FuturICT

FET Flagship Proposal - Pilot Description

Human society continuously makes decisions with massive social, economic and environmental implications on the basis of very limited understanding of the inherently complex social mechanics of our world. FuturICT seeks to revolutionise support for advanced decision making in the face of complexity, by driving paradigm shifts in ICT to enable planetary scale simulations of our social system powered by massive real time data. In doing so, FuturICT will provide massive empowerment to decision support, enhancing prospects for international cooperation and a sustainable future.

A brochure describing the aims of the projects is available at
http://www.futurict.ethz.ch/data/flyer/FuturICT-Flyer-to-view.pdf

Contact person: Prof. Steven Bishop, UCL – s.bishop@ucl.ac.uk

Key partners:

Henri Berestycki *(EHESS, France; Managing Complexity and Institutional Design)*
Steven Bishop *(University College London - UCL, UK; Coordination)*
Tassos Bountis *(Patras, Greece; Complexity-Net and Complex Models)*
Anna Carbone *(Politecnico di Torino, Italy; Smart Energy, Econophysics)*
Rosaria Conte *(ISTC-CNR, Italy; Social Simulation, in particular Corruption)*
Andreas Flache *(Groningen, Netherlands; Social Science, Agent-Based Models)*
Dirk Helbing *(ETH Zurich, Switzerland; Modelling and Managing Complex Systems)*
Carlo Jaeger *(PIK, Germany; Climate, Sustainability, Economics and Policy)*
Janos Kertesz *(Budapest University of Technology and Economics, Hungary; Network Theory, Analysis of Large Socio-Economic Datasets)*
Jörn Kohlhammer *(Fraunhofer Institute, Germany; Visualisation)*
Paul Lukowicz *(Passau University, Germany; Data Mining and Computer Architectures)*
Thomas Lux *(Kiel Institute for the World Economy, Germany; Economics Modelling)*
András Lörincz *(Eötvös Loránd University, Hungary; Education, Privacy and Ethics)*
JB McCarthy *(University College Cork, Ireland; Business Practices and Stakeholder Engagement)*
Eve Mitleton-Kelly *(London School of Economics, UK; Policy-Maker Engagement)*
Kai Nagel *(TU Berlin, Germany; Supercomputing and Traffic Modelling)*
Björn Ola-Linnér *(Linköping, Sweden; Interfaces for Policy-Makers and Citizens)*
Andrea Scharnhorst *(Virtual Knowledge Studio, Netherlands; Innovation and Social Change*)
Thomas Schulthess *(ETH Zurich, Switzerland; Supercomputing)*
Alex Vespignani *(Institute for Scientific Interchange, Italy; Social Systems, Health and Wellbeing)*

As befits a major project, we are expecting to have around 40 signing partners and a further 115 associate partners. All partners will benefit and be involved with the project, either by organising events or helping in the writing of the final proposal. The ones listed here merely indicate some key areas and connections. Another 200 researchers have declared their support for the project, and are listed on the project website, alongside a number of institutional letters of support. Senior figures will act as members of the Advisory Board. The project will organise widely advertised open workshops and events to facilitate involvement of any interested parties from ICT to the natural, engineering and social sciences. There will be open competition for the Flagship funds, such as international stipends, awards/prizes, and travel grants, irrespective of this list.

http://www.futurict.eu/

Mission

The mission of the project is to enable decision-making that will enable humanity to tackle urgent and profound global challenges ranging from environmental change and shortages of natural resources to financial and economic instability. These challenges all derive from difficulties in managing our collective global activities and their consequences. To fulfil this we shall bring together the fields of computer science, mathematics and engineering together with the fields of social science and economics to develop a new **planetary scale data science** and **planetary scale models**.

Vision

The planetary scale models developed by FuturICT would be not only massive in scale, but also wide in scope, considering the interactions between the social, economic, technological and environmental systems of our world. Such groundbreaking models can only be constructed by pushing ICT systems beyond their current limits and creating a new planetary scale data science. This new science will encompass real-time acquisition, analysis and interpretation of massive volumes of data from sources ranging from mining of the web and social networks through to infrastructure sensors and personal mobile devices. This data will be used to drive and verify the models and simulations at scales previously unattainable. The new data science will also include novel methods for quantitative and qualitative interpretation and visualisation of both raw data and simulation output, to transform this massive scale data into information that humans can understand and act on.

The primary goal of the FuturICT project extends beyond the scientific desire to understand the operation of our society and economy, and lies in the creation of tools that will be invaluable to policy makers and citizens alike. Specifically, the project will initially focus on the application of the models in three core areas:

- **Crisis mitigation and avoidance**: real-time analysis of raw data input and simulation output to detect early warnings of impending crisis events, including instabilities in the financial system, to enable successful counter-action.
- **Policy exploration:** simulation powered multiple scenario testing of different policy options, in areas such as energy, climate, transport, recycling and waste, health, education and the design of future cities; creation of large interactive multimedia arenas for policy makers, and of online tools and programmable simulation interfaces for citizen interaction.
- **Advancing of science, technology and innovation policy:** accelerating research, development, and the creation of new business opportunities.

State of the art and challenges

To achieve this vision, we must vastly increase the scale and scope of current scientific models and the technology that drives them. The core challenges can be roughly broken into four areas: a) planetary scale data acquisition and analysis, b) computer architectures and processes for planetary scale modelling, c) human interaction with planetary scale data and models, and d) development of complex models of planetary scale and scope.

Past work has brought advances in data acquisition both from the Internet (texts, search queries, and social networks) and sensor data (data from infrastructures, such as traffic sensors and CCTV cameras, or data from mobile devices). However, current technology does not provide the scale and scope of data required in order to build models of the massive scale and scope proposed by FuturICT. To enable the construction of such models, we need to simultaneously gather data from all of these sources, and do this on a planetary scale. Previous work has also largely focused on offline data analysis. To implement real-time crisis detection and response

functionality, we need to achieve real-time analysis of the data. It is also vital that technologies are developed to protect privacy and confidentiality in data mining, storage, and processing.
It is clear that vast computing power will be required to run models of this size. Much past scientific research has focused on developing faster high performance computers. However, the peak performance of such computers is only achieved for particular applications for which they have been optimised. No research so far has focused on optimisation of supercomputers for real-time interactive social data-analyses and simulations. Some social simulations are based on differential equations, and related research in this area may be applicable. However, we expect that new research will be required to optimise architectures for the execution of other modelling approaches such as large-scale agent-based models. Development of the models themselves will also present a challenge. Software engineering methods must be established to ensure model reliability and that changes to the models and their relationship to generated data are reliably recorded. A final challenge lies in the development of programming methodologies to allow social science experts with little experience in programming to quickly code complex simulations.

The recent onslaught of data in our world has led to great interest in interaction and visualisation of this data and models based on the data. The core aim of such work is to transform vast quantities of numbers into information which is comprehensible to humans and can be acted upon. However, the volume of data which will be collected by FuturICT, and generated by its models, far surpasses the size of data sets which have gone before. Equally, the models themselves will be of an unprecedented scale. For FuturICT to be successful, systems will need to be developed which allow users to ask questions and receive answers from these planetary scale data sets and models in a language and form, which is intuitive to the user and conducive to action upon the information. A principal challenge lies in making the FuturICT tools usable in a way similar to today's web search engines. This will facilitate creation of applications targeting not only political decision makers but also interested citizens alongside broad consumer, business and public service markets.

In complexity science we have seen systems which change in unexpected ways. Emergent phenomena fall into this category. Systems whose structure and dynamics can be represented nonlinearly often exhibit catastrophes, bifurcations, and phase transitions. These kinds of dynamics provide one of the baselines for complex systems science. So far, this focus has been largely developed in direct correspondence with physical systems, where rapid and surprising change is relatively easy to define and simulate. Progress, however, in understanding such change in human systems has been slow. Yet rapid, unexpected change in human systems is not unusual. Indeed, recent discoveries suggest that changes may occur frequently, and that the task of the social sciences is to define systems of interest in ways that reveal such change. The idea that catastrophic socio-economic change is due to the interaction of bifurcations through cascading effects, occurring in parallel and simultaneously, is a helpful metaphor, and it is this thinking that we believe is useful for the development of a science of complexity that is applicable to many global crises contemporary societies face.

Impact

Science and technology

The FuturICT project will lead to substantial progress and major innovations in science and technology. The achievement of planetary scale modelling of human society and its interaction with the environment will represent a landmark scientific victory, a major advance in social science and hence a dramatic step forward in understanding the world we live in. This scientific progress will be made possible through major technological innovation, in the shape of the creation of a new planetary scale data science. This will drive progress across the breadth of Computer Science, in areas such as sensor networks for planetary scale data acquisition; software

engineering and supercomputing architectures for planetary scale analysis and simulation; and machine learning and human-computer interaction for informative interpretation and visualisation of these vast volumes of data.

Progress in data science is needed not only in academia but also in business. Here, the recent surge in data available on consumer behaviour and preferences offers desperately needed opportunities to boost profits and fight against the current economic downturn. The scale up in data science that the FuturICT project will bring will lead to both a vast increase in the data available for businesses to analyse, and substantial improvements in their ability to locate and understand the relevant data patterns within this sea of information.

Society
Equally importantly however, the FuturICT project will bring clear and unprecedented benefits for society. The ability to detect upcoming crises will open up a possibility of avoiding them. The ability to explore the outcome of applying different policies in different scenarios will permit well-informed, evidence-based policy-making and allow us to work towards a sustainable society. FuturICT has the potential to move policy forward in a number of areas, including energy, climate, transport, recycling and waste, health, education, and the design of future cities. In particular, the project will focus on informing and improving policy and practice for science, technology and innovation, offering a large boost to the productivity of our society.

Dissemination
To maximise the impact of the project on FuturICT, there will be a strong focus on dissemination of the outcomes, to scientists, business people, policy-makers, and citizens alike. Planned activities include the establishment of a new cross-disciplinary journal; major workshops for business associates, and particularly for start-up companies, for whom insights into new innovation approaches would be of particular interest; media activity, including a strong web presence, but also extending to involvement with the BBC and film makers with whom relationships are already being developed; and arts and technology exhibitions explaining issues around the FuturICT project and its latest discoveries, designed to be accessible to a general audience. Workshops will be organised to assess effectiveness of qualitative methods and in particular the use of narratives for the transmission of ideas to policy makers. The idea here would be to engage with people active in chosen fields but then bring to the table experts from outside the field to share experiences and develop new ways to tackle the global problems.

Ethical considerations
FuturICT will be designed to benefit society as a whole. To achieve this goal, FuturICT will dedicate research resources to investigating ethical issues from the outset, considering a range of issues from privacy of the individual to transparency of policy-making and availability of data and simulations to citizens as well as policy-makers. Furthermore, likely impacts of current and future ICT systems on societies and economies will be studied. A specific committee will be set up to arrange this and expert advice from outside, including legal advice, will be sought.

Integration
The FuturICT project will gather scientists from more than 25 countries, within Europe and beyond, with associate partners joining from the US, Singapore, China, Israel, Japan, amongst others. These scientists are drawn from a range of leading universities including University College London, Cambridge, Oxford, Imperial, London School of Economics, ETH Zurich, Bologna, Politecnico di Torino, Warsaw University, Warsaw Technical University, the Santa Fe Institute, MIT and Harvard University as well as institutions such as the Fraunhofer Institute, the Potsdam Institute of Climate Research, CNR (Italy) and supercomputing centres in Switzerland,

Germany, and Spain. Links have also been established with existing European Commission projects and initiatives such as Complexity-net, Climate-KIC, PEER, Global Systems Dynamics and Policies, ESSA (European Social Simulation Association), e-Governance, ICT4Peace, and COST (European Cooperation in Science and Technology). The project will also engage with other communities working in social systems, including the Complex Systems Society.

At an unprecedented scale, the FuturICT project will bring together expertise in understanding humans (sociology, cognitive science, anthropology), the systems we have built (economics, political sciences and law) and the environment we live in (geosciences, biology and ecology) with technological expertise (computer science, engineering) and expertise in modelling complex and interrelated systems (mathematics, physics). Input from technological and modelling experts will lead to more advanced models and understanding of human society, and the challenge presented by such large-scale modelling of human society will drive exceptional progress in technology and simulation techniques.

Leadership
The FuturICT project will be coordinated at UCL, ranked fourth in the world in the 2010 QS World University Rankings. FuturICT is strongly in line with UCL's 'Grand Challenges' in Global Health, Sustainable Cities, Intercultural Interaction and Human Wellbeing. UCL is actively establishing mechanisms whereby its expertise and analysis of these challenges can be brought into public fora to engage funding agencies, opinion-formers and legislators. Institutional support means that the FuturICT project receives the backing from a vast array of world leading research experts. Project coordination at UCL will be further supported by expertise from UCL's specialist European Office, where they have vast experience in project management and coordination of major EU projects.

Professor Steven Bishop (Maths, UCL), who will be coordinating the management of the project, has a strong track record of successful collaborative research projects and conference organisation. A recent EC funded grant (GSD) awarded to him together with partners across Europe investigated how a complex systems approach can be used within a policy-making context. Many contacts were made in both industry and government. This experience of crossing into the policy and decision-making domains together with the many contacts gathered will be vital in the research proposed here.

The project will be scientifically led by Professor Dirk Helbing of ETH Zurich, Continental Europe's leading university according to the QS World University Rankings.

Milestones
July 2010 – Open Kick-off meeting, followed by WP think tank meetings, London
July 2011/12 – Formation of Flagship consortium
Jan 2013 – Project commences
2015 – Design of new simulation and data collection concepts, prototype decision arena
2016 – First data collectors and crisis observatories in operation
2017 – First version of a reputation-based quality evaluation platform for innovation
2018 – Parallel world modelling and scenario simulation
2019 – Demonstration of reality mining (new zero-delay sensing applications)
2020 – Visualisation of demonstrator areas
2021 – Theory and concept of sustainable economies
2022 – Planetary scale simulations running