MULTIPLEX

Foundational Research on MULTIlevel comPLEX networks and systems

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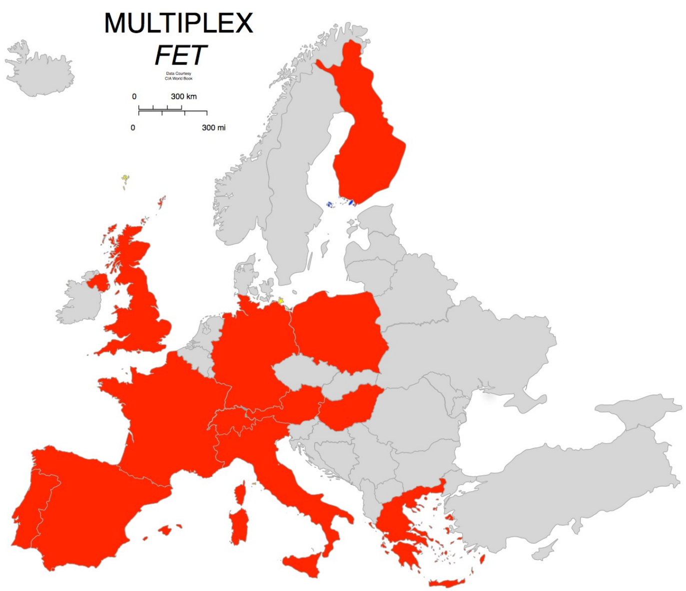
Participant no.	Participant organisation name	Part. short name	Country
1 (Coordinator)	IMT Alti Studi Lucca	IMT	Italy
2	Universidad de Aveiro	UA	Portugal
3	Bar-Ilan University	BIU	Israel
4	Universitat Rovira I Virgili, Tarragona	URV	Spain
5	London Institute for Math. Sciences	LIMS	UK
6	Central European University, Budapest	CEU	Hungary
7	CNRS, Marseille	CNRS	France
8	ETH Zuerich	ETHZ	Switzerland
9	Aalto-korkeakoulusäätiö (Aalto University)	AALTO	Finland
10	ISI Torino	ISI	Italy
11	Paderborn University	UPB	Germany
12	Medical Institute of Wien	MUW	Austria
13	Computer Technology Institute & Press Diophantus	CTI	Greece
14	University Sapienza, Rome	UNIROMA1	Italy
15	University of Zaragoza	UZ	Spain
16	University of Warsaw	UW	Poland
17	University of Wien	UNIVIE	Austria



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SEVENTH FRAMEWORK PROGRAMME
















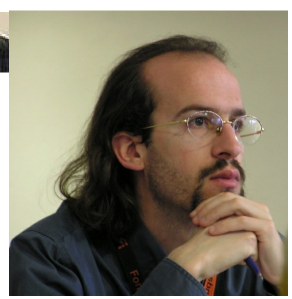

node leaders

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Other (not all!) Colleagues

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The Science of Complex Systems is regarded as a success story among the emerging fields of science. However, further progress in the ICT domain is hampered by the lack of deeper knowledge about how multi-level complex systems function. Preliminary findings indicate that interactions in a multi-level system cannot be treated as interactions in a single-level system. For example, multi-level dependencies may amplify cascade failures or make more sudden the collapse of the entire system, as indeed was observed in recent large-scale blackouts resulting from cascades in the power-grid coupled to the control communication system. A better understanding of multi-level systems is essential for future ICT's and for improving life quality and security in an increasingly interconnected and interdependent world. In this respect, complex networks science is particularly suitable for the many challenges that we face today, from critical infrastructures and communication systems, to techno-social and socio-economic networks. MULTIPLEX proposes a substantial paradigm shift for the development of a mathematical, computational and algorithmic framework for multi-level complex networks. Firstly, this will lead to a significant progress in the understanding and the prediction of complex multi-level systems. Secondly, it will enable a better control, and optimization of their dynamics. By combining mathematical analyses, modelling approaches and the use of massive heterogeneous data sets, we shall address several prominent aspects of multi-level complex networks, i.e. their topology, dynamical organization and evolution. On the empirical side, the theories, models and algorithms developed by MULTIPLEX will be tested and validated in relevant economic, technological and societal contexts. Long-term objective of the project is to bring the newly developed formalisms to other areas of complexity and to supply new tools for EU policy makers, stakeholders and citizens

O1. Mathematical Description Of Networks Of Networks

Develop mathematical and algorithmic frameworks that will enable us to describe, both analytically and numerically, multi-level complex networks. To this aim, appropriate variables and parameters will be identified in order to determine the topology and to describe the evolution of such systems, as well as to optimize some of their functionalities. The set of new quantities will allow: measure the persistence over time of the statistical properties of the system; describe the properties of graphs in the infinite limit of its size; to assess the coarse grain similarity across different systems and across different scales; to detect multi-level communities; incorporate the notion of hypergraphs; to account for multi-level cascading effects and multi-level rare events

O2. Mathematical Description Of Controllability and Feedback Between Topology And Dynamics

Multi-level networks evolve continuously as a result of feedback loops between endogenous dynamics internal to the system, exogenous forces shaping the overall structure, and the system's topology. Our objective is: firstly to develop a mathematical framework to describe this behaviour; secondly to clarify to what extent the structure of a real (or computer generated) multi-level complex system can be reconstructed from the partial information about nodes, edges and dynamics. Once the key quantities describing the system are determined, then we aim at assessing the conditions under which it is possible to control the future evolution of the system. Moreover, we will provide a rigorous characterisation in terms of limitations and potential for distributed algorithms, running on multi-level complex networks.

O3 Modelling

Building on the framework resulting from Objectives 1-2, develop models, which will be able to predict and optimize the propagation of information, opinions, influence, epidemics and socio-economic trends within multi-level complex networks. In particular, we will develop Game-Theoretical models of competitive agents and will analyse physical models that explain global behaviour from the interaction between neighbouring agents.

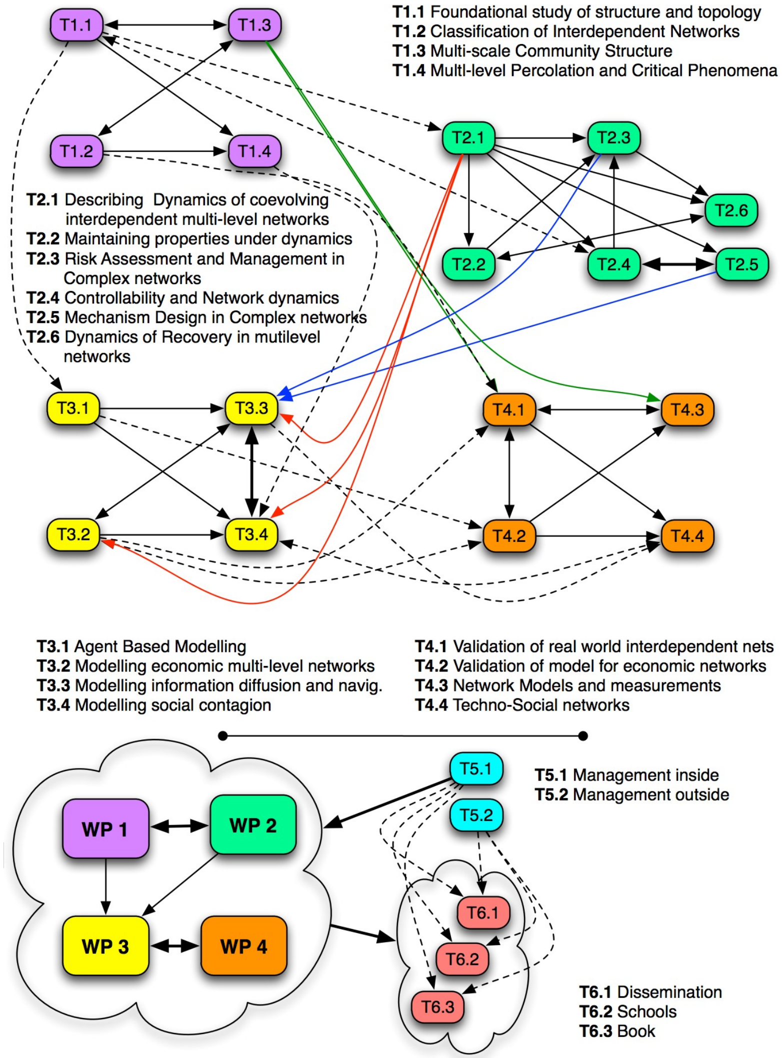
Exempla: characterize speed and size of information spreading in terms of few relevant parameters that characterize the physical and combinatorial structure of multi-level complex system.

O4. Validation On Real-World Data

The theoretical framework developed in the project will help in identifying relevant quantities from large sets of data. We aim at progressing towards the definition of a general methodology that allows abstracting models of multi-level complex systems through analysis of large heterogeneous datasets. Conversely, the proposed models will be extensively validated on real world datasets.

Exempla: Abstract a multi-level model from data collected in networks of proximity contacts at the level of individuals, at the level of the cities and the level of connections in online social networks.

The activity is divided in Specific Tasks
all analysed with an
Interdisciplinary approach
Based on methods of Statistical Physics
Mathematics, Algorithmics applied to
COMPLEX NETWORKS



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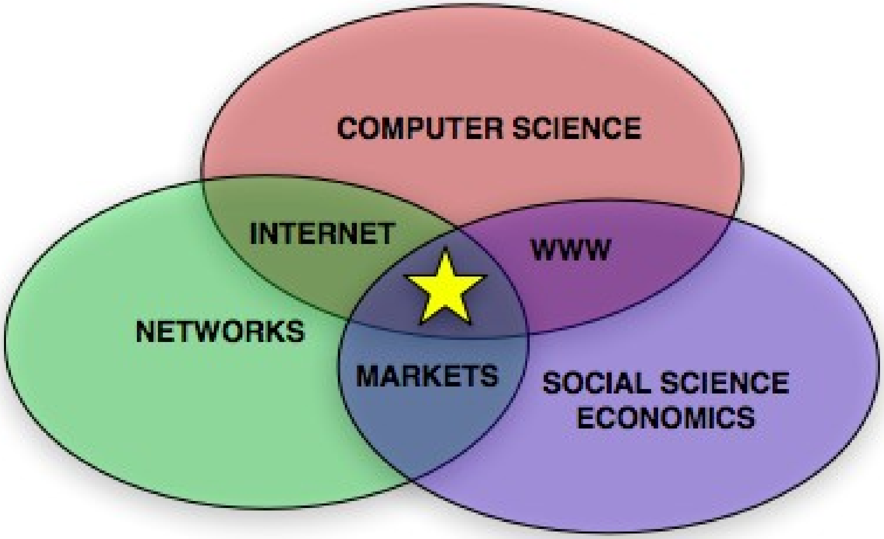
Major Area Challenges

- Interdependent netw
- Controllability
- Self-healing
- Scale separation in da
- Algorithmic problems
- Multi-scale optimisati



Foundational Network Science is cross cutting these challenges

Key questions

- Mathematical description of endogenous and exogenous effects in network dynamics (coevolution and multiscale problems);
- Network evolution and dynamical process in absence of time-scale separation;
- Control theory for dynamical process on complex networks

Comprehensive network theory as an operative definition of Complex System

Advancing Complex Systems

- Move the attention to mathematical foundations
- General classes of algorithmic tools and models applicable to complex techno-social systems
- New techniques for generation of hybrid models integrating synthetic and real-world data
- Predictability of extended dynamical systems in complex realities

Foundational Network Science is cross cutting these challenges

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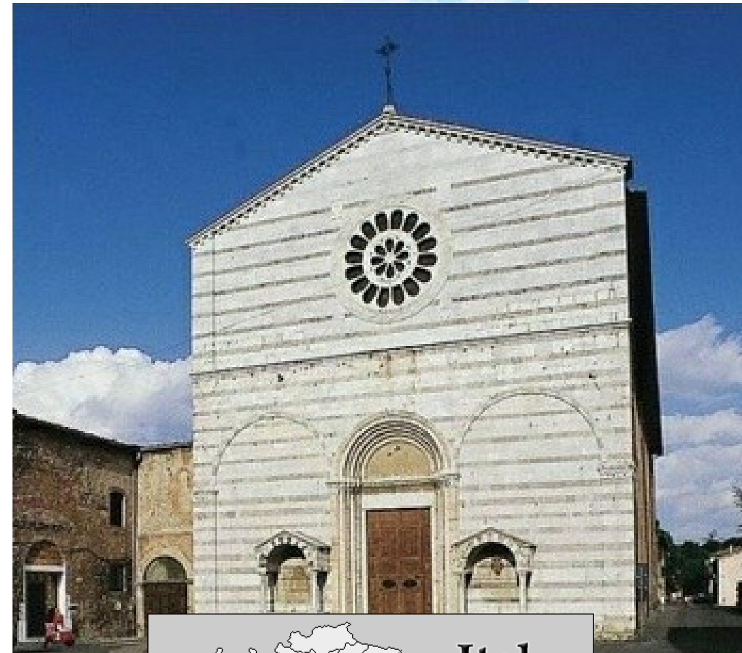
SEVENTH FRAMEWORK PROGRAMME

IMT Alti Studi Lucca has the necessary logistics to organize common meetings and workshops for the consortium and (if agreed) for the proactive initative.



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