Power-efficiency, Performance, Programmability:

Architecture and Design in Bristol

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Micro-electronics in Bristol

Bristol's microelectronics activity started in 1979

Inmos - backed by British government

Single-chip microcomputers known as *transputers*

Inmos became part of STMicroelecronics at the end of the 1980s

STMicroelectronics has continued to develop advanced microprocessors in Bristol

Bristol microelectronics industry

STMicroelectronics:	consumer - DVD
Infineon:	automotive
Broadcom:	communications - DSL
Picochip:	high performance DSP - base-stations
Elixent:	configurable logic
Quadrics:	high speed interconnect
Clearspeed:	low-cost supercomputing
Icera:	low-power wireless

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Bristol Computer Science

Collaboration with industry

- microelectronics design companies
- computer companies including Hewlett Packard
- animation and games design companies

Our current research includes

- Architecture, Design and Verification
- Mobile and Wearable computing, Digital Media
- Machine Learning and Data Mining
- Cryptography and Security, Quantum Computing

You can find more information at www.cs.bris.ac.uk.

Mobile and wearable computing

New technologies - and how they can be used

Many collaborators including universities and industry

Trials involve novel content and many mobile users

Technologies include

- Wireless communications
- Location systems - GPS, ultrasound
- Accelerometers, gyroscopes and compasses

Soundscapes

With headphones, location and orientation information

- we can position a sound in space

The sounds to the ears are continually adjusted

- so that the sound appears to stay in the same place

We can cover an area with a collection of sounds

- a *soundscape*.

We have developed technology to support soundscapes

- and an authoring package to create them

Mobile computing

We are currently planning new projects

Mobile vision - tracking and object recognition

Interaction between mobile computing and ubiquitous computing

- aim to carry as little as possible on the person
- rely on computers throughout the environment

Challenges and opportunities for electronic design

- power-efficient processing and communications
- integrated sensors

Issues in electronic systems design

Computing without power - processing and communication using

- power derived from the surroundings
- batteries which last as long as the product

Single chip supercomputers for use in

- embedded computing
- high performance computing

Our research on architecture and languages aims to

- minimise complexity
- maximise power-efficiency, performance, programmability

Industry evolution

Increasing costs of new designs - and design verification

Applications Specific designs are becoming too expensive

More design by programming or configuring standard products

- FPGAs
- single chip processor arrays

Emergence of companies which use applications expertise to program and configure standard products

Computing without power

Minimising power use in ubiquitous and mobile systems

- process technology
- circuit design or logic design
- ‘low-power’ modes of operation

Our work focuses on architectural techniques

- efficiency of program and data representation,
- use of physical resources - registers, caches, execution units

Existing architectures do not optimise power efficiency

- inefficient instruction representations
- large register files and caches

Computing without power - Events

Most of the interface requirements are low-speed

- interface control and data transfer can be done by software

Event-driven systems: powered-off most of the time waiting for

- specific environmental conditions
- messages from another device

Some of these systems will use multiple processors

- but they will be switched off most of the time

We'd like to collaborate in these areas

- on sensing, processing or communications

Single-chip Supercomputers

We can fit a lot of processors on the same chip!

Picoarray

- 150 million transistors
- 460 general purpose processors with DSP instructions
- on-chip network using time-division multiplexing
- 200 billion instructions/second

Key issues for these architectures

- maximise the power-efficiency of the processors
- minimise communication overheads between them
- event-driven processing and communications

Supercomputers - Programmability

It’s important to support several processing techniques

- pipelines
- systolic arrays
- concurrency
- and of course good sequential processing!

We think it’s time to explore flexible architectures

We’d like to collaborate with people who have

- technology
- applications requirements

Co-design

More use of FPGAs with embedded processors

But problems remain in architecture and tools

- difficult to move functions between hardware and software
- narrow interface between processor and hardware

Our work in this area addresses both aspects

- express designs in terms of concurrent programs
- provide multiple paths between processor and hardware

Recent evaluations using EEMBC benchmarks are promising

- we are now interested in industrial collaboration

Security and Cryptography

We also work on cryptography

- elliptic curve cryptography for mobile devices

Architecture and software work to

- find efficient low-power implementation techniques
- provide defence against side-channel attacks

Security is a major issue in mobile and ubiquitous systems

New project on secure, low power, low-speed communications

- we'd welcome collaborators

Verification

Early work on formal verification of microprocessor designs was done in Bristol in the 1980s

Research on verification must involve industry collaboration

- it's important to address real problems

Recent projects

- formal design techniques for processor pipelines
- automatic generation of test programs for microprocessors

Verification has become a major issue in design

- we look forward to more collaborations

Collaboration

We are open to most forms of collaboration:

- we have visiting industrial staff
- our own staff - and students - visit industrial collaborators
- we have projects with both academic and industrial staff
- we act as consultants on industrial projects

For more complex projects we have 3Cresearch

- projects involving several industrial or public organisations
- computing, communications, content: www.3cresearch.co.uk

If we need to, we will form new organisations - or companies

Exploitation

We exploit the results of our work in many ways:

- some of it we publish
- some we licence or sell
- some we use as the basis of spin-out companies

We have support for new ventures:

- UK government initiatives
- high-technology investors

In 2005 there will be a new Bristol science park

- it will have an innovation centre
- we expect microelectronics to be one of the themes

Summary

Bristol has a concentration of expertise in microprocessor design

In the University, we aim to support microprocessor design by

- research projects
- educating students

We are interested in

- forming collaborations based on our research
- discussing potential new research areas