UNIVERSITÀ DI PISA

**DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE**

**Dottorato di Ricerca in Ingegneria dell'Informazione**

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Doctoral Course

# "Monitoring of SoS – evolution and challenges"

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**Short Abstract:** Intelligent monitoring systems can effectively predict or detect anomalies and issues in smart working systems and ecosystems and implement the proper countermeasures.

In their effective and efficient use, attributes like responsiveness, performance, quality and trustworthiness should be appropriately tested and assessed before integrating the monitoring system into an ecosystem.

At the same time, predicting security and trust vulnerabilities is crucial for IoT interconnected systems and ecosystems, especially when integrating new, third-party, or open-source components.

The proposed course will overview the challenges and primary functional and non-functional properties assessment methodologies. It will also provide guidelines for successful monitoring and testing activities and illustrate the commonly adopted tools and techniques. An introduction to Complex Event Processing technologies will also offered.

**Course Contents in Brief:**

- Event-Driven monitoring concepts
  - pros/cons
  - event
  - rules
  - sources and probes
- Introduction of functional and non-functional properties
  - Property definition and selection
  - Who should be involved?
- Monitoring of complex systems
  - Representing the behavioral model
  - Business Processes (BPMN) for monitoring industrial systems
  - Instrumentation of a system
  - Data acquisition and timing

    - Analysis and Vulnerability detection
- Knowledge representation and management
    - Using Ontologies
    - Using Generative AI
    - Complex Event Processing language
- Monitoring for Cybersecurity
    - Integrating access control
    - Malicious behavior detection
    - Mitigation strategies
    - pros and cons
- Intelligent predictions and predictive failure detection
    - Exploiting Digital Twin
    - Exploiting failure detection model
    - Exploiting AI
    - Prediction and time constraints
- Assessing monitoring systems
    - Main testing approaches
    - Testbed definition
    - Performance evaluation

**Total # of hours of lecture**: # 16

**Books:**

[1] Event Processing for Business – Organizing the Real Time Enterprise – David Luckam

[2] Activiti in Action – Executable Business Processes in BPMN 2.0 – Tijs Rademakers

[3] Designing Event-Driven Systems - Concepts and Patterns for Streaming Services - Ben Stopford

**References:**

[1] MOTEF: A Testing Framework for Runtime Monitoring Infrastructures. IEEE Access (2024)

[2] Towards enhanced monitoring framework with smart predictions. Log. J. IGPL 32(2) (2024)

[3] DAEMON: A Domain-Based Monitoring Ontology for IoT Systems. SN Comput. Sci. (2023)

[4] An automated framework for continuous development and testing of access control systems. J. Softw. Evol. Process. 35(3) (2023)

[5] Boosting a Low-Cost Smart Home Environment with Usage and Access Control Rules. (2018)

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**CV of the Teachers**

**Antonello Calabrò** received a Bachelor's Degree from the University of Pisa and a Master's Degree from the University of Rome; he is a Researcher with ISTI-CNR. He has participated in different roles for ISTI-CNR to several national and international EU projects and actively participated in more than 15 national and international projects. His research activities focus on designing and developing smart monitoring infrastructure, responsive and adaptable complex event processing, and cybersecurity assessment. His research activities have been applied to several application domains, such as smart environments, SoSs, the IoT, vehicular networks, emerging technologies, and UAVs.

**Eda Marchetti** is a senior researcher at CNR-ISTI. She graduated summa cum laude in Computer Science from the University of Pisa and got a Ph.D. from the same University. Her primary research focuses on software testing in general and, in particular, on introducing novel methodologies for testing emerging software technologies, cybersecurity, value-based and ethical aspects. Her research topics include security and privacy testing, testing of access control systems, model-based testing, SOA and component-based testing, requirement management and assessment, monitoring business process, human-centric testing process management and scheduling, operational and structural testing, interoperability testing, domain-specific testing, product certification, and assessment. She has been responsible for ISTI-CNR of several national and international EU projects and actively participated in more than 20 national and international projects.

**Final Exam:** Report and oral discussion

**Room and Schedule**

Room: *Aula Riunioni del Dipartimento di Ingegneria dell'Informazione, Via G. Caruso 16, Pisa – Ground Floor*

April 1, 2025 – 09:00-12:00→Monitor basic concepts and functional and non-functional properties

April 3, 2025 – 09:00-12:00 → Monitoring of complex systems

April 7, 2025 – 14:00-17:00 → Knowledge representation and management

April 8, 2025 – 09:00-12:00 → Monitoring for Cybersecurity and smart predictions

April 10, 2025 – 09:00-13:00 → Monitoring the monitoring system and Practical examples.