UK COMPUTING RESEARCH COMMITTEE

UKCRC Briefing Document: Research Councils, scientific colleagues and academic leaders

This document is the second of three that articulate the landscape of Computing Research in the UK. This article is aimed particularly at Research Councils, scientific colleagues and academic leaders such as Vice Chancellors and Principals.

The key messages for this audience are:

- The impact of ICT is huge: computing and communications are now core technologies that underpin all areas of science, engineering, government, health services, and society at large.
- The pervasiveness of computing should ***not*** be misinterpreted as indicating that the field is no longer a hot-bed of innovation. Progress in computing is accelerating, and advances over the next 50 years can be expected to exceed those of the last 50 years.
- UK computing research is healthy, exciting, and much of it is world-leading.
- World-class computing research in the UK is vital not only to the delivery of government aspirations towards a knowledge economy, but also to sustain many areas of excellence in science and engineering research.

1. The impact of ICT

Few technologies, if any, have had a greater impact on the everyday life of humanity than ICT (Information and Communication Technology). That it is only 60 years since the first computer ran a program stored in its electronic memory[1] underlines the staggering speed with which this technology has moved from speculative research to global impact. Although the internet can be traced back to the early 1960s, it is only 20 years since it entered the consciousness of the general public as a result of a British computer scientist, Tim Berners Lee, inventing the world-wide-web. Yet already the web is a major vehicle of science and commerce, and of growing importance to government. Today most of the computing power on the planet is based on designs licensed from ARM, a medium-sized British company based in Cambridge, whose business has grown over the same 20 years from nothing to ten million microprocessor shipments a day.

The central role of ICT in everyday life is clear. For better or worse, every train carriage is occupied by people talking on mobile phones, listening to iPods, browsing on Blackberries, and absenting themselves from their physical environment to engage in virtual business, family or leisure through the medium of ICT. But these visible gizmos are just the tip of the ICT iceberg. They rely on an infrastructure of considerable sophistication whose capacity and

[1] The Manchester University 'Baby' ran the world's first computer program on June 21 1948.

capabilities are expanding at a stunning rate. And increasingly, this same infrastructure is being exploited to support services for government, health services, science, and pretty much the whole gamut of human activity[2].

2. They think it's all over…

The rate of progress of computer technology over its first 60 years has surely been impressive. Today's computers are a *hundred billion* times more power-efficient than their early forebears, and a *million* times faster. Storage technologies can hold a *million* times more data than they could just 30 years ago. That is just the hardware. Software advances on the back of this staggering progress deliver orders of magnitude more functionality than that of early mainframe computers.

Despite these technological advances, the common perception of computing is that the major trend, at least since the advent of home computing in the early 1980s, has been one of stasis and consolidation. Now that computers are pretty much everywhere, that's it. All we need are a few more programs, then computers will do all they are capable of and we can focus research on other areas with greater potential for progress.

This is not true: the rate of technological progress is accelerating. Moore's law continues to give us advances in computing power. Advances in software technology and the means to construct and manage ever more complex hardware and software systems means that advances in computing over the next 50 years are likely to be even greater than those of the last 50 years. No-one can foresee what this will entail: Advanced machine intelligence? A merging of physical and virtual existence? Brain prostheses? Think back 50 years and try to predict mobile phones and iPods from the technology base of the 1960s, and you will see the problem. For example, on a shorter timescale things are somewhat easier to predict – using computer vision and other sensors embedded in road vehicles we could certainly achieve a significant eradication of road fatalities, if we were minded to do so.

What is clear is that computing research is now more exciting than ever, and has more potential than ever to transform the future. The UK must aspire to sustain its position at the leading-edge of computing research if it is to influence how this vital technology will take an ever more central place in the human experience both from the perspective of wealth creation and social welfare.

3. UK international standing

Section 1 provides three examples of British technological contributions that led (and in two cases still lead) the world in advancing computer technology. It is clear that computing research is a global pursuit, and the UK's research contribution is just one component of the wider whole, but these three contributions exemplify the quality of the UK computing research base.

[2] Including, of course, crime, terrorism, pornography and spam!

It is difficult to assess the ultimate impact of current research as it can take 20 years for the full impact of a new research idea to become apparent – the examples of ARM and the world-wide web show this. However, there are correlates of research impact that can be used on shorter timescales to estimate the likely ultimate impact. The 2008 Research Assessment Exercise showed that a considerable proportion (20%) of UK computing research can be considered world-leading, and almost two-thirds was judged to be internationally excellent. The subject was found to be healthy and growing[3], and more rigorous, more interdisciplinary, more experimental and more user-oriented than in the 2001 RAE. International reviews of UK computing research have also found the subject to be thriving.

4. Computing excellence underpins everything

While it is evident that the UK must stay at the forefront of computing research if it is to play an influential role in determining the directions that computing should take, this is only part of the case for computing research. The pervasiveness of computing means that excellence in computing research is necessary to support excellence in all areas of human endeavour.

At the abstract level, computer science ideas ("computational thinking") increasingly pervade science, engineering and the arts, e.g. philosophy and linguistics. Developments in computer science and technology have created a new vocabulary of concepts, models and metaphors that are finding increasing utility in other disciplines (and in everyday life). Complex systems, for example, are often best understood in terms of the dynamics of the information flows that determine their emergent properties.

At the more tangible level, computer simulations and models play increasingly important roles in science, engineering, economics, climate modelling, and such like. These models are frequently limited in their fidelity by the efficiency of the computer hardware and software, and advances in computing research lead to concomitant advances in these respective areas. The knowledge economy is a case in point – central to this ambition is access to the most advanced information processing capabilities that research can deliver.

Ever more scientific research is now conducted by mining vast databases of experimental results, created either by central capital-intensive equipment as in particle physics, radio astronomy and earth satellites, or amassed from the results of large numbers of independent experiments as in many areas of biology. UK computing research has already yielded significant advances in e-Science and Grid technology that support this research, but much more remains to be achieved.

For all of these reasons, computing research will continue to be vital to progress in many disciplines, and maintaining a vibrant UK computing research capability will yield benefits across the entire domain of academic and industrial research and in our ability to exploit the knowledge economy to maximum benefit.

[3] Though there are concerns over the researcher pipeline – see the UKCRC briefing note for government and policy makers.