U.S. DEPARTMENT OF ENERGY | OFFICE OF CYBERSECURITY, ENERGY SECURITY, AND EMERGENCY RESPONSE

Containerized Application Security for Industrial Control Systems

Sandia National Laboratories (SNL)

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Cybersecurity for Energy Delivery Systems Peer Review

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

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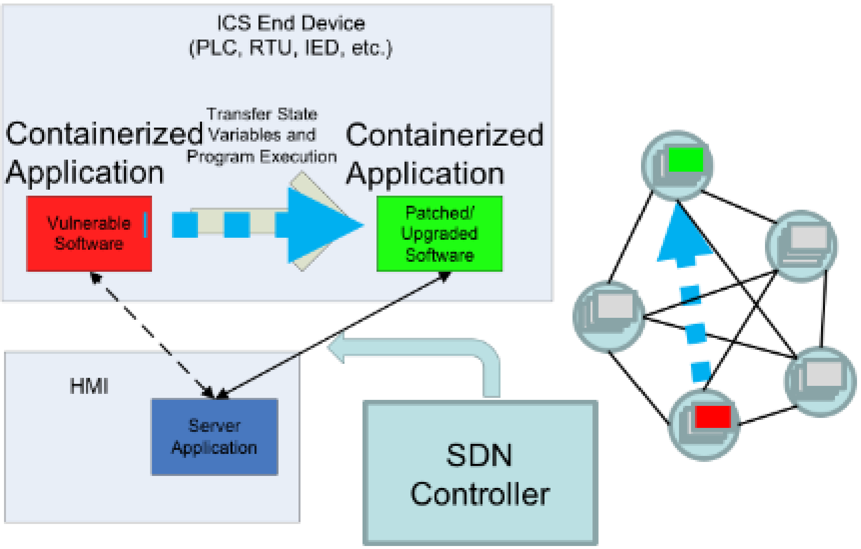
Summary: Containerized Application Security for Industrial Control Systems

Objective

- Increase the availability and resiliency of control systems by dynamically migrating, updating, and restoring applications during a cyber incident.

Schedule

- 5/10/18-5/9/21
- Kickoff meeting 5/10/18; Literature review 7/12/18; libmodbus containerized 10/4/18
- Updating software and creating a moving target defense at the application level in near real-time without interruptions in availability or operation.


ICS End Device
(PLC, RTU, IED, etc.)
Containerized Application
Transfer State Variables and Program Execution
Containerized Application
Vulnerable Software
Patched/ Upgraded Software
HMI
Server Application
SDN Controller

Total Value of Award:	**$2.5M**
Funds Expended to Date:	**4%**
Performer:	**Sandia National Laboratories**
Partners:	**Chevron, Grimm, PNNL, SEL, and Ft. Belvoir NVESD**

Advancing the State of the Art (SOA)

- **Currently, interruptions in service are necessary to update/upgrade software**
- **BlackEnergy, Shamoon, and Stuxnet are examples of malware that targeted an application to propagate through a control system network**
- **Application containers used within IT environments but not within OT environments**
- **Virtual machines used within OT environments but heavyweight**

Advancing the State of the Art (SOA)

- **We will leverage open source and open platform tools**
  - Docker, SoftPLC, libmodbus, and opendnp3
- **Containers isolate applications and help prevent lateral movements**
- **Docker containers checkpoint/restore in userspace**
  - Update/patch/upgrade software in near real-time
  - Increase resilience of OT environments
- **Moving target defense in live-migration creates uncertainty for adversary**

Progress to Date

Major Accomplishments

- Kickoff meeting (May 10, 2018)
  - Completed contracts for all partners
- Completed literature review on available container solutions (July 12, 2018)
  - Docker, Buildah, CoreOS Rocket, Linux Containers, Virtual Machines, Orchestration engines, …
- Developed use cases and scenarios (July 12, 2018)
  - Libmodbus, openDNP3, and SoftJace
  - SoftPLC
- Developed threat scenario and con-ops (July 12, 2018)
- Libmodbus containerized (October 4, 2018)

Challenges to Success

Minimize downtime during upgrade/patching software in OT environments

- Leverage Docker CRIU capability
- Identify upgrade points with minimal state in software
- Checkpoint and transfer state of old software to upgraded software

Migrate application containers

- Leverage orchestration technologies (Kubernetes)
- Reroute traffic using SDN

Develop an interoperable solution

- Docker is portable across a number of operating systems
- Applications can be containerized with the aid of an executable or source code

Collaboration/Technology Transfer

Continue working with partners throughout R&D process

- Targeting both vendors and asset owners
- Working with Chevron, Ft. Belvoir, and SEL to guide/drive our R&D towards commercialization
- Independent red team assessment scheduled towards the end of year 2
  - Continuous input and communication throughout
- Demonstration and testing scheduled for project close out at partner site