Doctoral School of Computer Science, UPB
Department: Engineering Taught in Foreign Languages
PhD supervisor: prof. Luca Dan Serbanati, PhD

PhD Admission Session

1. Scientific domain **PE6 – Computer Science and Information Technology.**

2. Research areas (according to ERC Panels)

PE6_6 Informatics and Information Systems
- Biomedical Informatics, in particular advanced electronic health records (EHR), integrated health information systems, decision-support systems in healthcare, etc.
- Enterprise information systems: ontology, business processes, enterprise system integration
- Semantic and organizational interoperability

PE6_8 Intelligent Systems
- Multi-agent systems (MAS), in particular organizations of agents
- Applying the R2V2R (*Real To Virtual To Real*) paradigm to benefit the Real

PE6_10 Modeling tools
- Conceptual tools for complex systems modeling: belief/desire/intention (BDI) modeling, multi-faceting, views, concerns, aspects
- Ontology of the Health State (an endurant entity) and Treatment (a perdurant entity) concepts

PE6 _14 Systems and software
- Complex system partitioning and specification in Systems engineering
- Software development methodologies according to advanced paradigms in Software engineering,
- ICT services for guidance in disease prevention and optimizing citizens' lifestyle.
- Digital ecosystems, specifically digital health ecosystems.
- Internet of things (IoT)

3. PhD thesis topics, objectives, and specific research areas

1. Prevention modeling aiming to support prevention activities by ICT. For this, the person's conceptual model using her/his personal profile, health status, mental status, risk factors for health and health damaging behaviors are needed.

Objective: design and implementation of a cloud resource prototype which offers services that intelligently empower individual behavior by providing users with knowledge and guidelines for acting as co-producers of own health .

Specific areas of research: modeling complex systems, BDI (belief/desire/intention) modeling, cloud resourses, patient empowerment, MAS, machine learning.

2. Modeling a person's health state in a broader ecosystem of stakeholders (food industry, tourism, education, insurance companies, politics, social communities and media should be added).

Objective: design and implementation of a digital ecosystem prototype according to the R2V2R paradigm. It should behave as an intelligent agent team that recognizes a person's behavioral tendencies as they are represented by significant information captured from the ambient and internet communities for early detection of threatening health risks.

Specific areas of research: social and digital ecosystems, IoT, extended context-awareness, MAS.

3. "Digital Clinic" is an organization of ad hoc created and organized virtual teams supporting the socio-medical personnel involved in patients' care. Integration of all information systems in a region-wide health system as well as capturing all significant information from medical documents and a broad context (sensors, web) are needed.

Objective: identification of concepts, methods and architectures that allow the development of innovative models of care pathways as well as of business processes in a health system supported by virtual healthcare organizations.

Specific areas of research: healthcare modeling, digital enterprise, agent organizations, semantic web, data mining, R2V2R.

4. Modeling the health state of persons in longitudinal EHRs of new generation.

Objective: design and implementation of a web resource prototype that:

- captures clinical information from medical sources (physicians, laboratories, hospitals) and environment on changes of the health state of people in a community, using mobile devices and software platforms of convergence of computing and telecommunication;
- is able to respond to queries in natural language on a person's current state of health, clinical history, and ongoing treatments;
- adapts and calibrates its services depending on the current context and situation (including mood) of the patient and/or her/his doctor;
- enables people to become co-producers of their personal health, and maintain it in good condition.

Specific areas of research: modeling complex systems and situations, MAS, component-based software, semantic interoperability, virtual EHR, context-awareness, natural language, and computing continuum with smart objects, IoT, smart devices, and sensors.

5. *Dynamic, context-aware, collaborative environments*. In the environment of health services information is generated and interpreted in the context of purposeful conversations in relationships of care. The result is a complex web of conversations which take place over space and time and generate units of information that can have different meanings and significances in different contexts: the same items or sets of information may serve different clinical, management, governance or research purposes and, as a consequence, trigger different reactions.

Innovative issues:

- *Self-adaptive Software Systems (Research topic).* In changing environments only a self-adaptive system can operate continuously, and be robust and responsive. Increasingly systems must also interact with diverse external services that are not under the control of the system designer. This requires software that dynamically changes. A new paradigm is emerging for the architecture of such systems: inclusion of a control layer that takes responsibility for observing the system's behavior, and for maintaining or improving that behavior through run-time adaptation. This research explores the use of software engineering concepts and methods to provide advice as the system runs on how it should adapt and change itself, while still maintaining QoS requirements. Such self-adaptive systems are, in our opinion, species of some specific digital ecosystems.
- *Digital Healthcare Ecosystems (Research topic).* A self-organizing digital infrastructure aimed at creating a digital environment for networked healthcare providers and organizations that supports the cooperation, the knowledge sharing, the development of open and adaptive technologies and evolutionary business models in healthcare.
- *Virtualization and de-virtualization of health care environments (Research topic).* The real world is reflected in the DHE in the activities, knowledge, goals and organization of the digital species. Changes with relevant medical significance in the real world, for instance a Medical Act performed by a care provider, may trigger changes in the DHE determining digital individuals to act, according to their goals.
    - *Interoperability*. Due to the great heterogeneity of the health applications, their large scale integration imposes that the messages they exchange should contain all the sufficient and necessary information the receiver should possess to correctly interpret the intentions of its interlocutor. Information on relevant events and even business process descriptions for the main scenarios in the health system must follow the activity flow seamlessly, enclosed in interoperable messages. All these are possible only if domain- and process-oriented ontologies to be used by applications in the integrated environment are available.

Innovative issues:

- *The Virtual Healthcare Record.* A complete and authoritative representation of the patient's current health state, clinical history and ongoing care processes .
    - *Second generation EHR, interoperable clinical content*
    - *Third generation EHR, enterprise-wide architecture (Research topic)*
- *Agentification and de-agentification in healthcare supporting applications (Research topic). 1)* Agent-based monitoring of workflow-oriented care plans, and 2) Agent-based founding and management of *virtual* healthcare organizations around a clinical episode of the patient.
- *Towards a globally interconnected continuum (Research topic).* The idea of a globally interconnected continuum of devices, objects and things

envisages a plethora of heterogeneous objects interacting with the physical environment. Ubiquitous and pervasive computing and context-awareness are explored in the digital health ecosystem. The contribution of the Internet of Things field could be of great help.

- *Architectural reference model for the interoperability in the digital healthcare ecosystem* (Research topic)

6. *Complex computing systems.* Today many of the computing systems that we depend on involve a combination of physical and computational elements. These systems are difficult to be designed in part because they require expertise in many disciplines, such as control theory, physical design, software systems, and distributed systems. Their design is based on multi-view design methods where models originating from different domains of expertise should work together. These models should be integrated and checked for consistency through shared architectural models.
   – *Cyber-physical systems (Research topic).* They are complex systems that integrate computation and physical processes. Embedded computers, devices, and networks act as smart objects in the physical system that monitor and control physical processes, usually with feedback loops, where these processes affect computations and vice versa. Many challenges are present in designing such systems:
      - how could we maintain a deterministic approach to the system design while the embedded components often have a built-in predisposition for non-determinism?
      - how should cyber-physical systems contend with the inherent unpredictability of the highly- networked physical world?

4. Summary of scientific and research interests

My research was driven by topics that provide as accurate and formal as possible foundations to the design development of complex software systems. This means first of all working to make good design choices in the early design at the architectural level of the software systems, that is to identify design methods and analysis techniques for constructing software systems from subsystems and their constituent modules with a high level of reuse and an intrinsic value for its stakeholders.

PhD supervisor in the "Computer Science and Information Technology" domain since 1997.

Author of, among other books, "Implementing Tools for Software Development", a book on his research in software engineering, published by Prentice Hall, and "Languages and Compilers", a monograph on programming languages and their compilers, published by the Romanian Academy Publishing House used his scientific research to promote new academic courses.

In the ‘70s his research was in mathematically-oriented computer science (automata, formal languages, compilers) and he introduced the first courses in this area in UPB.

In the '80s his research projects in CASE (Computer-Aided Software Engineering) pioneered software engineering in UPB.

After 1995 his interest in research was directed towards medical informatics, a boundary area of Information Engineering that aims to support activities in medicine with ICT. All works he published in the last 15 years in this field have as main objective to transfer paradigms, concepts, models, and methods from systems and software engineering to health.

He participated as a project director of a national complex program that was focused on semantic interoperability of web services that public administration offers to entrepreneurs.

He was also a senior researcher with the Institute of Biomedical Technologies of the National Research Council in Italy. He conducted several research projects of the institute, playing also the role of software architect. Among these projects are:

- *MobiDis*, a project that dealt with the use of mobile devices in medicine
- *LuMiR*, an important project that introduced an innovative solution for integrating health information systems in the Basilicata region. The project aimed at achieving a region-wide distributed application according to a cloud community model that provides health organizations in the region with needed services to promote collaboration among caregivers during social and medical assistance of patients. Integration solution is based on an original idea, the citizen’s virtual healthcare record, essentially a web resource that collects and manages information on the health of all citizens in the Region and provides query services, clinical document management and notifications to subscribing physicians regarding all significant medical events in their patients’ life.

- *Smart Health 2.0*. Overall objective of the project, consistent with the action Smart Health of the call "Smart cities and communities and social innovations" of an Italian National Programme in Sicily, is the creation of an innovative technological infrastructure, also in Cloud environments, on which to develop services to high added value to allow the activation of new business models in health and wellness areas. The project addresses these two separate but complementary issues:
  - improving individual lifestyles (Wellness & Lifestyle) addressed to herself/himself or to her/his relatives by empowering single persons through behavioral and individual initiatives;
  - health prevention carried out by institutional entities (e.g. Ministries, Departments of Public Health, etc.) once they are supported in information collection and analysis to address actions for risk-factors containment and interventions for early detection."Smart Health" trying to focus so fully complement the two approaches, and enhancing at the same time all the possible synergies and integrations between their deliverables

The concepts and experiments are centered on the concept of Electronic Health Record of Second Generation viewed as a cloud-enabled platform that provides high-level services enhanced with data and diagnostic information resulted from clinical and diagnostics innovation of other research lines of the project.

4. Contact data

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