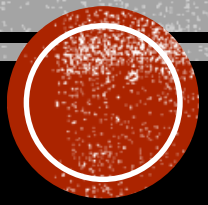
A REMOTELY ACCESSIBLE, CONFIGURABLE, INSTRUMENTED ICS LAB FOR ATTACK, DEFEND, AND FORENSICS RESEARCH AND EDUCATION



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Associate Professor, ECE
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Professor, SEOR
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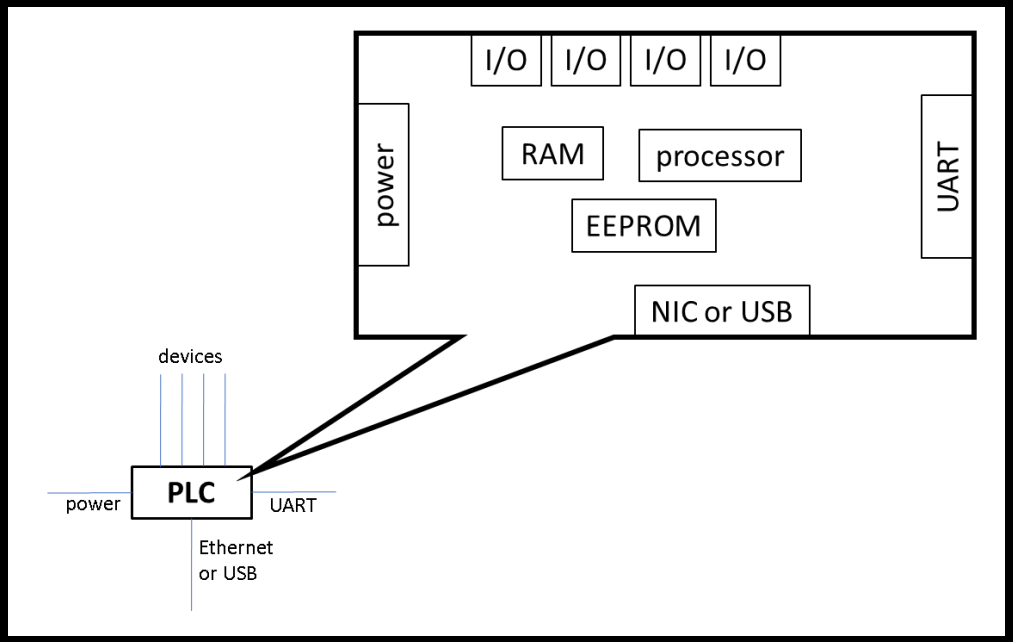
BACKGROUND

- **ICS: Industrial Control System**
- **PLC: Programmable Logic Controller**

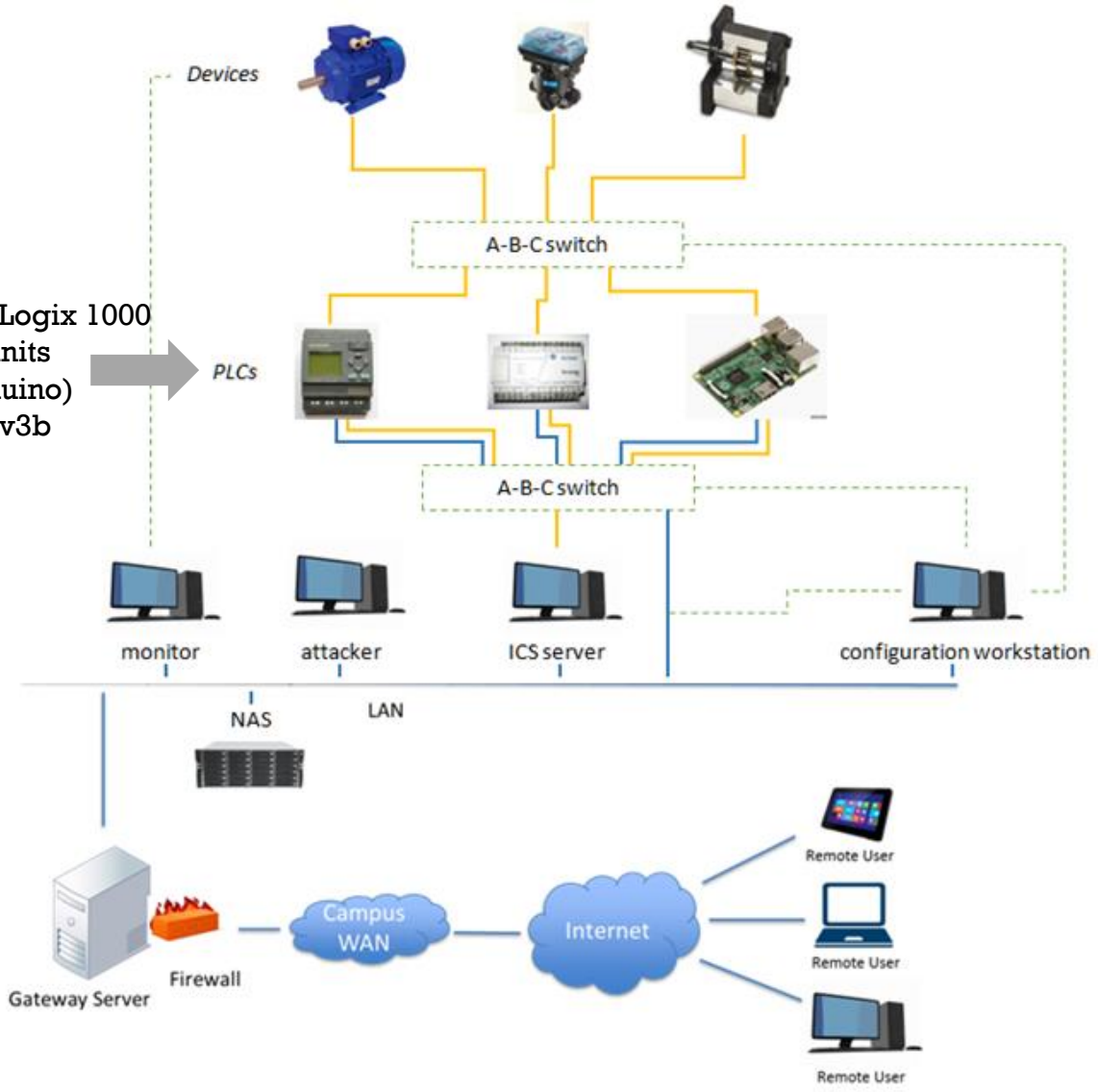


WHY? WHAT'S THE NEED, GAP, PROBLEM?

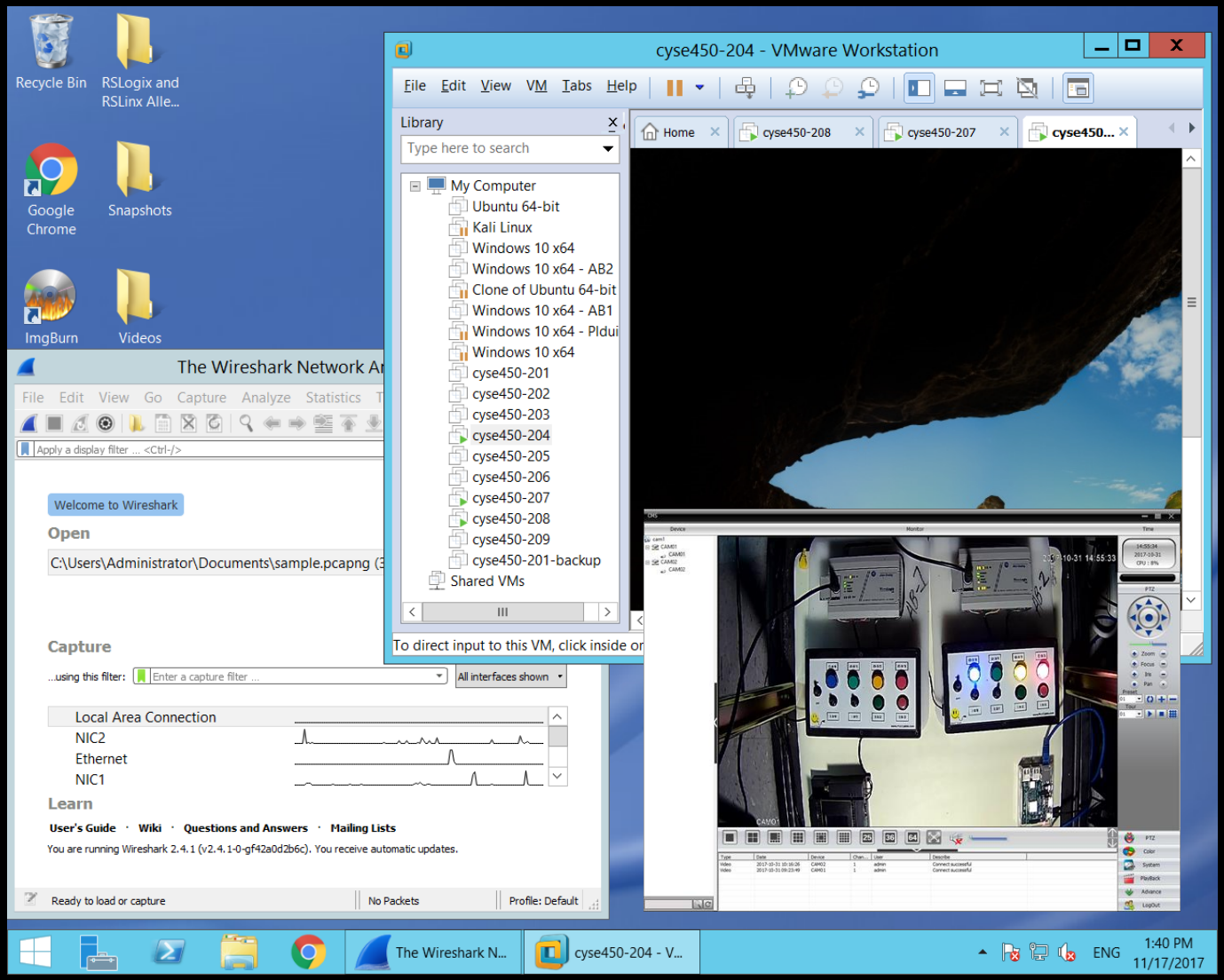
- **Academic programs:**
  - BS Cybersecurity Engineering
  - BS/MS Computer Engineering
  - PhD Information Technology with concentration in Digital Forensics
- **Research:**
  - Attack and compromise residual digital artifacts
    - persistent storage, volatile memory, and network
- **Need:**
  - Hands-on with realistic devices and environments
- **Problem:** virtual is useful for many cases, but with PLCs…
  - fidelity for deep forensics (e.g., storage behavior)
  - physical effects (e.g., power and other faults, inputs)
- **Goal:**
  - Real, remote environment for testing attack, defense, response, and forensics on ICS components (especially PLCs vs. control workstations)
- **Funding:**
  - NSA/US Army Reserve P3i grant

WHAT WE BUILT...

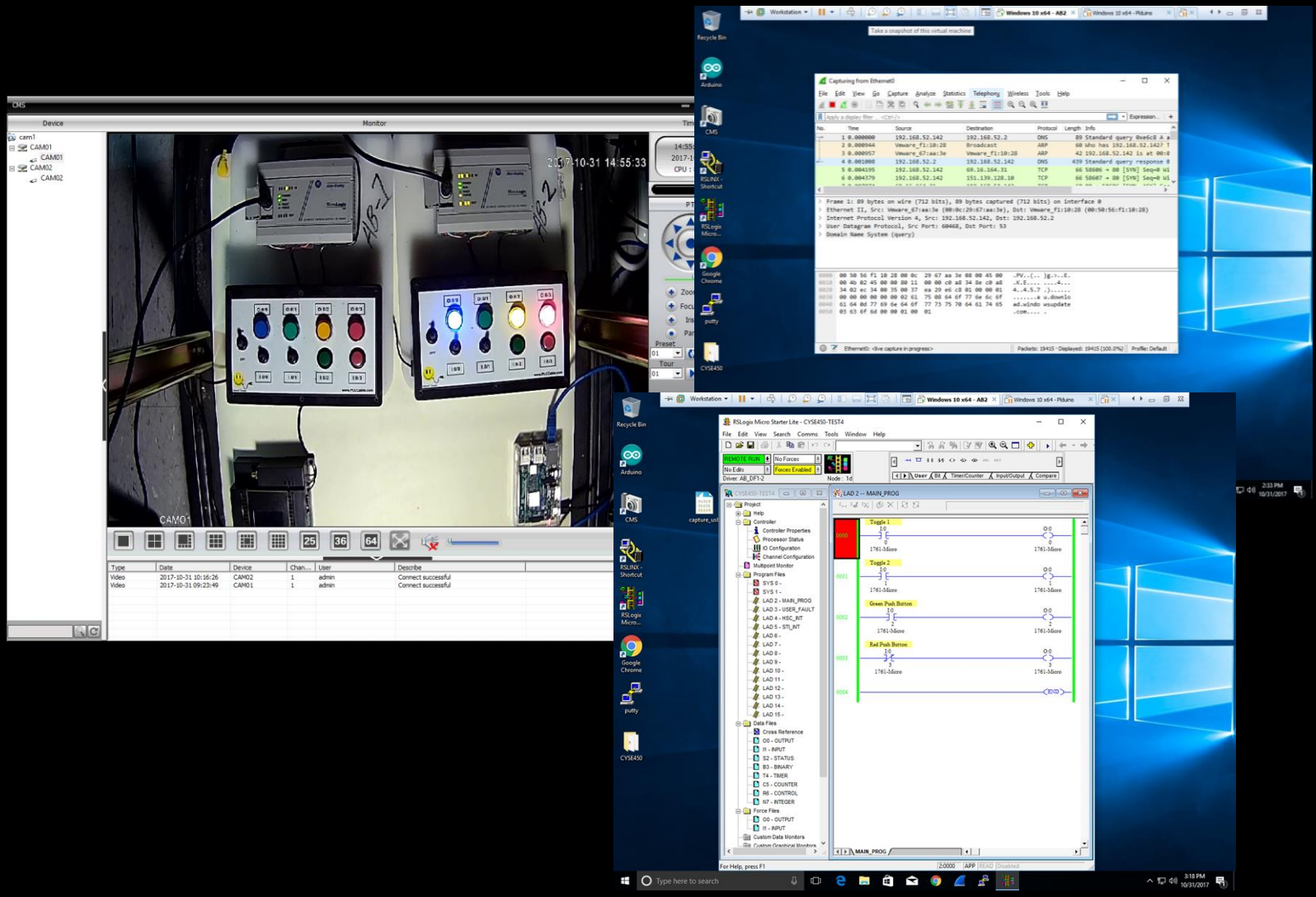
2 Allen-Bradley MicroLogix 1000
2 Siemens S7 units
1 OpenPLC (Arduino)
2 RaspberryPi v3b



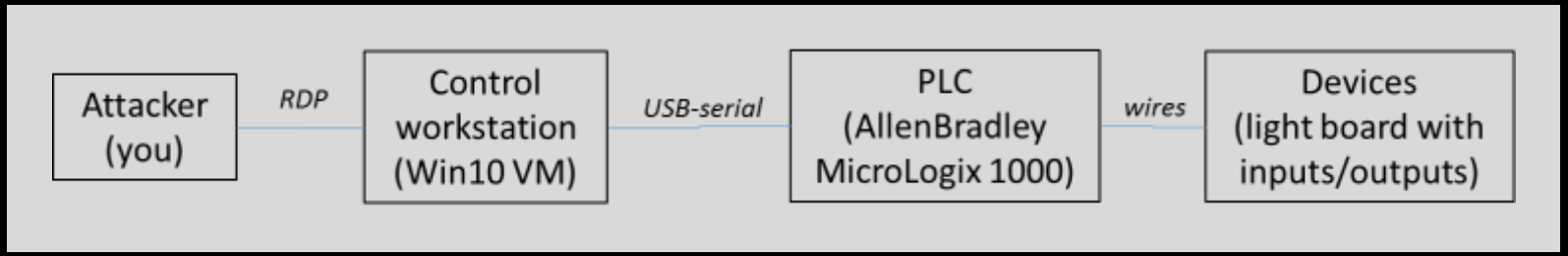
THE ADMINISTRATOR SEES...



THE STUDENT SEES…



STUDENT EXERCISE (CYSE 450)



Exercise Activities:

- Access VM (control workstation)
- Sniff Ethernet side
- Sniff USB/serial side
- Alter PLC states
- Capture running program
- Modify and load running program
- Analyze firmware
- Analyze memory
- Offensive and defensive considerations

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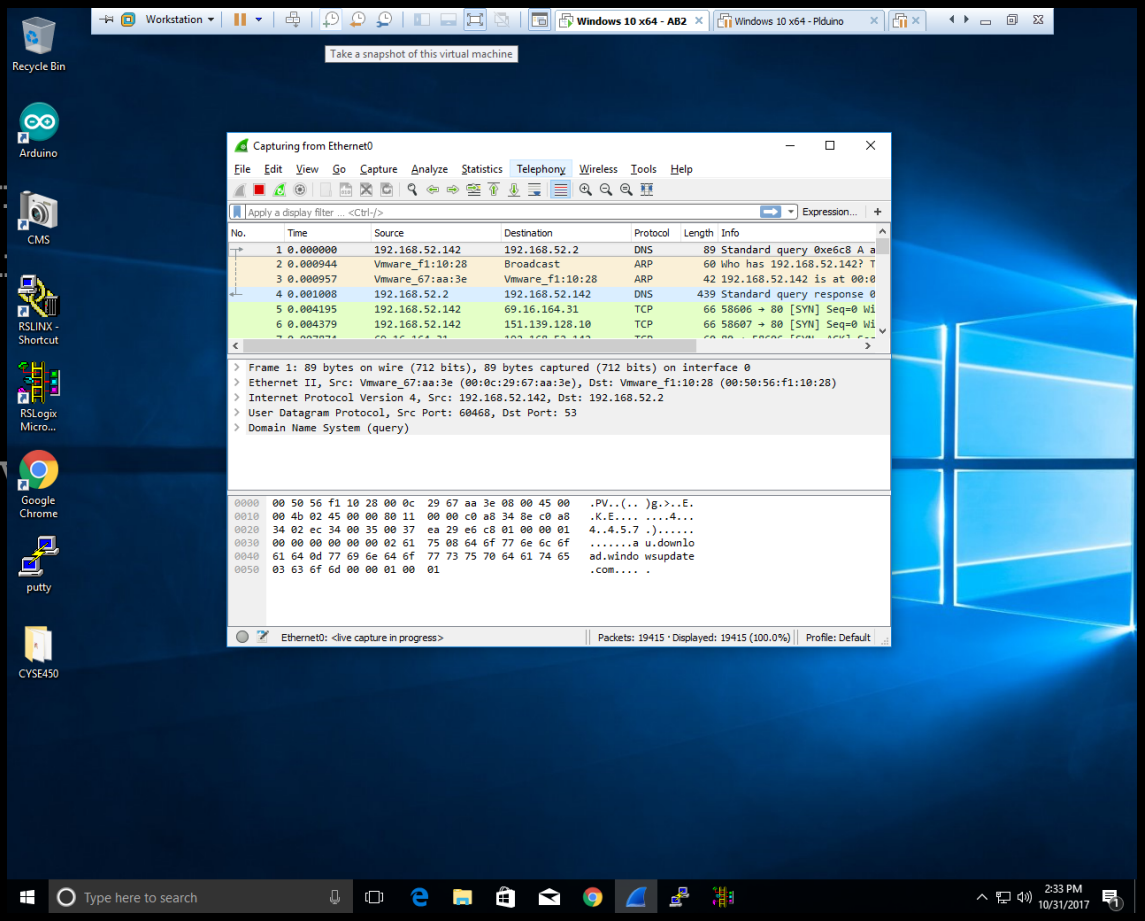

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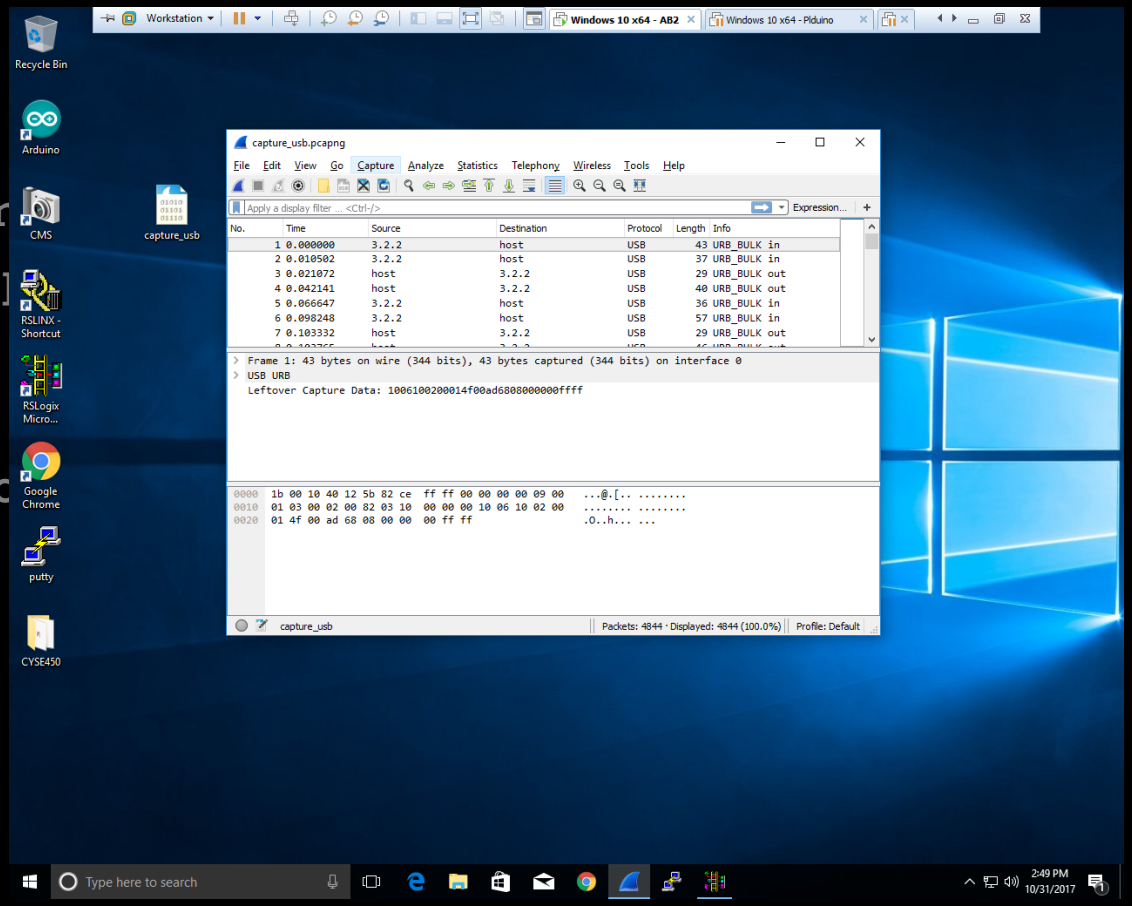

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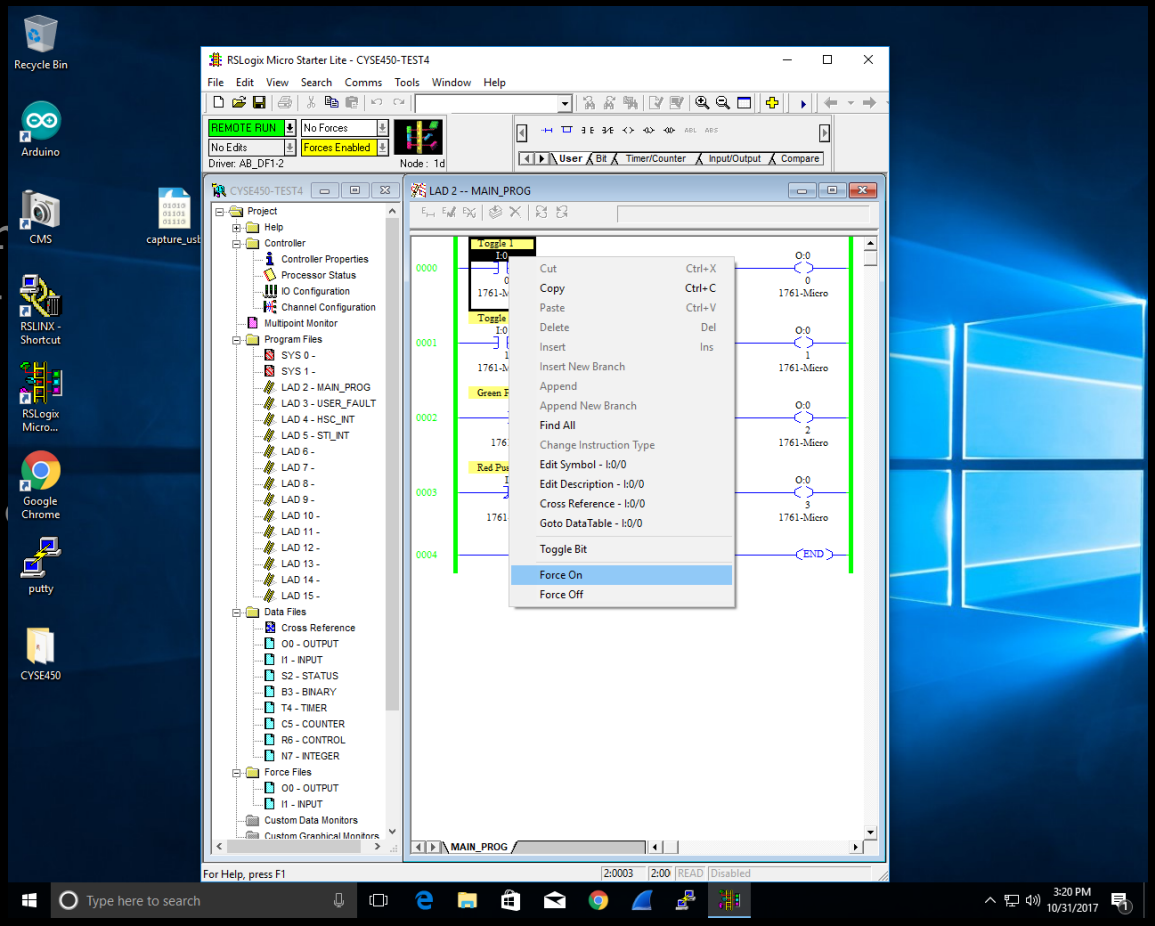

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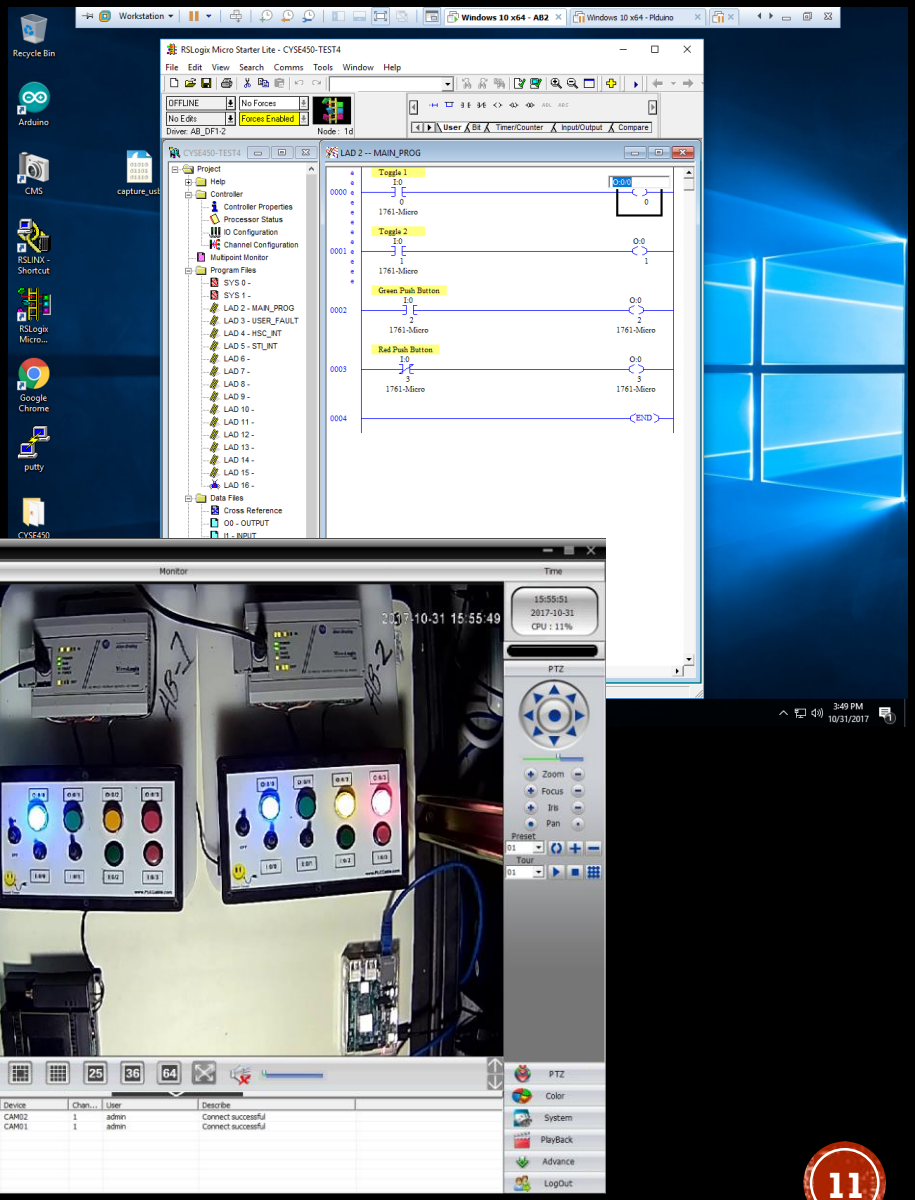

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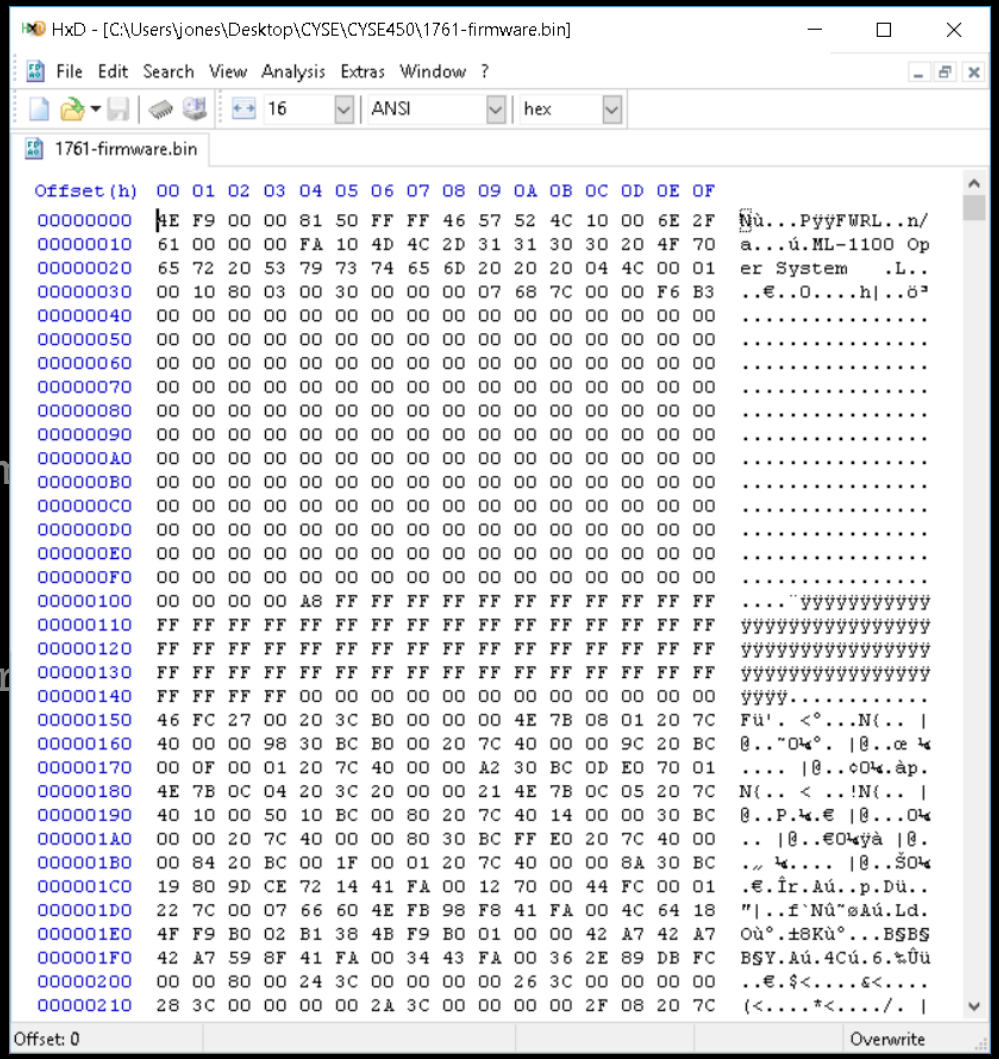

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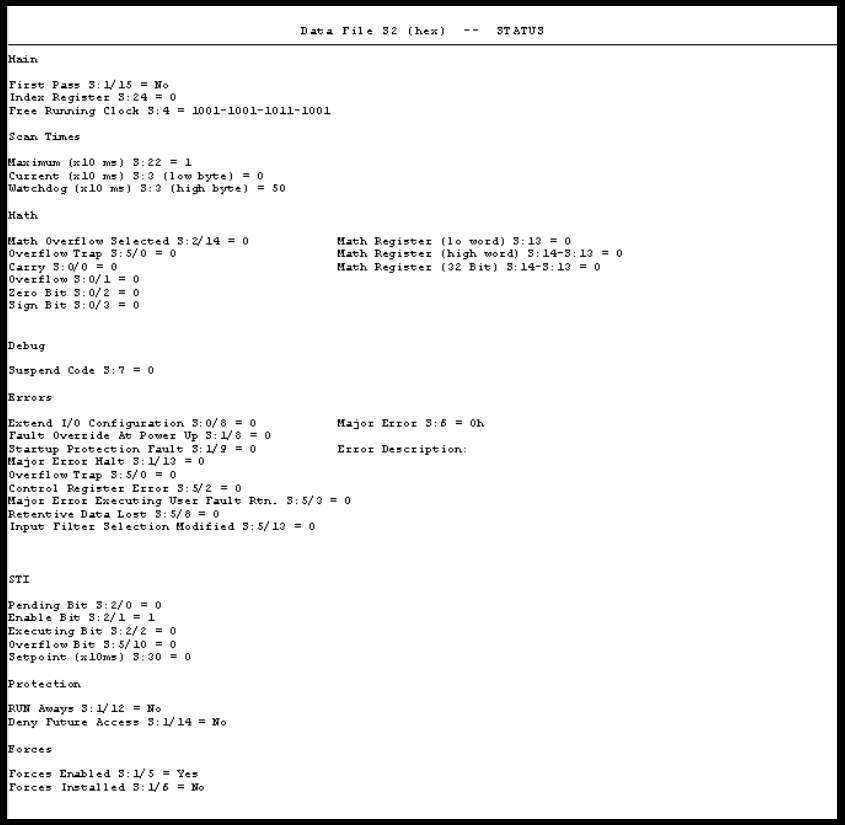


Data File S2 (hex) -- STATUS

Main

First Pass S:1/15 = No
Index Register S:24 = 0
Free Running Clock S:4 = 1001-1001-1011-1001

Scan Times

Maximum (x10 ms) S:22 = 1
Current (x10 ms) S:3 (low byte) = 0
Watchdog (x10 ms) S:3 (high byte) = 50

Math

Math Overflow Selected S:2/14 = 0
Overflow Trap S:5/0 = 0
Carry S:0/0 = 0
Overflow S:0/1 = 0
Zero Bit S:0/2 = 0
Sign Bit S:0/3 = 0
Math Register (lo word) S:13 = 0
Math Register (high word) S:14-S:13 = 0
Math Register (32 Bit) S:14-S:13 = 0

Debug

Suspend Code S:7 = 0

Errors

Extend I/O Configuration S:0/8 = 0
Fault Override At Power Up S:1/8 = 0
Startup Protection Fault S:1/9 = 0
Major Error Halt S:1/13 = 0
Overflow Trap S:5/0 = 0
Control Register Error S:5/2 = 0
Major Error Executing User Fault Rtn. S:5/3 = 0
Retentive Data Lost S:5/8 = 0
Input Filter Selection Modified S:5/13 = 0
Major Error S:6 = 0h
Error Description:

STI

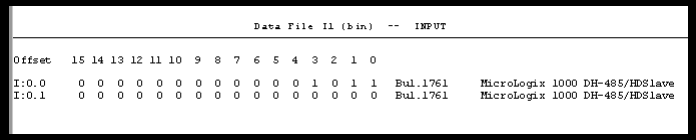
Pending Bit S:2/0 = 0
Enable Bit S:2/1 = 1
Executing Bit S:2/2 = 0
Overflow Bit S:5/10 = 0
Setpoint (x10ms) S:30 = 0

Protection

RUN Aways S:1/12 = No
Deny Future Access S:1/14 = No

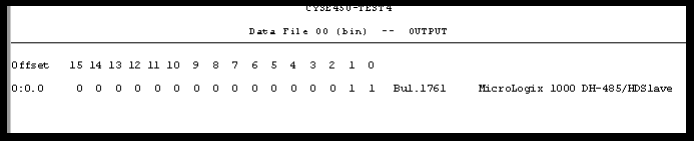
Forces

Forces Enabled S:1/5 = Yes
Forces Installed S:1/6 = No



Data File I1 (bin) -- INPUT

Offset	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
I:0.0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	Bul.1761	MicroLogix 1000 DH-485/HDSlave
I:0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Bul.1761	MicroLogix 1000 DH-485/HDSlave



CYSE450-TEST4

Data File O0 (bin) -- OUTPUT

Offset	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
O:0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	Bul.1761	MicroLogix 1000 DH-485/HDSlave

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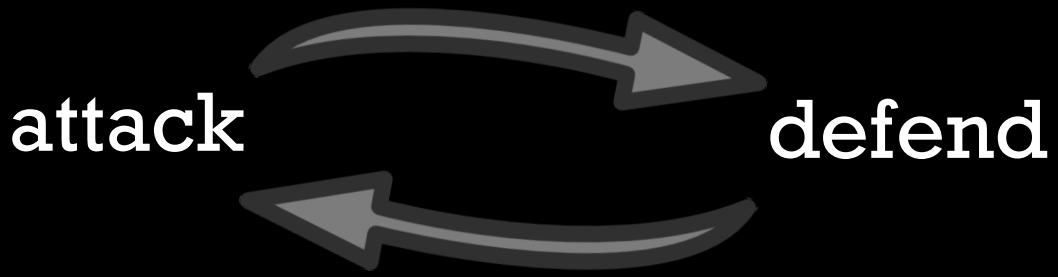

RESULTS AND NEXT STEPS

RESULTS:

- Minimal problems walking through guided portion of lab
  - Exposure to PLCs, ladder logic
- Applied existing skills analyzing network, code, firmware, memory
- Offense and defense:
  - ideas from lab and open sources
  - applied iterative security assessment model

NEXT STEPS:

- Additional hardware (more PLCs)
- Additional exercises (attack and manipulation; forensics)
- More instrumentation
- Sequential memory snapshot analysis under adversarial activity

QUESTIONS?

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