ATTACK-AWARENESS FOR SPIRE (INTRUSION-TOLERANT SCADA)

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1.

BACKGROUND

What is Spire? What is SCADA?

What is SCADA?

- Supervisory Control and Data Acquisition
- Allows for centralized control over systems that are spread out over large distances
- Monitors and controls devices that collect information from and interact with the physical world such as power breakers, valves, HVAC controllers, factory machine computers
- Used widely in critical infrastructure:
  - Electrical grids, water treatment facilities, power plants buildings, factories, facilities etc.

SCADA System Layout

- PLCs/RTUs
  - Sensors and/or control units
  - Closest level of interaction with process
- SCADA Master
  - Coordinates network of PLCs/RTUs
- HMI
  - Interface through which human operators can monitor and give commands to the system

Current SCADA Vulnerabilities

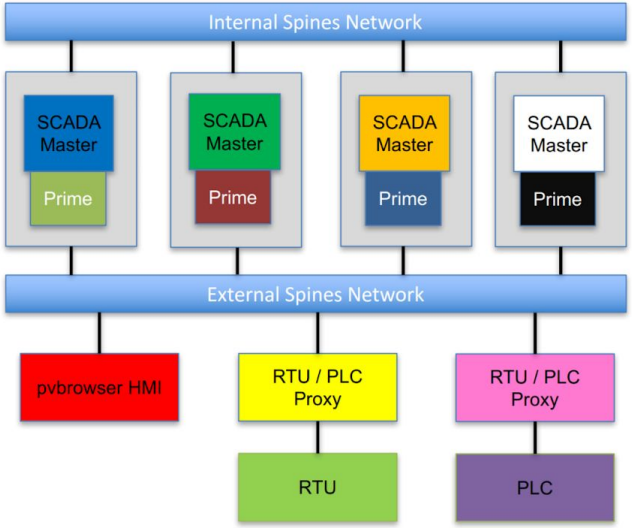
- Use in critical infrastructure makes SCADA systems valuable targets to attack, especially by state actors
  - Stuxnet
- Compromised SCADA systems can disable or potentially permanently destroy critical infrastructure
  - 2015 Ukrainian Power Grid Attack
    - Power cut for 230,000 people
- Transition from closed networks to IP exposes SCADA systems to the internet, easier to attack
  - Experiment with honeypot of PLCs were attacked 39 times from 14 countries in a month(Aron)

What is Spire?

- Spire is an open-source, intrusion tolerant SCADA solution over IP
- Many components work together to prevent attacks
  - Spines: Networking
  - Prime: Timely Byzantine Fault Tolerance
  - Multicompiler: Entropy
  - Scheduled Resets
- RTU/PLC Proxy

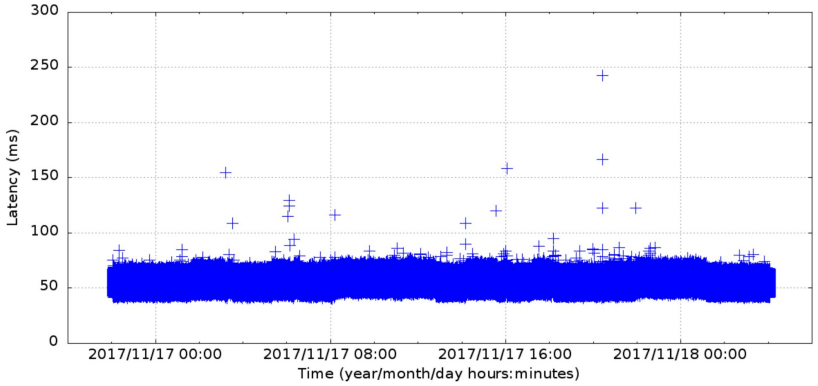
How It Actually Works

Spire Architecture: Single Control Center



Effectiveness – Does It Work?

- Short Answer:
- Resisted an extensive attack by a Sandia National Laboratories
- Also retains timeliness consistently, with some variations because of special circumstances



2.
OUR WORK

Introducing attack-awareness to an intrusion-tolerant system

Attack-Awareness

- Spire handles many attacks silently, without notifying a human operator
  - Bad leader in byzantine agreement protocol
  - Dumb DDoS attacks (from compromised device)
- These problems could be easily resolved with human awareness (i.e. unplugging a compromised master)
- Our goal: Displaying HMI alerts to notify operators of ongoing attacks of different types

Attack Types of Note

DDoS Attacks

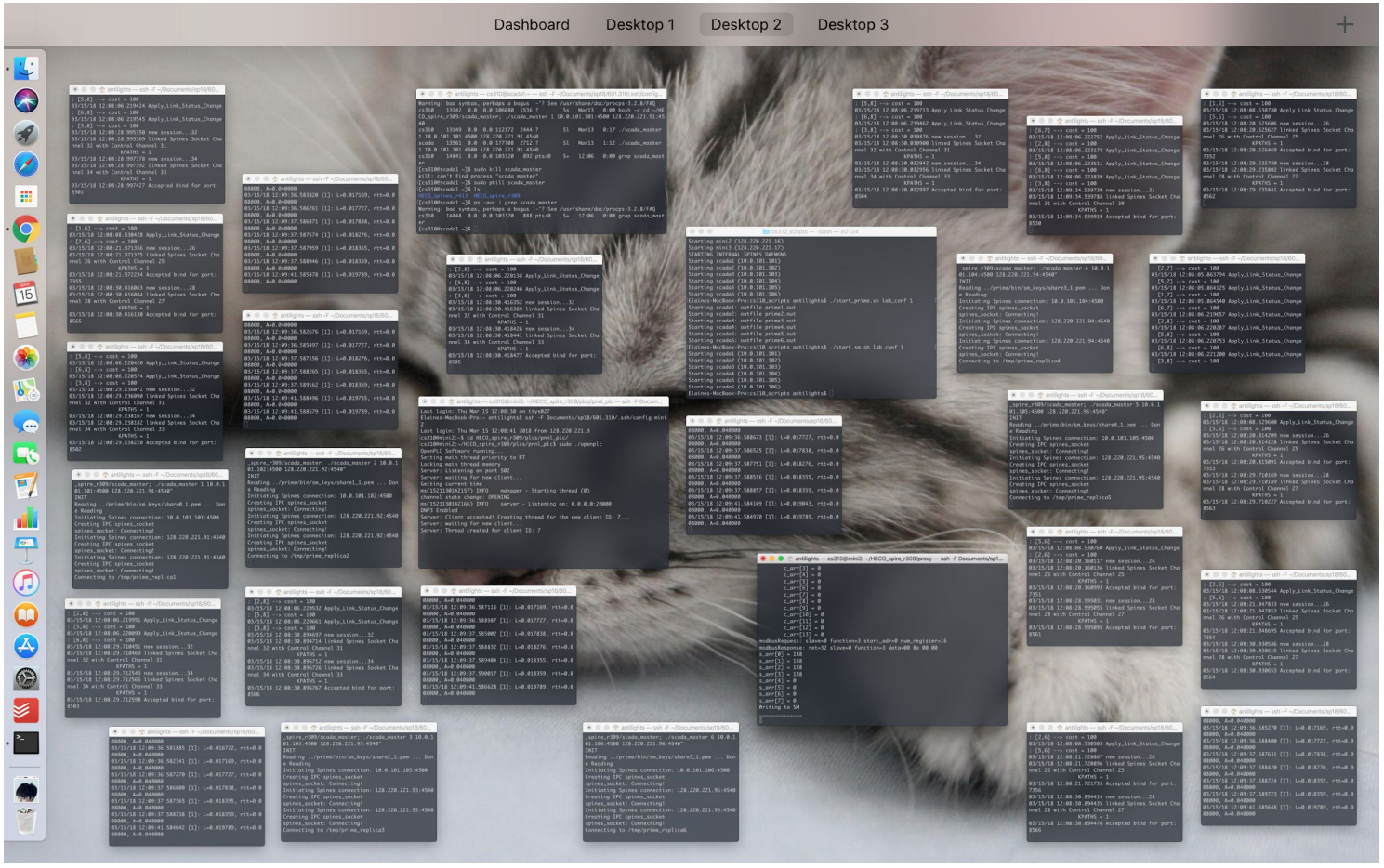
- Dumb attacks from adversaries who may have compromised part of the system and are spamming it with random messages
- Can happen at HMI, proxy, and firewall levels

Bad Leader Attacks

- A compromised SCADA master who leads the agreement protocol sends inconsistent messages to other masters, delaying instruction execution
- This occurs inside prime

What We Have Accomplished (Part I)

- First few weeks: Just getting to know the code
  - Exploring the codebase, learning about Spire in general
  - Setting up VMs to work with HMIs on PVBrowser
  - Getting to know PVBrowser
- Then: Learning how to set up the full system (HMIs, PLCs, SCADA masters, oh my!)


Dashboard
Desktop 1
Desktop 2
Desktop 3

What We Have Accomplished (Part II)

- First: A plain alert message on HMI for internal DDoS attacks
- This later became a table displaying which SCADA master is spamming the HMI, and is therefore the compromised machine
- Similarly, we display an alert when the proxy is being spammed
- Adding an alert for bad leaders in the Prime agreement protocol
- Adding logging for possible firewall spam

DEMOS!!!!!

Challenges

- Getting through the codebase
- PVBrowser/Ubuntu/Centos issues with freezing
- Mostly, didn't/haven't had enough experience with the system to develop an intuition of where different kinds of bugs could be coming from
  - Weird problems like clock synchronization for Spines communication or temp files that we needed sudo access to delete
  - Sometimes just had to restart the whole thing

Future Work

- Generalizing the alert system
  - Ex. There are a lot of places where Prime can detect suspicious activity, but doesn't alert
  - Detecting replay attacks (a less dumb DDoS attack) which forces system to decrypt before discarding message
- Integrating logging for firewall spam into the HMI
- Cleaning up; this was mostly proof of concept

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