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A Dataset to Support Research in the Design of Secure Water Treatment Systems

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TECHNOLOGY AND DESIGN
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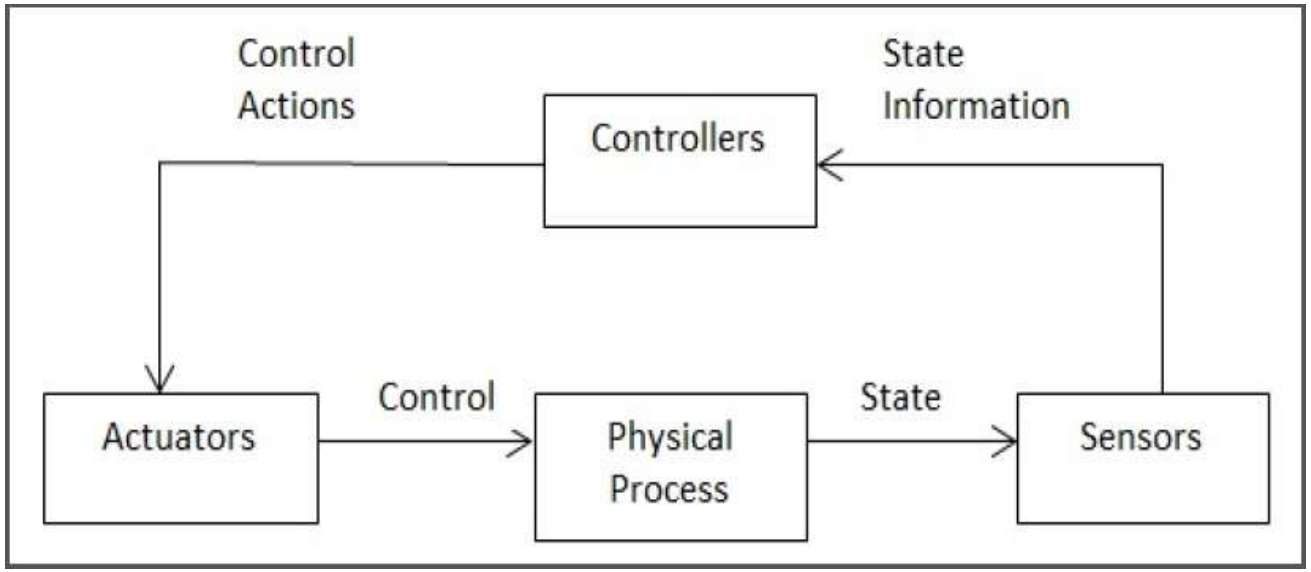
Cyber Physical Systems

- CPS is a combination of physical process, computation and communication.
- CPS are across different sectors: energy, water, transportation, healthcare, manufacturing, etc.



Water treatment Systems

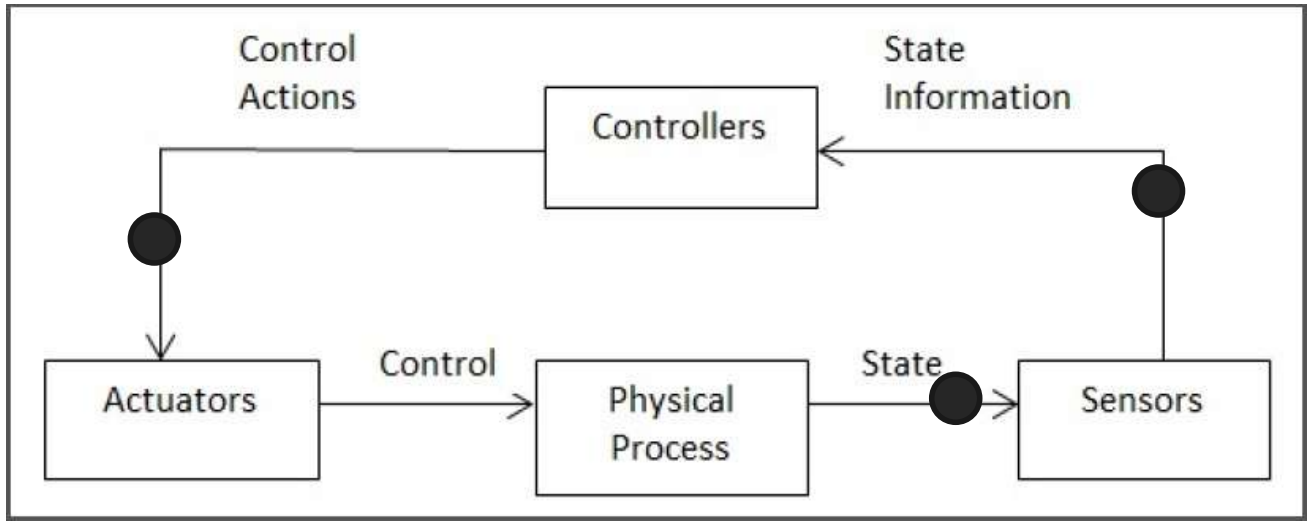
Hyflux Ltd.'s SingSpring Desalination Plant in Singapore. PHOTO: BLOOMBERG

The Secure Water Treatment (SWaT) testbed at the Singapore University of Technology and Design

Attacks on Cyber Physical Systems

- “Cyber attack" refers to an attempt at disturbing the state of CPS through its communication network and affect system behaviour with an intent to cause some economic harm.

  - Moaroochy shire: 2000
  - Stuxnet: 2010
  - Ukraine black out: 2015



Problem

- Machine learning researchers are learning physical behaviour of the Cyber Physical Systems (CPS), in order to asses the safety and security of CPS.
- Verification researchers are modelling CPS using formal models to verify safety, security of CPS.
- These researchers have a limited datasets available to advance this field of study.

Datasets in CPS systems

- Limited availability of operational data sets in this research community to advance the field of securing CPS
  - DARPA Intrusion Detection Evaluation Dataset
  - NSL-KDD99 Dataset
- These are simulations in a network environment.

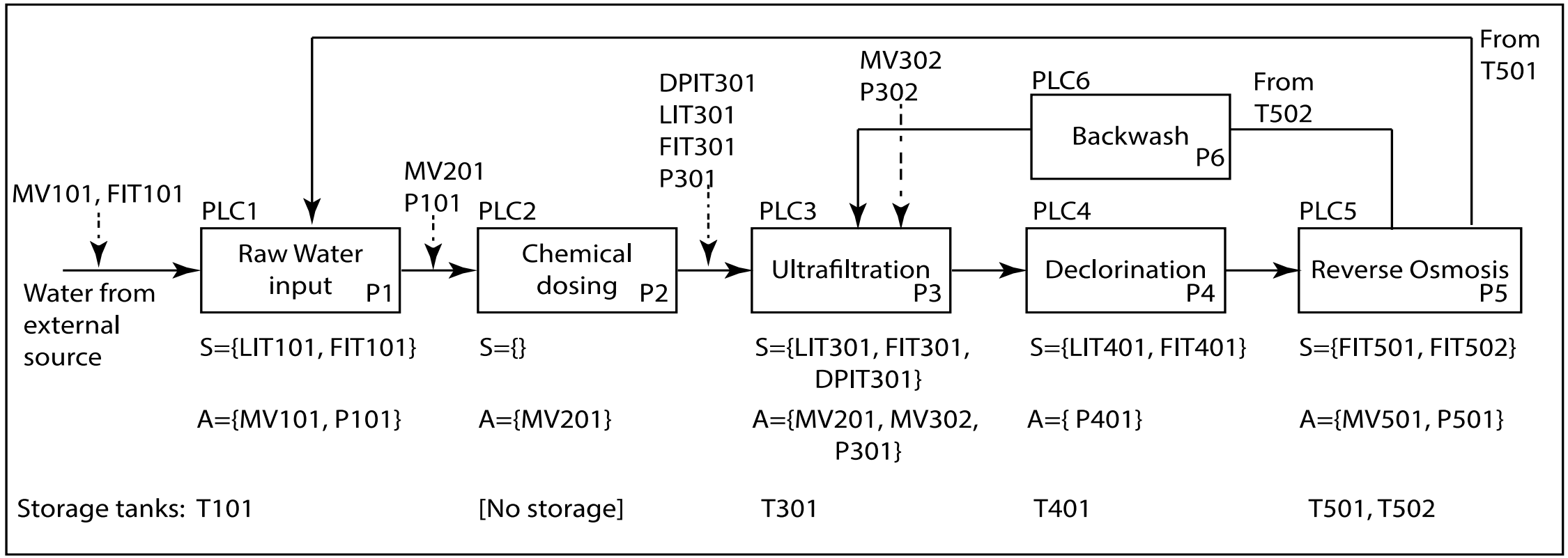
- Mississippi State University: Power, Gas, Water testbeds.
  - However, power dataset is simulated data and water, gas datasets were obtained from a very small scale laboratory testbed.

Contributions include

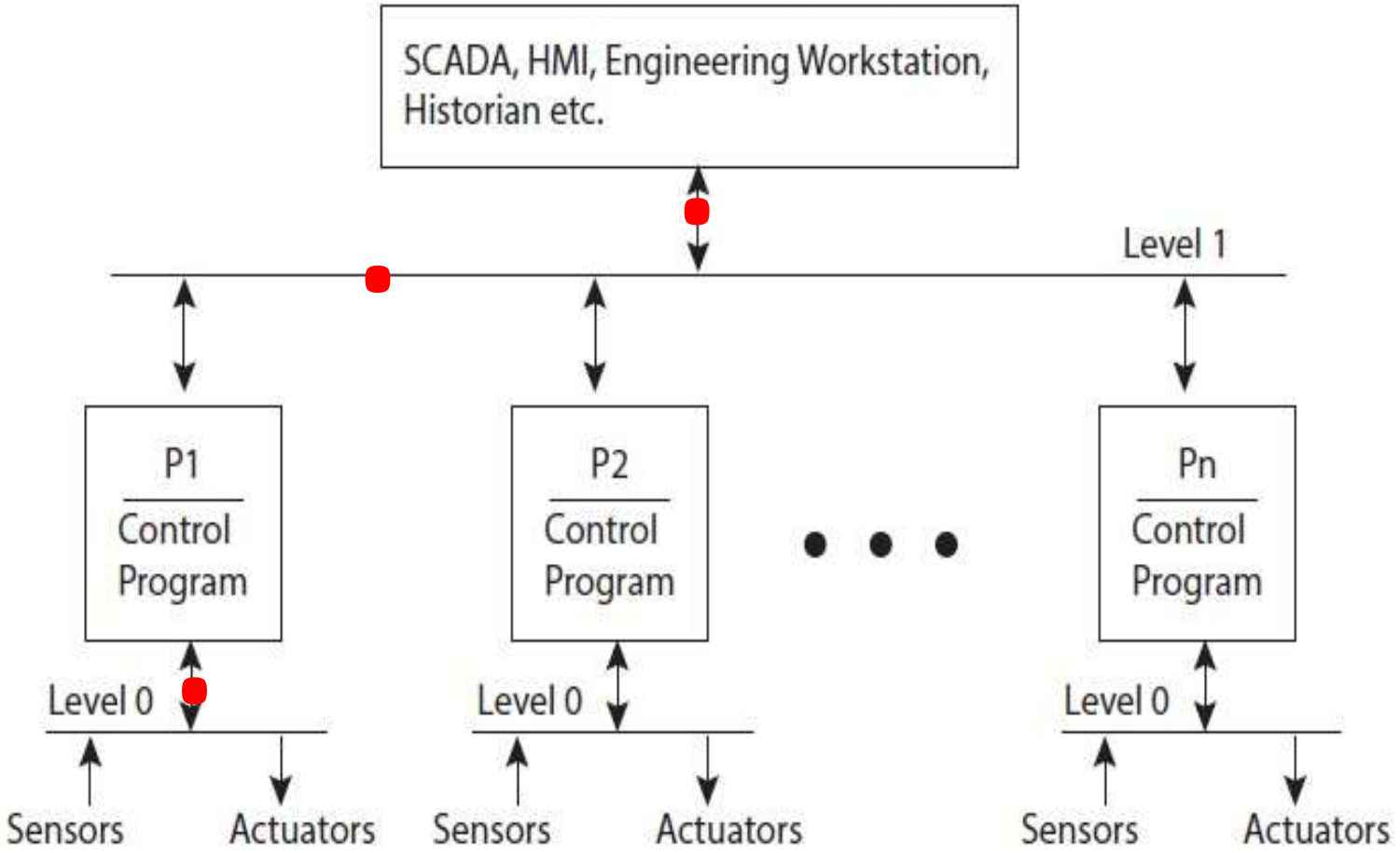
- Provide a realistic dataset
  - To design and evaluate CPS defence mechanisms.
  - Test mathematical models and formal models of CPS.

- A large scale labelled-normal and attack-dataset collected from a realistic testbed for sufficient complexity.
  - Includes both network traffic and physical properties of data.

Secure Water Treatment (SWaT)



Architecture of SWaT: Communication



Number of Attacks

- A total of 36 attacks were launched during the data collection process.

- Which include:
  - Bias attacks
  - Replay attacks
  - Single point attacks
  - Multiple point attacks

Data collection process

- Data collected continuously for 11 days.
- All tanks in SWaT were emptied prior to starting data collection; i.e. the data collection process starts from an empty state of SWaT.
- During first seven days SWaT was operating normally.
- During the remaining four days SWaT was under attack
- SWaT was either allowed to reach its normal operating state before another attack was launched or the attacks were launched consecutively.

Physical Properties of SWaT

- In total, 946,722 samples comprising of 51 attributes were collected over 11 days.

- Attributes include:
  - Sensor readings: water tank level, flow meter's, water properties, pressure.
  - Actuator readings: water pump, motorized valves, Ultraviolet De-chlorinator

Network Traffic

Category
Date
Time
Origin
Source IP
Destination IP
Protocol . . .

Labelling data

- Start time ----Time when attack starts
- End time ----Time when attack ends
- Attack Points ----Sensors or actuator which will be compromised
- Start State ----Current status of the point
- Attack ----Description of attack
- Attack Value---- Substituted value of sensor (based on the attack)
- Attacker's Intent ----The intended affect of the attack

Conclusion

- This paper presents a dataset to support research in the design of secure Cyber Physical Systems.
- Real industrial CPS facilities may not be able to provide datasets, where datasets include the process was under attack, as faults or attacks can only be assumed at best.
- Our goal is to make the collection of CPSs datasets an on-going process to benefit researchers.
- The data collected will be continuously updated to include datasets from our new testbeds as well as new attacks derived from our research team.

Thank You!

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