Towards a Highly Secure PLC Architecture for CPS

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Short Presentation
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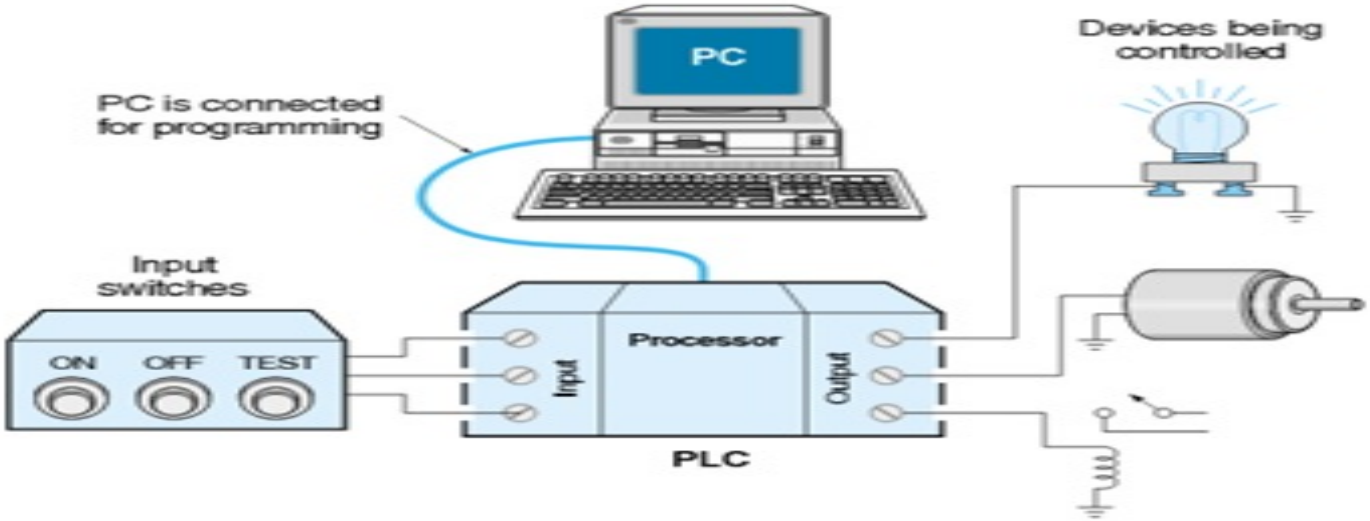
Introduction

- Recent attacks on cyber physical system (CPS)
  - Rootkit is planted in PLC, PLCpw
  - Most on power grid
- Discovery of the Stuxnet attack
  - Based on software subversion malware
- Demonstrate vulnerabilities in the current CPS
- Industrial Control Systems (ICS) components
  - Programmable Logic Controller (PLC)
  - Human Machine Interface (HMI)
  - Software development environment.

How to Make CPS Secure?

- Design security in from the beginning
  - System is secure only with respect to a policy
  - Especially include Mandatory Access Control (MAC)
  - Often no explicit security policy in current systems
- Apply proven high assurance technology
  - Reference Monitor security engineering principles
- Create a reusable "Trusted Device"
  - Start with existing proven MAC security kernel
  - Integrate with hardware to support PLC and HMI
  - Reminiscent of a reusable PC or sever motherboard

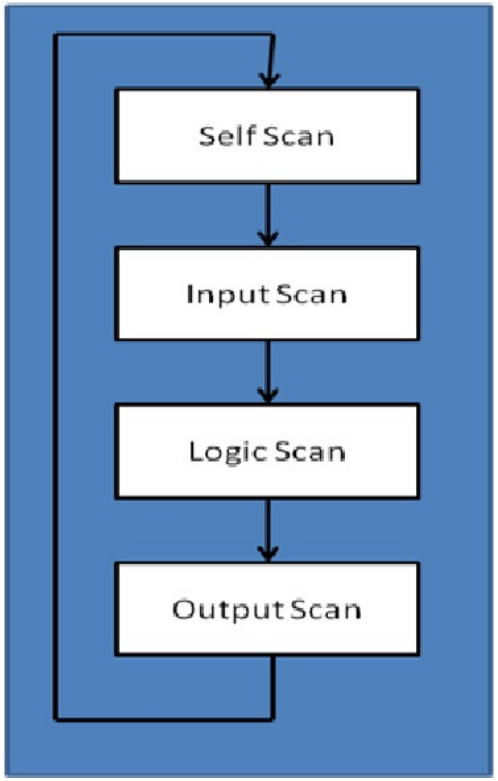
Example Securing PLC in ICS



- PLC controls the state of output devices
- ICS program executes on PLC trusted device
  - Continuously monitors the state of input devices
  - ICS program makes decisions for control of devices

Illustrative ICS Scan Cycle

- Two modes of operation: Run and Stop
- Typically four stages of run mode
- These will be repeatedly executed
  - Self Scan
  - Input Scan
  - Logic Scan
  - Output Scan



*Automating Manufacturing Systems with PLCs by Hugh Jack

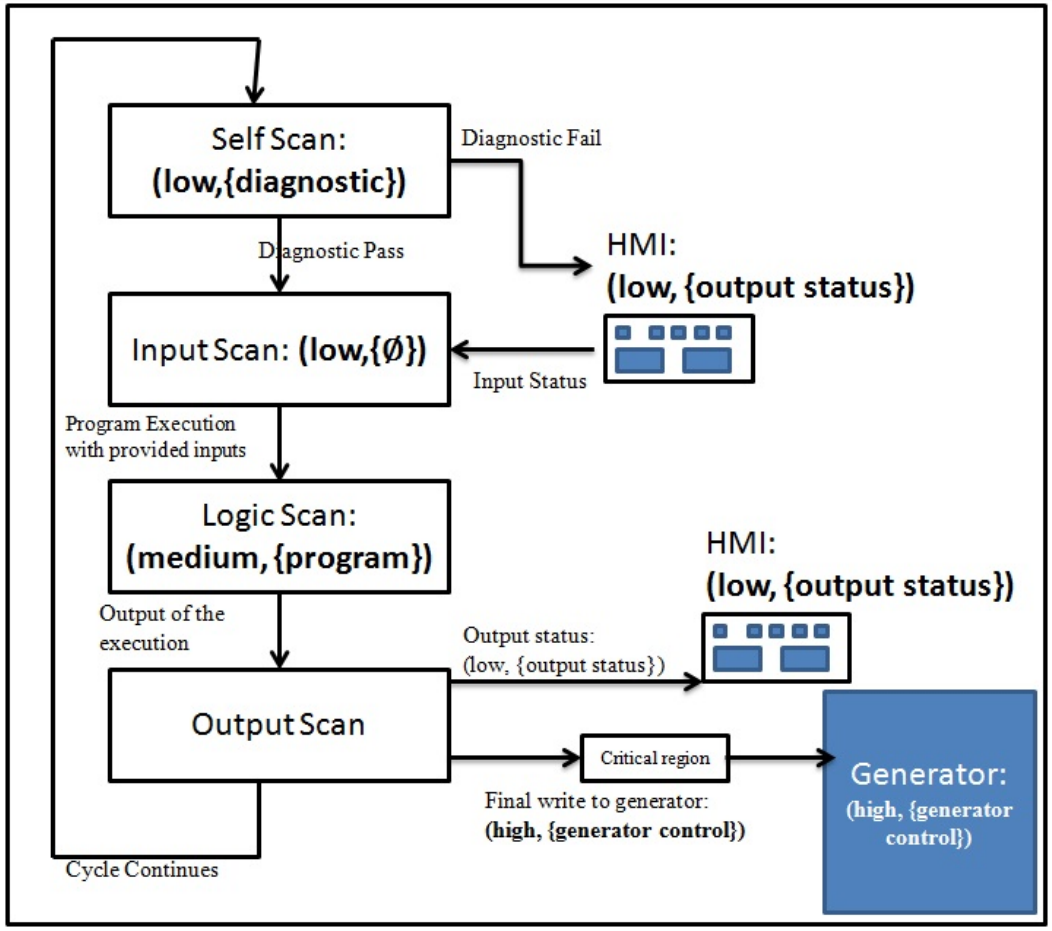
Decompose Scan Cycle for Security

- Repeating scan cycle is important PLC property
- Not all steps equally critical to ICS
  - Reflect importance in MAC integrity class
- Decompose stages into independent tasks
  - Each performs different task important for PLC
  - Each task will be implemented in different process
  - Assign each task MAC integrity class of importance
  - Trusted Device MAC security kernel fully supports
- Build scan cycle as cooperating processes
  - Use OS synchronization to preserve nature of cycle

Security Techniques

- Use assured pipeline so that each process involved shall communicate with genuine process that it needs to respond or communicate
- A assured pipeline limits the communication within a sequence of the processes so that each process in pipeline can only receive information to the next process
- An example would be Aesec virtual Guard Architecture

Restructure Scan Cycle by Integrity



Key Properties of Architecture for CPS

- High assurance MAC to mitigate subversion
- Delivered by reusable Trusted Device for MAC
  - Integrate into high assurance PLC
- Decompose ICS to leverage Trusted Device
  - Each cooperating task designed for a MAC integrity
  - Security kernel enforces integrity MAC (e.g., Biba)

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Leverage MAC Integrity

Subject	Integrity Level	Category
Developer	Medium	program
Local HMI	Low	output status
Remote HMI	Low-Low	output status
Self Scan	Low	diagnostic
Input Scan	Low	ϕ
Logic Scan	Medium	program
Output Scan to HMI	Low	output status
Output Scan to Generator	High	generator control
Generator	High	generator control

Object	Category
PLC Prg	Program
Input	General Control, Operation Status
HMI	General Control, Operation Status, Billing
Output	Output Status, Diagnostics, Generator Control, Operation status

We need to apply Biba Integrity interpretation, 3 conditions that must satisfy with respect to Subject S and object O are as follows

- Simple Security Condition: S can read O IFF S leq O
- *-Property: S can write O IFF O leq S
- Invocation Axiom: S1 can invoke S2 IFF S2 leq S2