Grand Challenges for Systems and Services Sciences♦

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HPL-2006-99
July 13, 2006*

systems, services, challenges, Europe, society

The Grand Challenge

To establish attainable expectations that services systems will function to specification, at predicted costs and over their intended lifetimes.

* Internal Accession Date Only
♦ FET/FP7 Workshop, Brussels, January 31, 2006
Approved for External Publication

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EC –FET –ONCE –CS –FP7 Workshop

The Grand Challenge

To establish attainable expectations that services systems will function to specification, at predicted costs and over their intended lifetimes.

Why is this a Grand Challenge?

Designing and managing efficient, reliable and cost effective services is not easy as frequent commercial and public sector failures continue to demonstrate. There are few organisations that do not, at least in private, acknowledge that we are rapidly approaching a crisis. Industry, academia and customers must either learn to specify and manage the complicated systems that services represent or risk economic stagnation.

There are many reasons for why services are difficult to both specify and maintain, key amongst these are

- scale – these systems are the most complicated and ambitious artefacts we have ever attempted to engineer;
- integration – these require that hard academic disciplines as diverse as social sciences, mathematics, engineering and economics be combined in understandable and controllable manner;
- the environment – many of these systems operate in a world of uncertain and/or shifting policy, legislation and economics;
- communications – few of these systems can be comprehended in their totality by key stakeholders, leading to a poor understanding as to how key decisions in areas as diverse as process, technologies, expectation setting and financial policy will impact the effectiveness of the whole system.

Systems failures frequently have multiple factors – for example the United Kingdom Child Support Agency appears dogged by interactions between the dynamics of the underlying information systems that support policy, internal working processes, political policy and goals, and the external social environment and personal expectations.

Whilst the exact nature of these interactions and their impact on the success or otherwise of service changes from example to example, their recurrence in late, over-budget and under-performing

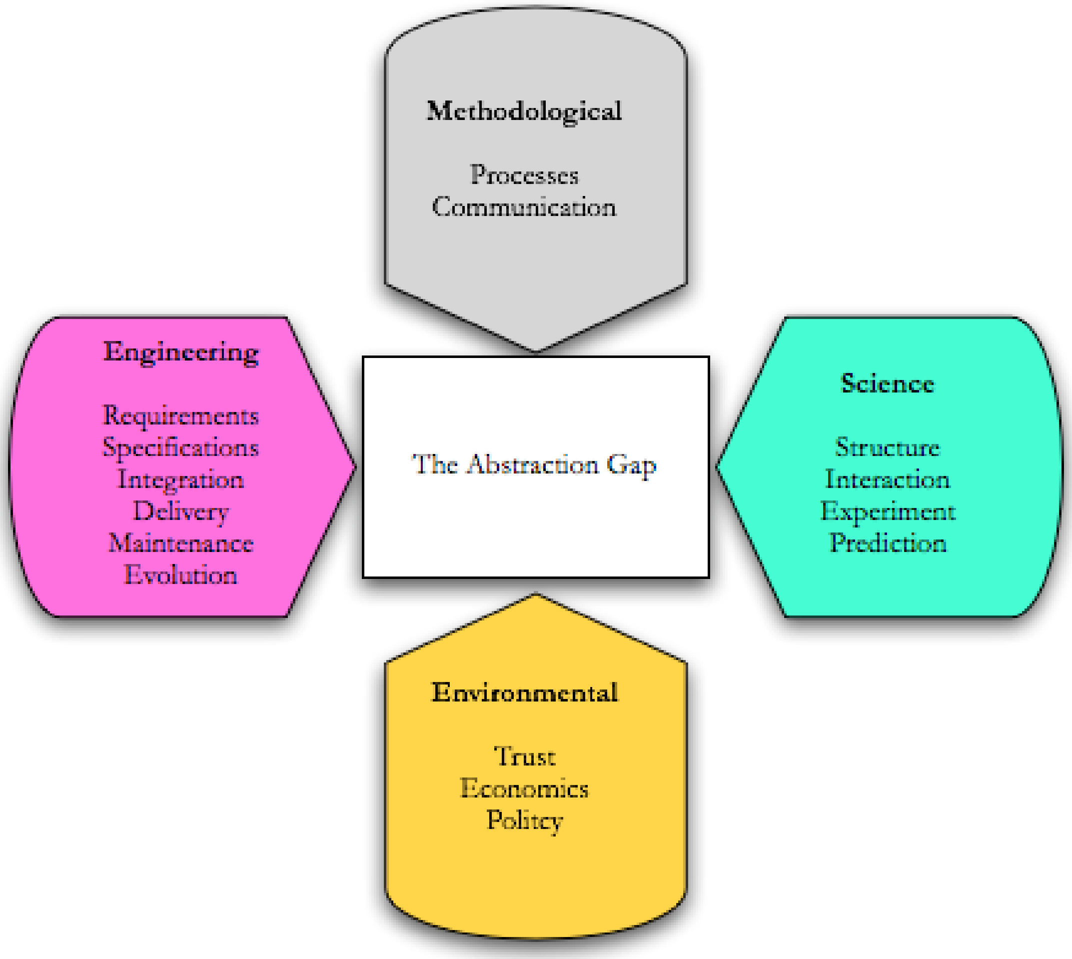
[1] This paper was prepared as a position statement for the Future and Emerging Technologies – FP7 workshop held in Brussels on January 31 2006. Please contact the authors for more information.

programmes illustrates the need to develop the integrative sciences and their corresponding engineering disciplines that will make the expectation that complicated, robust systems can be constructed and managed a realistic one. As challenges go, they do not come much grander!

What is the solution?

Recall, then, our Grand Challenge: Establish attainable expectations that services systems will function to specification at predicted costs and over their intended lifetimes

The key outcome conveyed by this challenge is the attainable expectation of function and performance, and the key mechanism for delivery is specification against predicted cost. The first thing to understand here is specification of a service system requirement: functionality, availability, reliability, other performance criteria, as well as integrity and security, regulated by service-level agreements (SLAs). In order to meet specifications, systems must be provisioned against predictable costs and demands.



How can we begin to have an engineering science to support this activity?

We would argue that there is a need for basic research in the underlying mathematical, computational, social, and economic sciences, together with an essential transfer of the understanding revealed to robust engineering processes.

Within this conceptual picture we can identify, by way of being leading examples, two necessary emergent socio-technological-economic frameworks: first, trust, between technologists, service providers, service users, and regulators; second, an economic environment supporting a market in services, depending shared understanding between trusted partners of trade-offs between, for example, cost and performance.

We would suggest that the way forward is via formal modelling, at levels of detail and abstraction that are appropriate for the various components of the service system. Note that this is not a manifesto for formally specifying the construction, behaviours and interactions of every detail of every subsystem. Rather, we would propose the use of a range of appropriate mathematical methods — e.g. stochastic, logical, dynamical — together with and within a framework of experimental scientific method, deployed at appropriate levels of detail in order capture the essential aspects of systems required for specific purposes.

Impact

The consequences of attempting this Grand Challenge could be profound for the future of both European industry and the future of multi-disciplinary research and engineering.

Broad economic consequences

The most obvious consequences will be felt by both suppliers and their customers. The relatively modest gains in systems understanding and management that can be guaranteed to come from this work will make significant differences to the ability of both European companies, and indeed Europe itself to compete in a world where rapid and efficient development and deployment of technologies core to success.

New models for cross-disciplinary research

Effective multi-disciplinary research is difficult –research culture, language and experience tends to mitigate against success. The bulk of successful collaborations (such as mathematics and biology) tend to be relatively small scale and combine two, or at most possibly three disciplines.

There is already direct collaboration in the area of complicated integrative systems between industrial and multi-disciplinary academic groups. One such example is the Centre for Systems and Services Sciences.

This Grand Challenge requires a level of cooperation which is an order of magnitude greater than anything that has been attempted before. As the systems under consideration are concrete and have enormous economic value, this will provide both motivation and a concrete grounding for effective research results.

New design methodologies for complicated systems

A rigorous systems engineering approach to the design of complicated systems will provide the necessary framework for understanding the relationship between business processes that determine the economic success of the enterprise, the information systems that embody those processes including the business applications (e.g. ERP), and the supporting infrastructure.

Design that leads to predictable behaviour in the sense of attainable expectations from both vendors and customers requires understanding the tradeoffs that have to be made across this space; this is the enablement of system tri-design. For example, poor processes will be exacerbated by embodiment in IT leading to increased costs – precisely the opposite of what was intended by procuring the IT system in the first place. Another example would be costly over provisioning to meet perceived requirements for performance which could be mitigated by a suitable embodiment of the business process into an information system based on appropriate model based analysis.

Measurement and management

At present we have evidence of large scale IT procurement failures through reporting from the public sector mainly because of requirements for open government and general accountability for tax euros. A recent announcement predicting that public sector spending on IT in the United Kingdom will rise 40% between now and 2010[2] (approximately €30Bn) indicates that expectations are high that IT will simultaneously deliver cost savings in the delivery of services, e.g. through shared platforms, but at the same time facilitate greater flexibility in the way in which services are delivered. With this example as context measurement must focus on characterizing expectations through use of more formal predictive approaches as described, leading to a replacement of gross characterisations of complicated systems by qualifiers such as 'greater flexibility' by meaningful terms derived from a systems engineering approach.

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[2] More computers, less staff equals efficiency – Guardian, 6th January 2005