Carlo Motta

Assessment and enforcement of resilience and security properties in control systems

Tutor: Prof. De Tommasi

co-Tutor: Prof. Santini

Cycle: XXXVI   Year:Second

My background

- **MSc degree in Automation Engineering, University of Naples Federico II**

- **Working team: DAiSyLab (Prof. Gianmaria De Tommasi)**

- **Co-Tutor: Prof. Stefania Santini**

- **Collaboration: UniSa (Prof. Francesco Basile); DIETI (RO group)**

- **PhD start date: Academic Year 2020-2021**

- **Scholarship type: "UNINA"**

Research field of interest

- To design supervisory control systems that are resilient (robust) to (cyber-) attacks.

- Security and privacy problems can be modeled in the framework of Discrete Event Systems.

- A system can be designed to be resilient to attacks, otherwise supervisory control can be used to enforce security by restricting the closed-loop behaviour
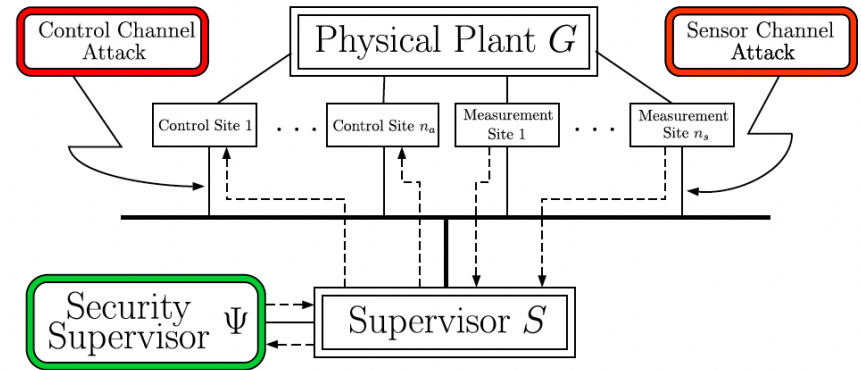
Summary of study activities

Courses

- **Big Data Architecture and Analytics**
- **Operational Research: Mathematical Modelling, Methods and Software Tools for Optimization Problems;**

Conference

- **MED** – THE 30TH MEDITERRANEAN CONFERENCE ON CONTROL AND AUTOMATION
Athens (Greece) 28/06/2022-01/07/2022
Presented Paper: "Assessment of Initial-State-Opacity in Live Bounded and Reversible Discrete Event Systems via Integer Linear Programming"
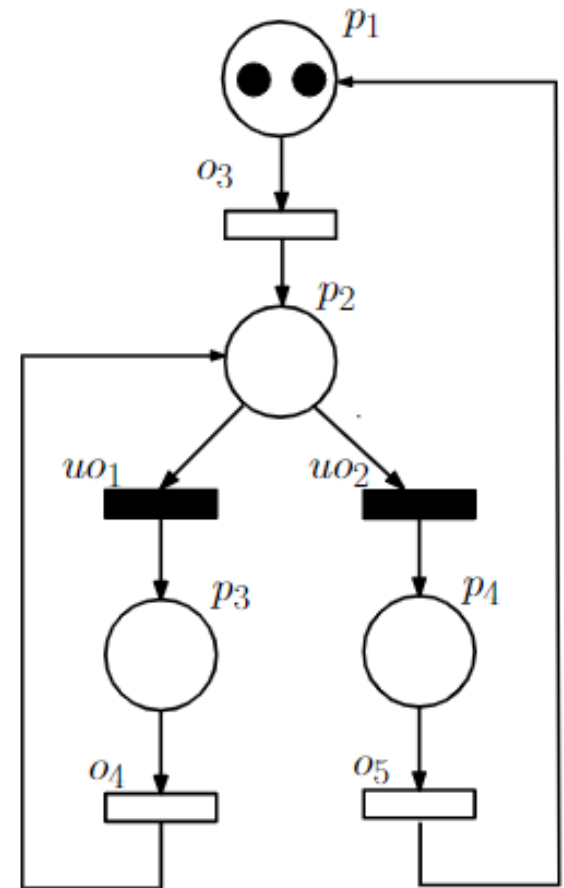
Research activity (1/3)

- Preventing an intruder to infer a secret and interact in a malicious way with safety-critical functions.

- In a distributed control system, information leaks and deceptions represent a threat to the system itself. The attacker's goal could be either to inflict damage or to learn secrets about the system.
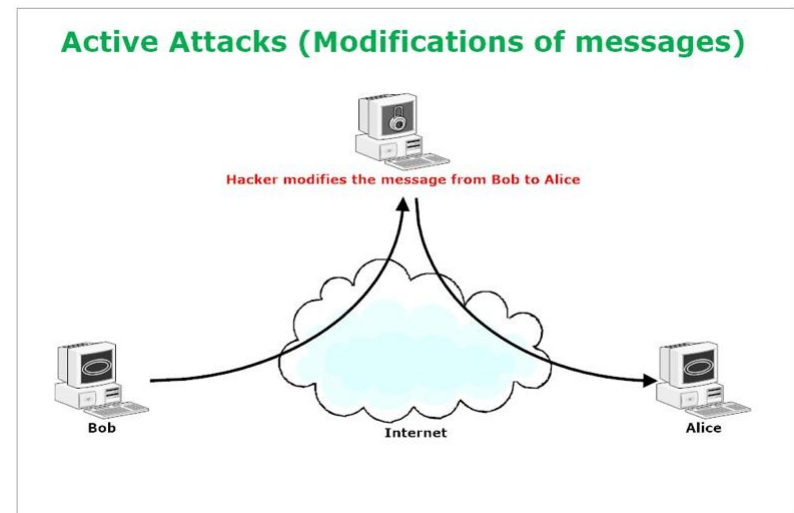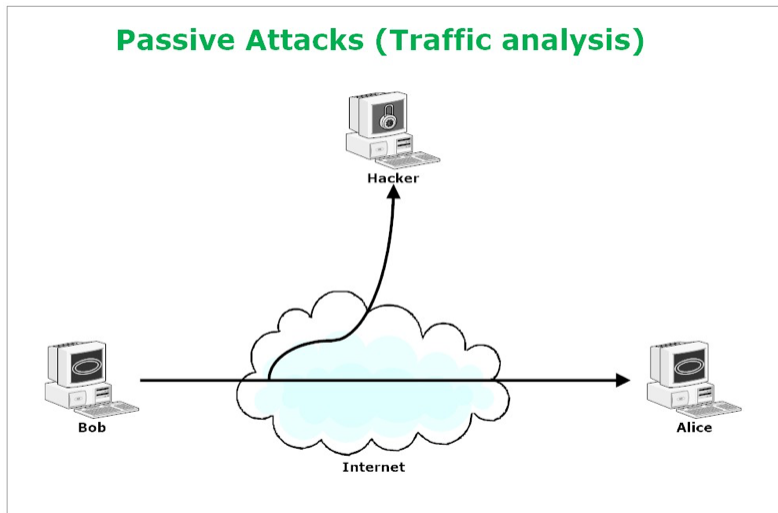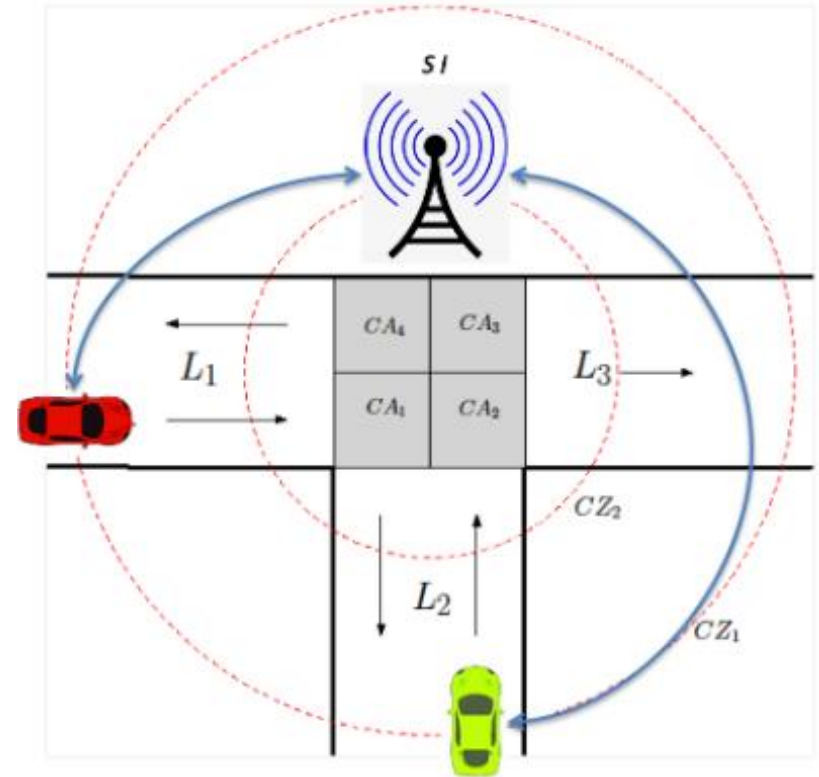
Research activity (2/3)

- Passive attacks: the system is *opaque* if a user cannot infer any secret if granted a partial observation of the system.
  - the system's initial state represents the *secret* → *Initial State Opacity (ISO)*
- Introduced a Necessary and Sufficient condition to conclude if a DES modeled as a Petri net (PN) is ISO based on the solution of Integer Linear Programming Problems.

  - "Assessment of Initial-State-Opacity in Live Bounded and Reversible Discrete Event Systems via Integer Linear Programming";
  - "Necessary and Sufficient Condition to Assess Initial-State-Opacity in Live Bounded and Reversible Discrete Event Systems"
  - "Assessment of Initial-State-Opacity in Live and Bounded Labeled Petri Net Systems via Optimization Techniques"

- This study is suited for PN models with a high level of parallelism such as control systems of industrial plants

Research activity (3/3)

- Active attack: The attacker's goal is to inflict damage on the system by counterfeiting the information exchanged between the actors.

  - Case study: in unsignalized intersection multiple autonomous vehicles interact with an Infrastructure (SI) to synchronize their timing to cross.

- We have modeled the action of an attacker trying to make the vehicles reach an unsafe state and then built a SI resilient to those attacks.
  - "Design of Resilient Supervisory Control for Autonomous Connected Vehicles Approaching Unsignalized Intersection in presence of Communication Delays"

- A similar work has been done for autonomous vehicle at crossings in presence of communication and actuation delays

itee PhD
information technology
electrical engineering

Products

[P1]	Francesco Basile; Gianmaria. De Tommasi; Carlo Motta; Alberto Petrillo; Stefania Santini *30th Mediterranean Conference on Control and Automation (MED)* "Assessment of Initial-State-Opacity in Live Bounded and Reversible Discrete Event Systems via Integer Linear Programming"
[P2]	Francesco Basile; Gianmaria. De Tommasi; Carlo Motta; Claudio Sterle *IEEE Control System Letters* "Necessary and Sufficient Condition to Assess Initial-State-Opacity in Live Bounded and Reversible Discrete Event Systems"
[P3]	Renato Brancati; Giandomenico Di Massa; Carlo Motta; Stefano Pagano; Alberto Petrillo; Stefania Santini *The International Conference of IFToMM ITALY* "A Test Rig for Experimental Investigation on a MRE Vibration Isolator"
[P4]	Gianmaria. De Tommasi; Carlo Motta; Alberto Petrillo; Stefania Santini *IEEE International Conference on Networking, Sensing and Control (ICNSC) 2022* "Design of Resilient Supervisory Control for Autonomous Connected Vehicles Approaching Unsignalized Intersection in presence of Communication Delays"

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Future Works

- For next year it would be interesting to build supervisors able to counteract both delays issues and active attacks.
  - The study could be conducted on bigger and more complex systems.

- The same framework may be applied to Petri Nets in order to merge the concepts of active and passive attacks.

- We also intend to extend the study on passive attacks by introducing new theorems to ensure resilience on DES