SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

CPS-SPC 15 @ Denver CO

MiniCPS: A toolkit for security research on CPS Networks

DANIELE ANTONIOLI (SUTD) NILS OLE TIPPENHAUER (SUTD)

Hi!

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

- Personal:
  - DANIELE ANTONIOLI
  - SUTD's ISTD PhD (Prof N.O. TIPPENHAUER)
- SCy-Phy group:
  - Applied CPS security research

Why MiniCPS: Cyber-Physical Systems

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

- CPS are:
  - Complex
  - Critical
  - Connected

Why MiniCPS: Cyber-Physical Systems

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

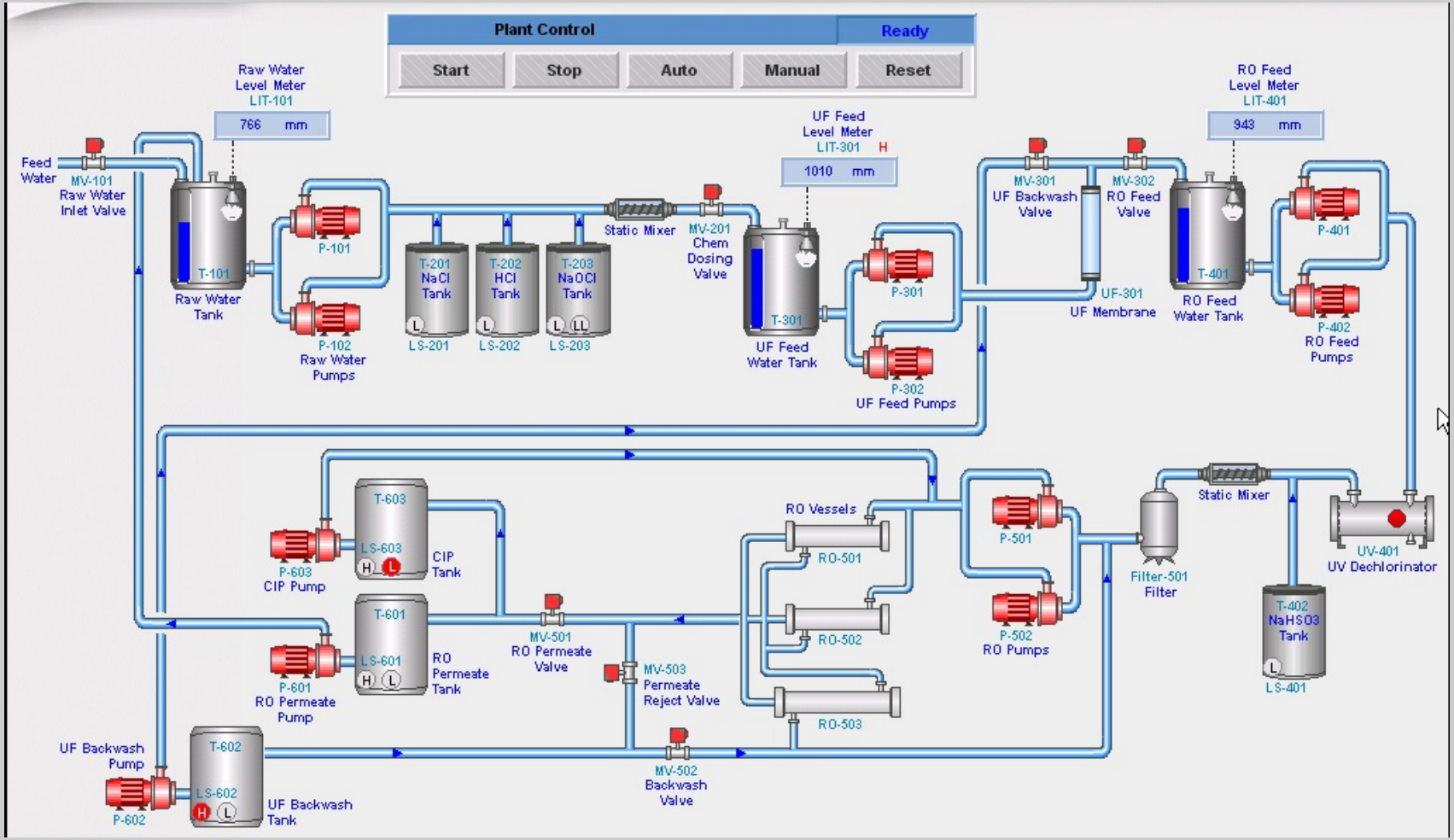
- CPS are:
  - Complex
  - Critical
  - Connected
- CPS information may be difficult to:
  - Obtain
  - Prove
  - Share

Why MiniCPS: Cyber-Physical Systems

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

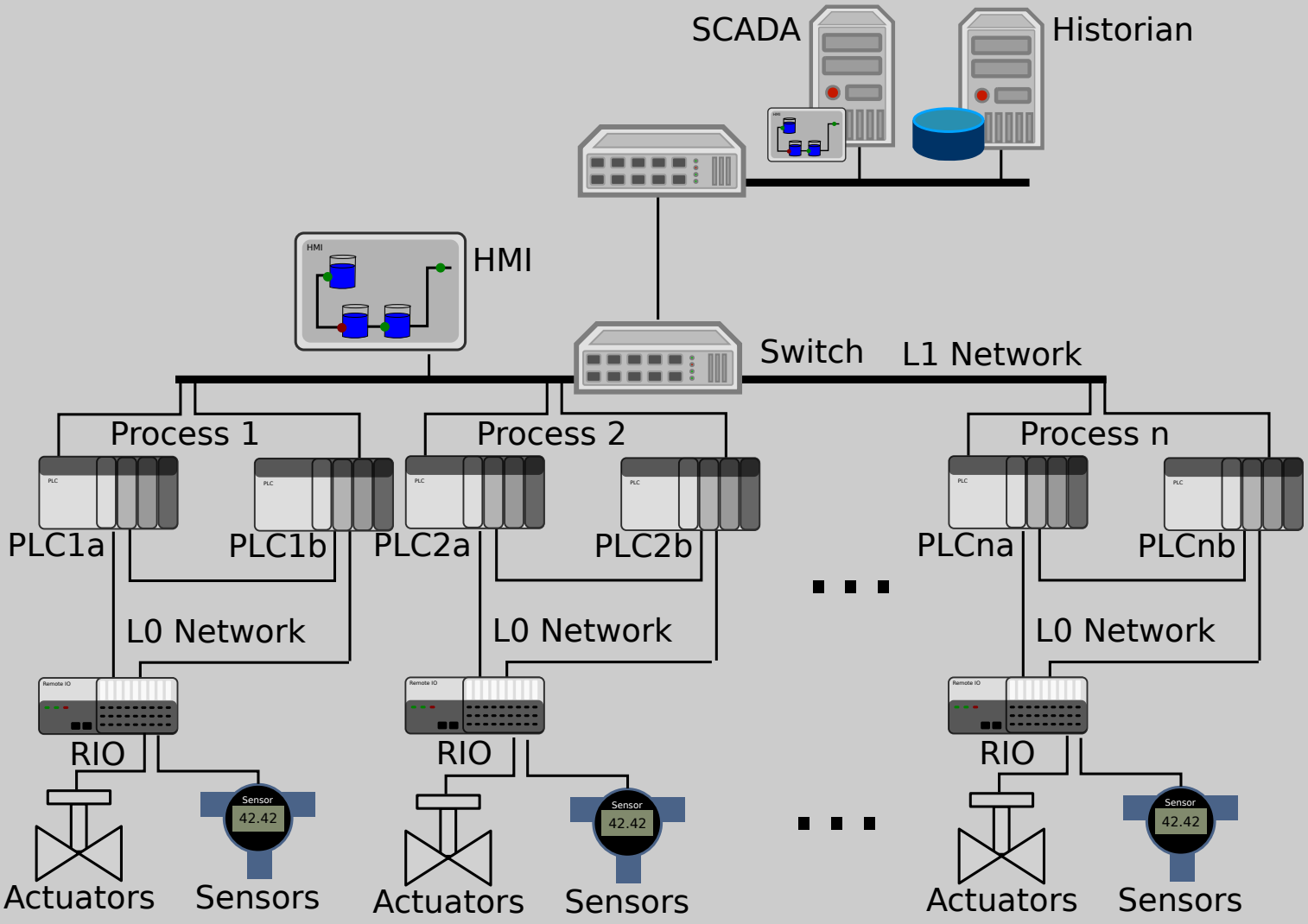
- CPS are:
  - Complex
  - Critical
  - Connected
- CPS information may be difficult to:
  - Obtain
  - Prove
  - Share
- CPS research requires different expertises:
  - Electronics, Automation
  - Networking, Computer Science
  - Physics. . .

Why MiniCPS: SWaT testbed



- Pure Water: 5 US gallons/min, $6.0 - 7.0$ pH, minimum conductivity of 10 $\mu S/cm^3$
- Recovered Water: 70% processed water, 50% dirty recirculation

Why MiniCPS: SWaT network



- Wired and Wireless links.
- Ethernet/IP, Common Industrial Protocol.

MiniCPS: Vision

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

- Research Environment:
  - Reproducible
  - Extensible
  - Shareable

MiniCPS: Vision

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

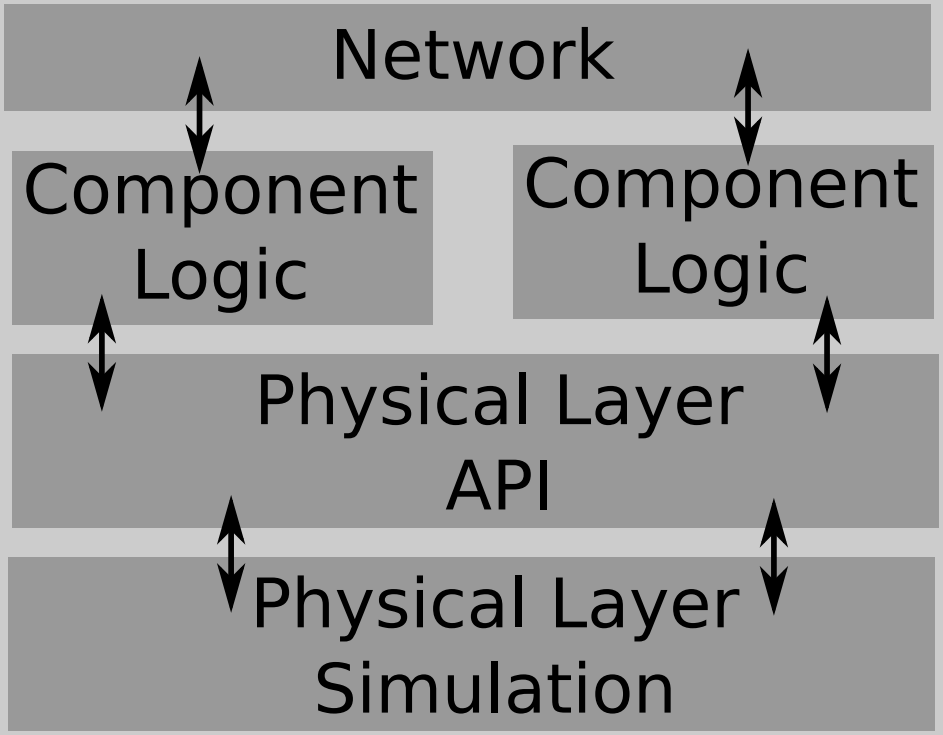
- Research Environment:
  - Reproducible
  - Extensible
  - Shareable
- Targeted to Cyber-Physical Systems:
  - Network communications
  - Control logic
  - Physical layer interaction

MiniCPS: Vision

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

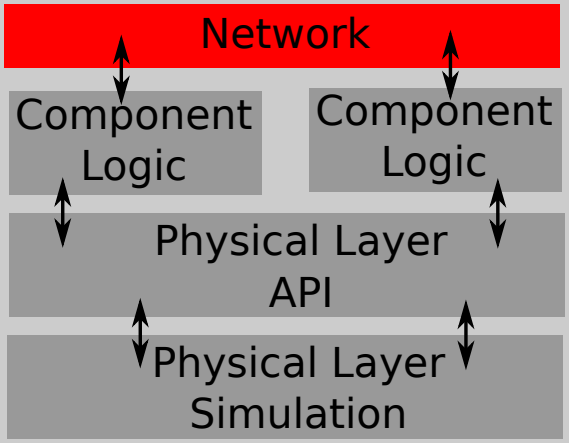
- Research Environment:
  - Reproducible
  - Extensible
  - Shareable
- Targeted to Cyber-Physical Systems:
  - Network communications
  - Control logic
  - Physical layer interaction
- Don't reinvent the wheels...
  - But: "*Stand on the Shoulders of Giants*"
  - Eg: `linux`, `python`, `mininet`, `git`

MiniCPS: Diagram



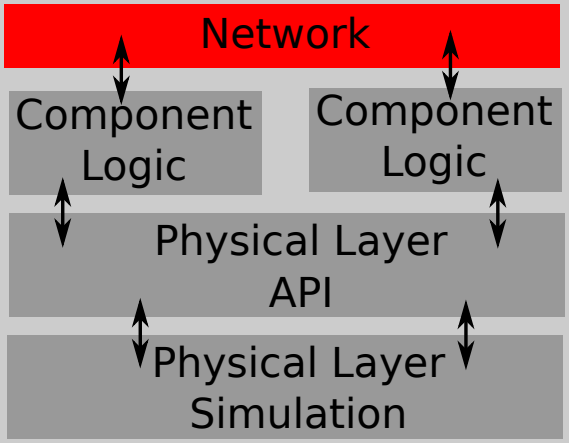
- (C)yber $\rightarrow$ Network Emulator
- (P)hysical $\rightarrow$ Process Simulation, State API
- (S)ystem $\rightarrow$ Control Logic Simulation

MiniCPS: What is Mininet



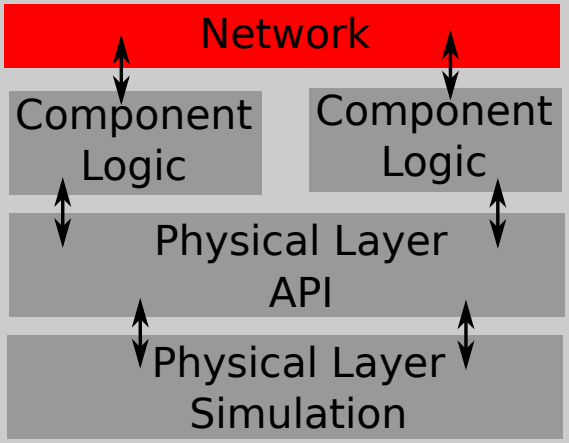
- Network-in-a-box emulator:
  - Reproduce (complex) topologies
  - Generating real packets using real protocols

MiniCPS: What is Mininet



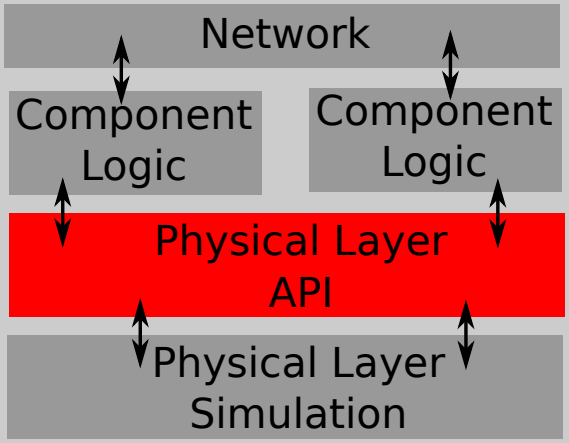
- Network-in-a-box emulator:
  - Reproduce (complex) topologies
  - Generating real packets using real protocols
- One Linux kernel, multiple devices:
  - Lightweight virtualization
  - Each device is a *container*

MiniCPS: What is Mininet



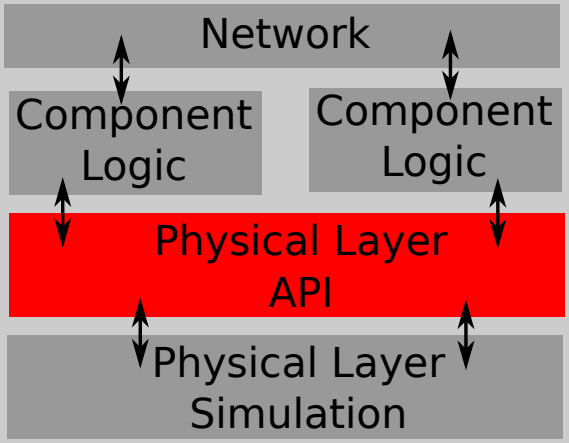
- Network-in-a-box emulator:
  - Reproduce (complex) topologies
  - Generating real packets using real protocols
- One Linux kernel, multiple devices:
  - Lightweight virtualization
  - Each device is a *container*
- SDN/OpenFlow development

MiniCPS: Physical Layer API



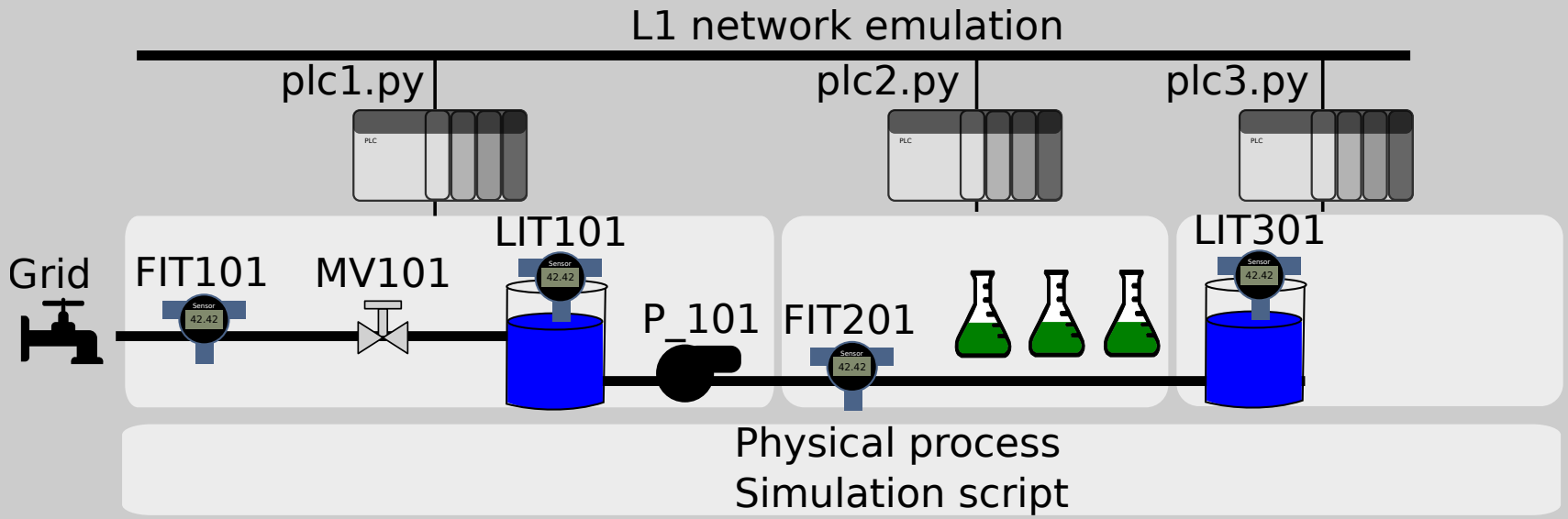
- Database to represent the (physical) state:
  - Abstract low-level details (SQL query)
  - Use high level semantic functions: `get`, `set`

MiniCPS: Physical Layer API



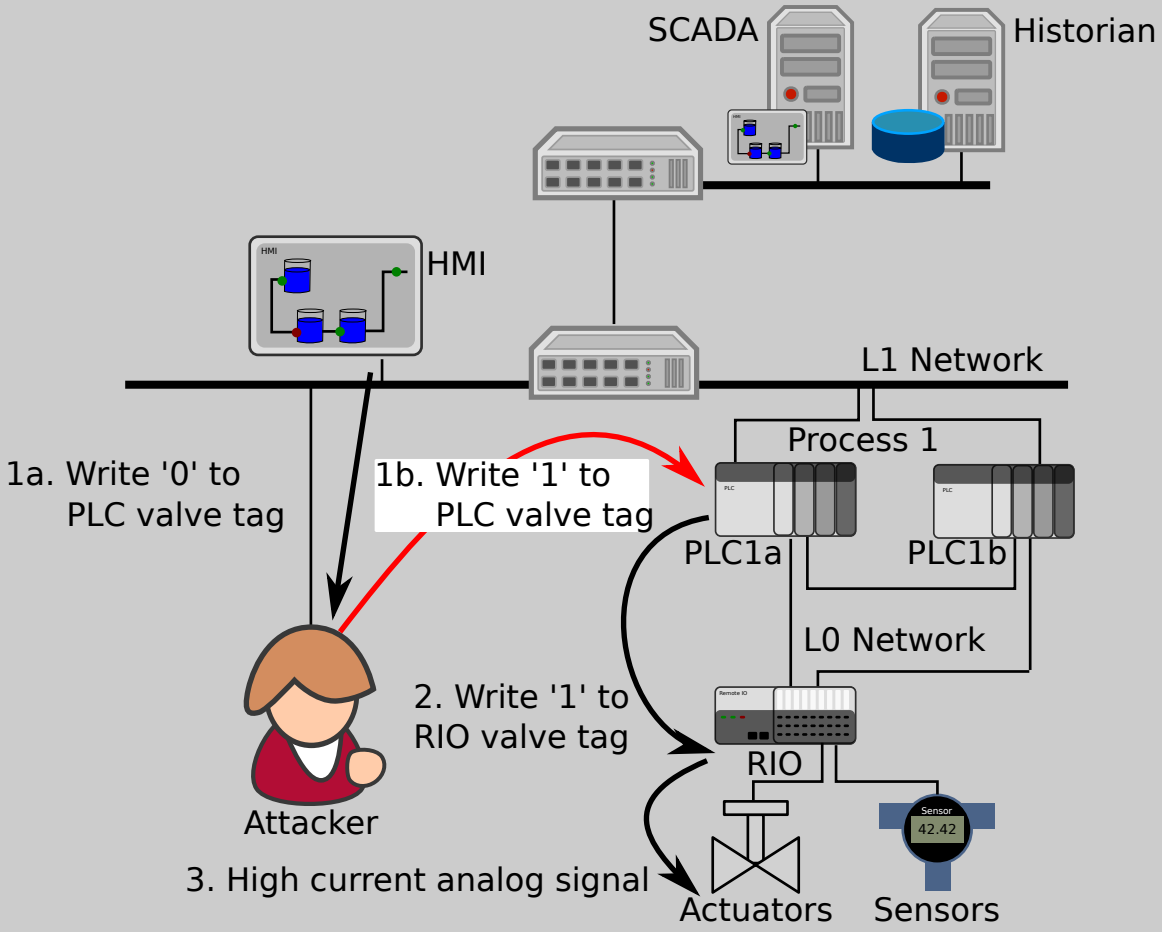
- Database to represent the (physical) state:
  - Abstract low-level details (SQL query)
  - Use high level semantic functions: `get`, `set`
- Compatibility layer:
  - Programming Language agnostic
  - Support different storage back-ends

MiniCPS: SWaT example



- Control strategy:
  - Sensors: level (LIT), flow (FIT)
  - Actuators: motorized valve (MV) and pump (P)
  - PLC1 takes decision with the aid of PLC2 and PLC3
  - Physical process simulation updates the state
- Network:
  - Realistic addresses (CIDR, MAC, ports)
  - Replicate services: web-servers, ENIP client/server
  - Optional Attacker and SDN Controller

MiniCPS: SWaT example II



- *Passive* and *Active* ARP poisoning MITM attacks
- *SDN Controller* for ARP poisoning Detection and Mitigation

MiniCPS: Conclusions

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

- MiniCPS is a CPS research platform:
  - Reproducible
  - Extensible
  - Shareable
- MiniCPS is used to investigate issues in real testbeds:
  - MITM attacks (`ettercap`)
  - Ethernet/IP reverse-engineering (`scapy`)
  - SDN controllers development (`pox`)

MiniCPS: Conclusions

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

- MiniCPS is a CPS research platform:
  - Reproducible
  - Extensible
  - Shareable
- MiniCPS is used to investigate issues in real testbeds:
  - MITM attacks (`ettercap`)
  - Ethernet/IP reverse-engineering (`scapy`)
  - SDN controllers development (`pox`)
- Contribute:
  - `http://scy-phy.github.io/index.html`
  - `https://github.com/scy-phy/minicps`
- Thank You!

Q & A