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ScienceDirect
Procedia Computer Science 00 (2011) 000–000
Procedia Computer Science
www.elsevier.com/locate/procedia

FET 11 Science beyond fiction

FuturICT: FET Flagship Pilot Project

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Abstract

The ultimate goal of the FuturICT Flagship is to understand and manage complex, global, socially interactive systems, with a focus on sustainability and resilience. Revealing the hidden laws and processes underlying societies constitutes the most pressing scientific grand challenge of our century. Integrating the three components of ICT, Complexity Science and the Social Sciences will lead to a paradigm shift, facilitating a symbiotic co-evolution of ICT and society. Data from our complex globe-spanning ICT system will be leveraged to develop models of techno-socio-economic systems. In turn, insight from these models will inform the development of a new generation of socially adaptive, self-organised ICT systems.

FuturICT as a whole will act as a Knowledge Accelerator, turning massive data into knowledge and technological progress. FuturICT will create the scientific methods and ICT platforms needed to address planetary-scale challenges and opportunities in the 21st century. Specifically, FuturICT will build a sophisticated simulation, visualization and participation platform, known as the Living Earth Simulator. This platform will power Observatories, to detect and mitigate crises, and Participatory Platforms, to support decision-making for policy-makers and citizens.

In the Coordination Action Pilot Study which is running from May 2011-April 2012, activities will take place to develop the scientific vision and roadmap, secure stakeholder commitment, establish the FuturICT legal and operational infrastructure, and build on our remarkable success in uniting previously fragmented research communities. The main aim of the activities throughout the project will be to refine the FuturICT vision and identify measureable milestones along the way. This will produce an ambitious large-scale, science-driven, visionary research initiative to promote and develop future research outcomes in ICT. Through these activities, the Coordination Action will allow Europe to grasp this unique opportunity for groundbreaking progress in science and ICT, with great impacts for society, governance and industry by launching the FuturICT Flagship in 2013.

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Keywords: ICT; complex systems; social systems

1. Overall Vision

We are surrounded by systems that are hopelessly complex, from the society, a collection of seven billion individuals, to communications systems, integrating billions of devices, from computers to cell phones that form our Information and Communication Technology (ICT). Many of these systems appear random to the casual observer, but upon closer inspection they are found to display endless signatures of order and self-organization. These systems are collectively called *complex systems*, and the research area that aims to explore and understand them is often referred to as *complexity*. Given the important role they play in

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our life, their understanding, quantification, prediction and eventually control is the major intellectual scientific challenges of the 21st century.

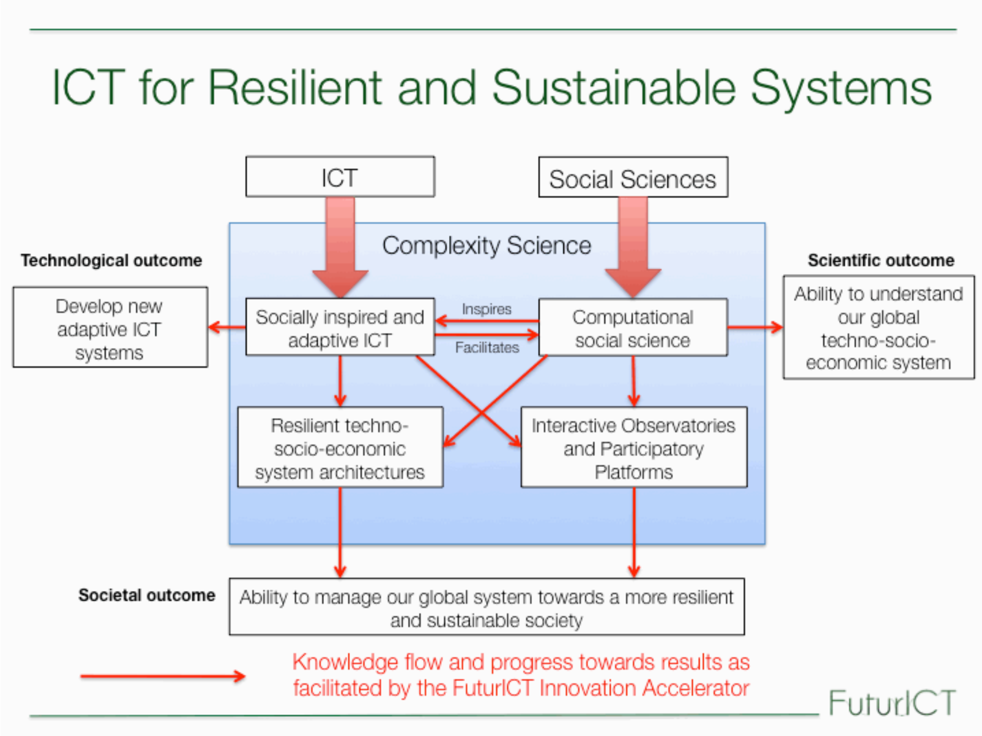

Figure 1. Interrelation of scientific and technological challenges in the proposed FuturICT Flagship project.

The ambition of FuturICT (www.futurict.eu) is to trigger a scientific paradigm shift by bringing the currently fragmented fields of ICT, Complexity Science and the Social Sciences to create the beneficial co-evolution of social and information systems (Figure 1). The FuturICT Flagship will leverage data from our global ICT systems to build a sophisticated simulation, visualisation and participation platform. This Platform that contains the Living Earth Simulator will act as 'Knowledge Accelerator' and 'cognitive extension', by turning massive amounts of diverse data into knowledge, combining theoretical approaches and supercomputer scenario simulations, with reality mining and experimental approaches (including web experiments). The data processed by this novel facility will be of a previous unimaginable scope, integrating the best knowledge of all relevant computational, engineering, natural, and social sciences. The framework of the platform will also develop new methods and tools for a better understanding of techno-socio-economic systems. The platform will integrate several practically relevant Demonstrator Areas that are addressed by Observatories, which will detect warning signs of potential disasters. In this way, we may use these simulation-empowered policy explorations in Decision Arenas to find ways to mitigate these crises through Contingency Planning. Eventually Participatory Platforms will be developed to support the integration of diverse knowledge and promote social, economic, and political inclusion as well as many new business opportunities. Finally, the Innovation Accelerator will help people from industry, politicians and scientists to find the best experts for projects, support the communication and flexible coordination in large-scale projects, co-creation, and quality assessment. The Innovation Accelerator will also form the basis of an innovative management of FuturICT.

2. How FuturICT will prevent or mitigate failure cascades

FuturICT will use the current and future global ICT infrastructure to create a 'nervous system of the society' that will provide real-time information about relevant events, social processes and structures, but with a strong focus on preserving privacy. It will collect and analyse a multitude of heterogeneous,

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dynamic data sources ranging from crowd sourced sensor information through digital media, social networks and blogs, to public infrastructure. Examples of the derived information are shifts in collective opinions and social attitudes, changes in consumer behaviour, emergence of tensions in communities, demographics, migration, mobility patterns, or health trends. This nervous system will facilitate social awareness and lead to the construction of the Living Earth Platform. The Flagship will develop a novel, data driven computational social science that builds on the real-time information to enable the comprehensive, real-time description of the techno-socio-economic dynamics on various temporal and spatial scales up to global scale (Palla et al. 2007, Song et al. 2010 or Vespignani 2010). One main aim is to avoid cascades of failure in connected systems (Buldyrev et al. 2010).

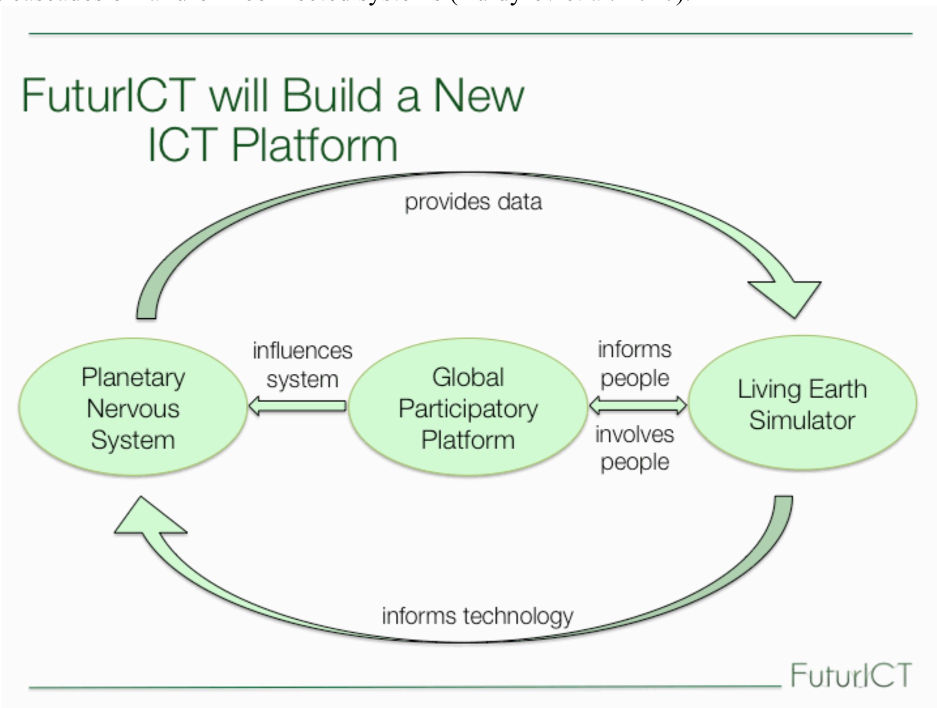

Figure 2. Most important ICT components of the proposed FuturICT Flagship project and their relationships.

FuturICT will make the global ICT system socially interactive by allowing it to adapt to social needs, react to unforeseen events and in general to increase systemic resilience of the society. The system will shuffle resources (e.g., information sources, bandwidth and distributed computing resources) to enable better monitoring and management of an emerging crisis situation to promote and support interaction in and between communities. It will also provide emergency ‘slow down and ask human’ mechanisms, preventing the system from accelerating a crisis leading to a systemic failure. The adaptation will be directed by high level, human-formulated goals and implemented by bottom-up, self-organised processes leveraging the systems’ social awareness and ability to comprehend complex social phenomena.

FuturICT will develop a novel complex systems science of ICT-society co-evolutionary dynamics to theoretically underpin this innovation. This new science will comprise models, theories and tools for the analysis of complex, dynamic interactions between society and socially adaptive ICT. It will also lead to novel methods enhancing trust, stability and reliability in self-organised ICT infrastructures by leveraging socially inspired mechanism for cooperation, coordination and reputation propagation.

3. Challenges in ICT

While social networking, swarm intelligence and crowd-sourcing, or indeed crowd-sensing, have become new powerful paradigms in the ICT world, there is much more potential for socially inspired technology. Societies are the most complex and multi-faceted systems that we know today. Developing

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future ICT systems poses similar challenges to organising a well-functioning society, including issues such as coordination, cooperation, adaptability, interaction, networking, group or community formation, collective (aggregate) behaviour, exchange, integration, differentiation, conflict resolution, stability, resilience, trust, deviance (malicious behaviour), (cyber)crime, (cyber)war, innovation, and culture. Future ICT systems should adapt to their users and their social context rather than requiring users to adapt to them, and they should be able to support social interaction. ICT systems must also be designed in ways that maintain socio-diversity and avoid undesirable collective behaviours such as herding effects, which will require us to re-think today's recommender systems and mass communication concepts. Classical optimisation and control approaches must be replaced by approaches to manage complexity, which respect the special character and requirements of techno-socio-economic systems.

A new trusted web architecture and data management is needed, which give users back control over their data and protects privacy and intellectual property rights. Machine Learning, Pattern Recognition and Data Mining will all be challenged to extract high-level information from the data present in the system, given the amount, diversity, and dynamic nature of the data sources, the need for distributed bottom-up processing and the extremely large semantic gap that needs to be bridged (Vinge 2006). Similarly, Semantic Technology and Artificial Intelligence in general will have to develop new methods to bridge the gap between high-level goals and corresponding low-level system requirements (e.g. Berners-Lee and Handler 2011). High performance computing research will have to develop new types of systems going beyond the focus on linear algebra centric problems, moving towards interactive rather then batch supercomputing. At the interface of Agent Technology, Distributed Systems in general, Computer Networks, Control Theory and Complexity Theory, new control mechanisms and models driven by the bottom-up socially inspired paradigm will have to be found. Furthermore, writing applications for the new breed of ICT will require novel concepts in Software Engineering and Data Management, and Digital Libraries (King 2011).

To get access to many interesting datasets, it will also be necessary to build up an open modelling and data platform with the possibility to provide commercial incentives and participation. Finally, presenting the data and making the system transparent to the user will require major advances in visualization technology and human computer interaction.

4. Challenges in Social Sciences

To date, in experimental social science (in the lab, via the Internet, through serious games, or in real life) it has been the exception rather than the rule in to use massive computer power, massive data sets or evolutionary optimization approaches to find improved systems architectures. Therefore, FuturICT aims at developing more realistic models of human behaviour in different contexts, particularly in those systems that involve new ICT. For this, one must address challenges that are at least as difficult as those to reveal the fundamental forces of nature. Identifying the processes that make society work seamlessly (or not) is one of the remaining unsolved scientific puzzles of this century (Roca and Helbing 2011, Haldane and May 2011, Helbing and Yu 2010, Lazer et al. 2009). This research will have to build on massive time-resolved data relating behaviours to demographic aspects as well as social networks and environments. Novel types of experiments involving sensors, virtual worlds and new large-scale participatory settings will require new types of methodological approaches to develop new, better grounded social theories. For example, despite its fundamental importance, we still do not have a standard way of measuring social capital (such as the level of cooperation, trust, etc.) nor do we have a dynamical world map of how this varies from one region to another.

Such challenges require a major combined effort of social scientists of various domains, together with ICT and complex systems experts. In particular, the major roadblock in identifying the fundamental limits of predictability and manageability of techno-social systems is their sensitivity and dependence on social adaptive behaviour as well as their exposure to innovation and cultural change. While one can imagine the use of evolutionary ecological-network types of techno-socio-economic models in combination with steady state data to forecast system behaviour under 'normal' conditions, in cases where we have a catastrophic event (e.g. the disruption of social order during emergencies such a major natural disasters) the behaviour of techno-social networks is driven out of equilibrium and depends on singular events.

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Interestingly, and ethically relevant, is the social response to predictions when those are made publicly available. Addressing these problems involves tackling an array of scientific challenges. The first is the gathering of large-scale data on information spread and social reactions that occur during the crisis. This is not presently out of reach, via large-scale mobile communication databases (mobile telephone, twitter logs, and social web tools), when still operating during disaster or crisis events (e.g. as an ad hoc network). The second challenge is the formulation of formal models that make it possible to quantify the effect of risk perception and awareness of phenomena of individuals on the techno-social network structure and dynamics. The third challenge concerns the deployment of monitoring infrastructures capable of informing computational models in real time. The real-time data feed will systematically improve the predictive powers of computational approaches by constantly allowing predictions to be adjusted for off-equilibrium behaviour, analogously to what is done in weather forecasts. Finally, another challenge is sustainable systems design, e.g. to identify mechanisms that avoid 'tragedies of the commons' in socio-economic and ICT systems, and help to resolve conflicting interests.

5. How can we use data to understand human behaviour

Given the important role that complex systems play in our life, their understanding, quantification, and management is the major intellectual scientific challenges of the 21st century. To a large extent, natural phenomena can be understood, quantified, and eventually controlled. It is less clear, to what extent *collective human behavior* can be understood, quantified, and influenced, but yet things are about to change in a very profound way. To make progress, one needs data; lots of data. But today, just about everything leaves digital traces in some database, which could be mined in a privacy-respecting way. Europe is poised to begin a new era of big science in complex social systems. The FuturICT project will create an understanding of complex systems through the real-time integration of massive amounts of data, not stored centrally but mined and interleaved with new models, allowing us to explore possible futures with a pluralistic science-based approach.

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