programming Models for Jamming Attacks on Network Traffic Flows, *6th International Symposium on Modeling and Optimization in Mobile, Ad Hoc, and Wireless Networks (WiOpt'08)*, April 2008.

Patrick Tague, David Slater, Jason Rogers, and Radha Poovendran, Vulnerability of Network Traffic under Node Capture Attacks using Circuit Theoretic Analysis, *27th Conference on Computer Communications (INFOCOM'08)*, April 2008.

Patrick Tague, Sidharth Nabar, James Ritcey, David Slater, and Radha Poovendran, Throughput Optimization for Multipath Unicast Routing Under Probabilistic Jamming, *19th Annual International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC'08)*, September 2008.

Patrick Tague and Radha Poovendran, Modeling Node Capture Attacks in Wireless Sensor Networks, *46th Annual Allerton Conference on Communication, Control, and Computing*, September 2008.

David Slater, **Patrick Tague**, Radha Poovendran, and Brian J. Matt, A Coding-Theoretic Approach for Efficient Message Verification Over Insecure Channels, *2nd ACM Conference on Wireless Network Security (WiSec'09)*, March 2009.

David Slater, **Patrick Tague**, Mingyan Li, and Radha Poovendran, A Game-Theoretic Framework for Jamming Attacks and Mitigation in Commercial Aircraft Wireless Networks, *AIAA Infotech@Aerospace Conference*, April 2009.

Awards

Outstanding Graduate Research Award, Center for Information Assurance and Cybersecurity CAE-R, University of Washington, 2009.

Yang Research Award, Department of Electrical Engineering, University of Washington, 2009.

Best Student Paper Award, IEEE PIMRC'07, 2007.

Spirit of Community Award, Department of Electrical Engineering, University of Washington, 2006.

Scholar, DoD/NSA Information Assurance Scholarship Program, 2005.