Interface Reasoning for Interacting Systems (IRIS)
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Summary of the Project

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1 Introduction

David Pym, at UCL, was the Principal Investigator. The project was collaboration between Imperial, London School of Economics & Political Science, Queen Mary, University of London, and UCL. It ran from 1 January 2018 to 31 December 2024. The Co-Investigators, listed by Institution, were the following:

- Imperial: Alastair Donaldson, John Wickerson
- LSE: Will Venters
- Queen Mary: Edmund Robinson
- UCL: James Brotherston, Tristan Caulfield, Byron Cook, George Danezis, and Peter O'Hearn.

The project's non-academic partners were: Amazon AWS, BT, Facebook, GridPP, HP Labs, and Methods Group.

We are grateful to Cliff Jones and Simon Gay for chairing our Advisory Board, and to the members of the Advisory Board for the generosity of their contributions.

At the date of this document, the UKRI page for this project, EP/R006865/1, is `https://gtr.ukri.org/projects?ref=EP%2FR006865%2F1`.

2 Summary of the Project

Our societies and economies are becoming increasingly reliant on digital ecosystems constituted of large, complex, dynamic, and highly distributed systems. Digital innovations including Platforms, Big Data, the Internet of Things, Smart Cities, Cloud Computing, and Artificial Intelligence, involve a myriad of interacting systems owned and operated by different companies which become tightly coupled through their interfaces. It is expected that the complexity and scale of systems' interdependence will increase by orders of magnitude in the next few years. This raises important technical and managerial challenges, and societal implications which are still not well understood.

We sought to develop a better understanding of the potential sources of vulnerability (threats to efficiency, reliability, and security) of these complex ecosystems of systems. Their smooth functioning is arguably not only dependent upon the correctness of programs but also on the correct and robust interaction between systems.

We contended that interfaces supporting such interactions are therefore the critical mechanism for ensuring that systems and the complex ecosystems they conform behave as intended. We aimed study how the interfaces between the components constituting these ecosystems work, and to verify them against their intended use. We used verification/modelling techniques that have been effective in ensuring reliability of low-level features of programs, protocols, and policies, but which have not yet been applied to reasoning about such large-scale systems and their interfaces. In so doing, we sought to drive the use of verification techniques and improve the reliability of large systems.

In addition, we needed to consider the social context in which such ecosystems are embedded to better understand how these develop in practice and with what consequences. Drawing on management and social sciences theories, we studied digital interfaces, and the challenges they face. We will also explore the organizational or management commitments embedded within digital interfaces, how coordination and control is achieved through the management of digital interfaces, and the role that digital interfaces play in the emergence of new organizational forms. We also explored the involvement, dynamics, and consequences of digital interfaces in boundary making.

The project drew upon on a range of disciplines, including logic, program verification, security, discrete mathematical modelling, economics, management science and social science. While interfaces at different degrees of abstraction and criticality can be studied independently and from different perspectives, no one level of abstraction or perspective offers all the answers. Our goal was to integrate various approaches, so that they can inform each other. For instance, our understanding of the challenges faced by organizations in developing or managing digital interfaces can inform and be informed by the mathematical modelling of systems.

It should perhaps be unsurprising that the project involved and led to fundamental work and contributions in its contributing disciplines.

Outputs

The project produced a vast range of outputs: please navigate to the websites of the project's contributors — the Investigators, the Fellows, and the PhD students — to find them.

3 Research Fellows & Associated Students

The following people were either employed as Fellows by the project or were PhD students whose work was closely associated with the project:

- Paul Brunet (Fellow, UCL)
- Jack Clark (Fellow, Imperial)
- Diana Costa (Fellow, UCL)
- Timo Eckhardt (UCL, Fellow)
- Kang Feng (Fellow, QMUL)
- Estibaliz Fraca (Fellow, UCL)
- Alexander Gheorghiu (Fellow, UCL)
- Tao Gu (Fellow, UCL)
- Anushri Gupta (Fellow, LSE)

- Marius-Constantin (Ilau, PhD and Fellow, UCL)
- Max Kanovich (Fellow, UCL)
- Vasilis Klimis (Fellow, Imperial)
- Timo Lang (Fellow, UCL)
- Quand Loc Le (Fellow, UCL)
- Roser Pujadas (Fellow, LSE)
- Enrico Rossi (Fellow, UCL & LSE)
- Alessio Santamaria (Fellow, QMUL)
- Matthew Windsor (Fellow, Imperial)