Information Systems Research and Development at CCLRC — *Accelerating Innovation through Technology Transfer*

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1 Formal Methods in Information Systems Development

The recent explosion of interest in the internet as the means for enabling new methods of working, be it e-Commerce, e-Science, e-Government, or e-Education, witnesses the immense impact that computing technology can have when translated from one domain to another. The meteoric rise (and corresponding fall) of the dot-com market over the last few years exemplifies the scale of commercial investment available in pursuit of early market share where there is widespread belief in the future viability of an emerging technology.

However, the typical lifecycle of such technology translation presents unique challenges for organisations wishing to remain at the leading edge of computing technology today. Timescales, which are often measured in decades up to some critical moment of take-off, can be astonishingly quick once a technology is seen to fly. Previous examples of this kind of revolution in computing technology are Object Oriented Programming and Graphical User Interfaces, both of which were in gestation for several decades before their almost instantaneous widespread up-take in the early and mid 1980s.

Formal methods, in the form of various technologies, have now had a significant presence in academic spheres, and some considerable success in particular commercial domains, for more than two decades. However, formal techniques have not, as yet, achieved any significant penetration into the mainstream IT systems market as a whole. In a workshop targeted primarily on formal methods for industrially critical systems, it is also interesting to consider the expansion of the application of formal techniques into other areas of software systems development.

At CCLRC, we promote high quality scientific and engineering research by providing facilities and technical expertise in support of the basic, strategic

and applied research programmes of the UK, Europe and elsewhere. This paper outlines the research and development activities in information system undertaken within the Business and Information Technology Department at CCLRC in support of this programme. Other related activities undertaken by the e-Science and Computational Science and Engineering Departments are not covered here.

2 Strategic Research and Technology Transfer

Formal methods research and development at CCLRC is focused on three kinds of activities

- strategic research directed by the long-term computing needs of the diverse scientific applications within the Science and Engineering Base,

- technology translation enabling the uptake of the most innovative computing in the scientific programme at CCLRC and elsewhere, and

- innovative development employing latest technologies emerging from the research domain into pilot and production systems.

The research tends to be application led, but looking to a 5-10 year horizon for exploitation. With this timescale, we bridge the gap between research intended purely to push the boundaries of scientific knowledge which is quite rightly undertaken in a university setting and more targeted research where the delivery of some particular result is the main objective which is the focus of commercial organisations and other units within our own.

3 Research Challenges

Several major initiatives currently underway in Europe and world-wide provide the context in which these activities are undertaken as well as significant longer-term challenges for computing science in general. For example:

e-Science. Metadata and formal resource description are a current focus in the effective co-ordination and delivery of resources to enable science. In the longer term, automated discovery and negotiation of resources will underlie the e- Science infrastructure[7][9].

e-Government. The current initiatives aim to provide open access to government information using metadata-based descriptions. The future potential is to enhance this service to the citizen through personalisation and intelligent information retrieval.

Semantic Web. This long-term initiative from the World Wide Web Consortium recognises that formal information modelling and machine-mediated analysis of those models communicated between agents will be required to support the automated web services of the future.

Trusted e-Services. Consumer confidence is recognised as the key barrier

to the predicted growth in e-Business. Establishing and managing trust relationships between agents interacting over the Web requires the secure transmission of information on products, services, and service provision, as well as information on the agents involved in transactions.

Ambient Computing. The predicted emergence of computing devices distributed throughout the environment requires the modelling, transmission and analysis of information on the environment, the agents involved, and the service required, within a ubiquitous computing framework.

A common theme in our response to these challenges the formal treatment of information, both in the design of software systems and directly as a feature of those systems themselves. The following research themes currently form the focus of our investigations:

- Information Modelling and Analysis
- Security and Trust Management
- Web and Grid technology.

The following paragraphs outline our approach to these topics and introduce some of the projects currently underway. Space prohibits further elaboration here, but more details on these and other projects, as well as their associated publications, can be found under the Research and Development heading of our Departmental Website at: `http://www.bitd.clrc.ac.uk`.

4   Research Themes

Information Modelling and Analysis

Information Science is often associated with librarianship, collection, analysis and publishing of written material. Whilst recognising the written word as one important form of information, we take a broader view of information as any form of structured, annotated and analysed data. In progressing the data and information infrastructure from a heterogeneous collection of data based archives, to a integrated data, metadata and analysis environment, a required step is to elevate the level of reasoning that is possible with this resource. This is the information and knowledge levels of the GRID and the Semantic Web ideas of W3C. Our activities aim to contribute to building towards the Information & Knowledge Infrastructure envisaged these initiatives, whilst ensuring knowledge transfer between this and evolving Web-based decentralised open distributed systems developed for e-Business.

Some R&D projects currently underway in this area are:

SWAD-Europe - Semantic Web Advanced Development in Europe [3] is an EU project supporting W3C's Semantic Web initiative in Europe and providing targeted research, demonstrations and outreach to ensure Semantic Web technologies move into the mainstream of networked computing

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(See http://www.bitd.clrc.ac.uk/Activity/ACTIVITY=SWAD-Europe;)

Pellucid - A Platform for Organisationally Mobile Public Employees
is an EU RTD project developing a customisable software platform, based
on agent technology, to provide knowledge management for public employ-
ees who move from one role to another in their organisation.
(See http://www.bitd.clrc.ac.uk/Activity/ACTIVITY=Pellucid;)

CRIS - Current Research Information Systems is an R&D initiative to
provide systems for handling information on R&D activities including projects,
people, organisations, products, patents, publications. Much of the work
involves reconciliation of heterogeneous distributed multilingual databases
using metadata.
(See http://www.bitd.clrc.ac.uk/Activity/ACTIVITY=CRIS;)

Security and Trust Management

It has been widely recognised that lack of consumer confidence is limiting
the growth of e-commerce and has contributed to the recent volatility in the
dot-com market. Despite the presence of effective base technologies such as
encryption and telecommunications, there remains a need for further innova-
tion before trust can be managed at the service level. In particular, there is
a need for practical, scaleable and adaptable technology to capture, measure
and manage the trusting relationships that underlie e-service transactions.
For e-services to achieve the same levels of acceptance as their conventional
counterparts, trust management has to become an intrinsic part of e-service
provision.

The internet, by its very nature, encompasses a heterogeneous variety of
systems and technologies, but its utility requires extensive and transparent
communication and co- operation on a global scale. Furthermore, the strongly
competitive nature of the internet- based marketplace, coupled with the need
for consensus, necessitates proactive mechanisms for the transfer of knowledge
between all parties. In view of the widespread commercial investment in this
area, such flows need to be not only from academia to industry, but also
between different businesses and from industry to academia.

Some R&D projects currently underway in this area are:

CORAS - A Platform for Risk Analysis of security critical system is
an EU RTD project developing a base modelling framework for security
management. Extensive user trials in the areas of e-commerce and telemedicine[5].
(See http://www.bitd.clrc.ac.uk/Activity/ACTIVITY=CORAS;)

iTRUST - Trust Management in Dynamic Open Systems is a cross-
disciplinary investigation of the application of trust as a means of estab-
lishing security and confidence in the global computing infrastructure[8][6].
(See http://www.bitd.clrc.ac.uk/Activity/ACTIVITY=iTRUST;)

Web and Grid Technology

Through the establishment of technologies branded under the banner of the World Wide Web, the internet has become a global resource with applications touching every aspect of society. The availability within the next few years of Grid technologies developed for the scientific domain will further facilitate the integration of computing resource into everyday life. The co-evolution of these two technologies will provide many challenges for application developers and service providers of information systems.

Some R&D projects currently underway in this area are:

GRASP - GRid-like architecture for Application Service Providers
Develop and evaluate a new advanced system infrastructure for Application Service provision based on GRID technologies.
(See http://www.bitd.clrc.ac.uk/Activity/ACTIVITY=GRASP;)

Subsystems Objects, Associations and Subsystems: a hierarchical approach to encapsulation will develop the formalisation of a notion of Subsystem in Object-Oriented Design Methodologies[1][2][10][11].
(See http://www.bitd.clrc.ac.uk/Activity/ACTIVITY=Subsystems;)

LeGE-WG - Learning Grid of Excellence Working Group is facilitating te development of a European Learning Grid Infrastructure.
(See http://www.bitd.clrc.ac.uk/Activity/ACTIVITY=LeGE-WG;)

gViz - Visualization Middleware for e-Science a UK-funded project to research and develop visualization middleware for e-science integrating existing systems with Grid technologies and developing XML-based descriptions. (See http://www.bitd.clrc.ac.uk/Activity/ACTIVITY=VisMidEsc;)

5 Dissemination

The World Wide Web Consortium (W3C) is established as the forum overseeing the progression of WWW technology. Research topics which are currently "hot" include: the semantic web with reasoning over formal models, formal resource descriptions in RDF, and redefining the internet as a global computing resource. On the horizon is ambient computing where agents and environment are continuously "wired" and exchanging information for mutually beneficial interaction. All of these require formal modelling and analysis in order to achieve quality and confidence in correctness. With ERCIM taking on the role of European Host for W3C (and CCLRC hosting UK Office) we are placed in a unique position to ensure that research in this area is taken up by the global community.

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