Department of the Navy SBIR/STTR Transition Program

Topic # N211-083
Automated Formal Verification of Software Defined Network Implementations
Galois, Inc.

WHO

SYSCOM: ONR

Sponsoring Program: ONR Code 31

Transition Target: US Navy SDNs for C4I and tactical afloat networks.

TPOC: Scott Batson
scott.c.batson.civ@us.navy.mil

Other Transition Opportunities: SDN and 5G/NextG deployments with high security and reliability requirements.

Notes: Founded in 1999, Galois develops technology to guarantee the trustworthiness of systems where failure is unacceptable. We apply cutting edge computer science

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and mathematics to advance the state of the art in software and hardware trustworthiness. Galois has received two Phase III awards in the past and has successfully transitioned DoD-sponsored technologies into commercial products such as Muse, TangramFlex, thatDot, Toz, and more.

5STARS builds on more than ten years of academic research from Cornell University, Princeton University, the University of Pennsylvania, and others. The 5STARS prototype integrates with software-defined networking (SDN) and 5G deployments and has exceeded early scalability milestones to verify security, integrity, and isolation requirements in mid-sized networks (10s-100s of switches).

WHAT

Operational Need and Improvement: Software-defined networks and 5G mobile networks are poised to enhance communication capabilities for DoD missions, such as those that require high mobility, and/or seamless connectivity between Navy vessels and UAV/USV/UUV/UGVs, each with rapidly changing positions. 5STARS is a new automated reasoning technology that improves network reliability, survivability, and resilience by providing dynamic, proactive, real-time network monitoring to detect and remediate network incidents introduced by bugs, operator misconfiguration, or adversarial action. 5STARS augments existing network monitoring solutions by detecting problems with network configurations rather than sampling network packets, meaning issues can be detected before network traffic compromises a security posture.

Specifications Required: A software-defined network (using an SDN controller for network orchestration) or a 5G mobile edge core deployed with a software-defined user plane, such as the Aether 5G stack.

Technology Developed: 5STARS is based on NetKAT, an algebraic foundation for network verification that has been actively developed since 2014. It constructs a digital twin of the network forwarding plane and uses a new kind of symbolic solver to verify the absence of bugs/vulnerabilities. 5STARS offers higher assurance and verifies more powerful properties than competing technologies. For example, competing tools may verify that one high-security host cannot send traffic to a specific low-security host; 5STARS verifies that no high-sec host can send or receive traffic to any low-sec destination.

Warfighter Value: With 5STARS, the Navy warfighter can more quickly detect and respond to network incidents, identifying issues when they first appear rather than when they are first exploited. 5STARS also ensures the confidentiality and integrity of SDN/5G slices, making it possible for a battlefield partner (of varying degrees of trustworthiness) to securely tunnel through Navy networks (and vice versa) and to detect and route around some kinds of rogue nodes.

WHEN

Contract Number: N68335-22-C-0411   **Ending on:** Jun 14, 2024

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Fully automated verification for 5G slicing.	N/A	Verified isolation on small network topologies (< 10 switches).	2	1st QTR FY22
Counterexample generation to assist identifying and remediating root causes.	N/A	Generated concise examples pinpointing network misconfigurations when properties were violated.	2	1st QTR FY23
Performance improvements to analyze mid-sized networks (10s-100s of switches).	N/A	Verified isolation on mid-sized network topologies.	3	3rd QTR FY23
Demo integration with Navy SDN platform in a lab setting.	Medium	Satisfies fleet network requirements.	4	1st QTR FY24
Extend demo integration with Navy SDN with monitoring dashboard, root cause analysis, and impact analysis.	Medium	Satisfies fleet network requirements.	5	3rd QTR FY24
Shipboard demo and evaluation.	Medium	Satisfies fleet network requirements.	6	1st QTR FY25

HOW

Projected Business Model: Galois's commercialization and DoD transition plan for 5STARS pursues two paths as part of our broader commercialization strategy:
- Incubation and launch of a spin-off company to sell and support proactive, real-time network monitoring software to SDN/5G operators.
- Direct licensing of capabilities to industry partners.

For the DoD, 5STARS will deliver demonstrable capabilities for Navy applications that we believe are directly transferable to DoD network and 5G/NextG deployments. We anticipate direct transition paths to targeted Programs of Record through existing systems integrator relationships. We are in active discussions with various industry partners who have expressed interest in using or licensing the productized results of our research.

DoD transition will be in parallel with our broader commercialization strategy. Galois has a track record of transitioning government-sponsored research and development into practical tools and products for both commercial and government entities. We are incubating or have launched eight companies: Tozny, Formaltech, TangramFlex, MuseDev, Niobium, ReplayLogic, ThatDot, and Free & Fair.

Company Objectives: Our goal is to integrate this technology into government and prime contractor SDN and 5G deployments with high security and reliability requirements.

Potential Commercial Applications: NetOps and DevSecOps in software-defined networks and 5G/NextG deployments.

Contact: Dr. Cole Schlesinger, Principal Architect
coles@galois.com   (607) 339-6732