Success Story

Queens University

"FPGAs give us tremendous advantages in terms of speed, portability and costs, but what's really powerful about SGI's RASC implementation is the flexibility and scalability of its shared memory. The big problem with parallel architectures is always exploiting memory access patterns, and the SGI solution enables us to focus on the problem we're trying to solve, rather than the limitations of the hardware we're using. We expect this to more than double the speed of our total systems development."

– Professor Danny Crookes, School of Computer Science, Queens University Belfast

RASC points the way forward for HPC

The Institute for Electronics, Communications and Information Technology (ECIT) at Queens University Belfast combines the capabilities of research groups including System on Chip; Speech, Image and Vision; and High Performance Computing. ECIT houses more than 120 researchers – and, with around £38 million investment, has major implications for the economic development of Northern Ireland.

Approximately 25 of ECIT's researchers are involved in development work related to Field Programmable Gate Arrays (FPGAs) – highly specialised devices that present significant advantages over traditional high performance computing (HPC) platforms. The researchers are focusing in particular on the use of FPGAs in high performance image and video processing, real-time video processing, new ways of developing silicon IP cores, and the application of FPGAs to programmable networks.

"For image and video processing we have several applications that need really high power computing. For instance, in processing ultra-large medical images such as the very high resolution scans used to identify cervical cancer, some of the images can be 100Kx100K pixels, which requires a vast amount of processing power," explains Professor Danny Crookes, Director of the Speech, Image and Vision Systems group.

"Normally these images are 2D, but because the samples themselves can be 3D, what you sometimes find is that different parts of the image are either in or out of focus. We're therefore aiming to get 3D information by using computational techniques to reduce the number of scans needed at different heights.

"In real-time video processing, meanwhile, we're looking at applications involving multiple video sources being processed simultaneously – for example for security surveillance where you might

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have multiple cameras and want to model the movements of people to recognise potentially suspicious behaviour. We're also investigating the use of mobile camera devices with local on-board processing for tracking and recognition – where power, portability and speed are obviously crucially important."

Why FPGAs?

In the past, Professor Crookes' team used supercomputer clusters to give them the performance they needed, and research concentrated on developing software tools (particularly programming languages and libraries) to enable applications to be written at a high level and then compiled onto a parallel system. In recent years, however, the team's focus for HPC has turned to the use of FPGAs.

"The advantages of FPGAs over a traditional supercomputer really depend on the type of processing you're doing, but for many applications, particularly image and video processing, you can get the same performance with an FPGA that you would with a supercomputer cluster – and with the added benefits of portability, lower cost, and low power if you want mobile devices," continues Professor Crookes.

"The disadvantage, however, is that the design time for designing efficient hardware is much higher than for software, and the skill set required is relatively rare - particularly among application developers. If you're designing for software and don't use the best design approach, you can lose a factor of two or three, whereas for hardware a naïve approach can lose you a factor of 1,000. We're therefore aiming to develop software tools providing a standard application development environment (for which we're using Matlab as the front end, but with a sophisticated reasoning engine and a way of describing 'intelligent' design components and design patterns) which will result in a very efficient hardware implementation - almost automatically."

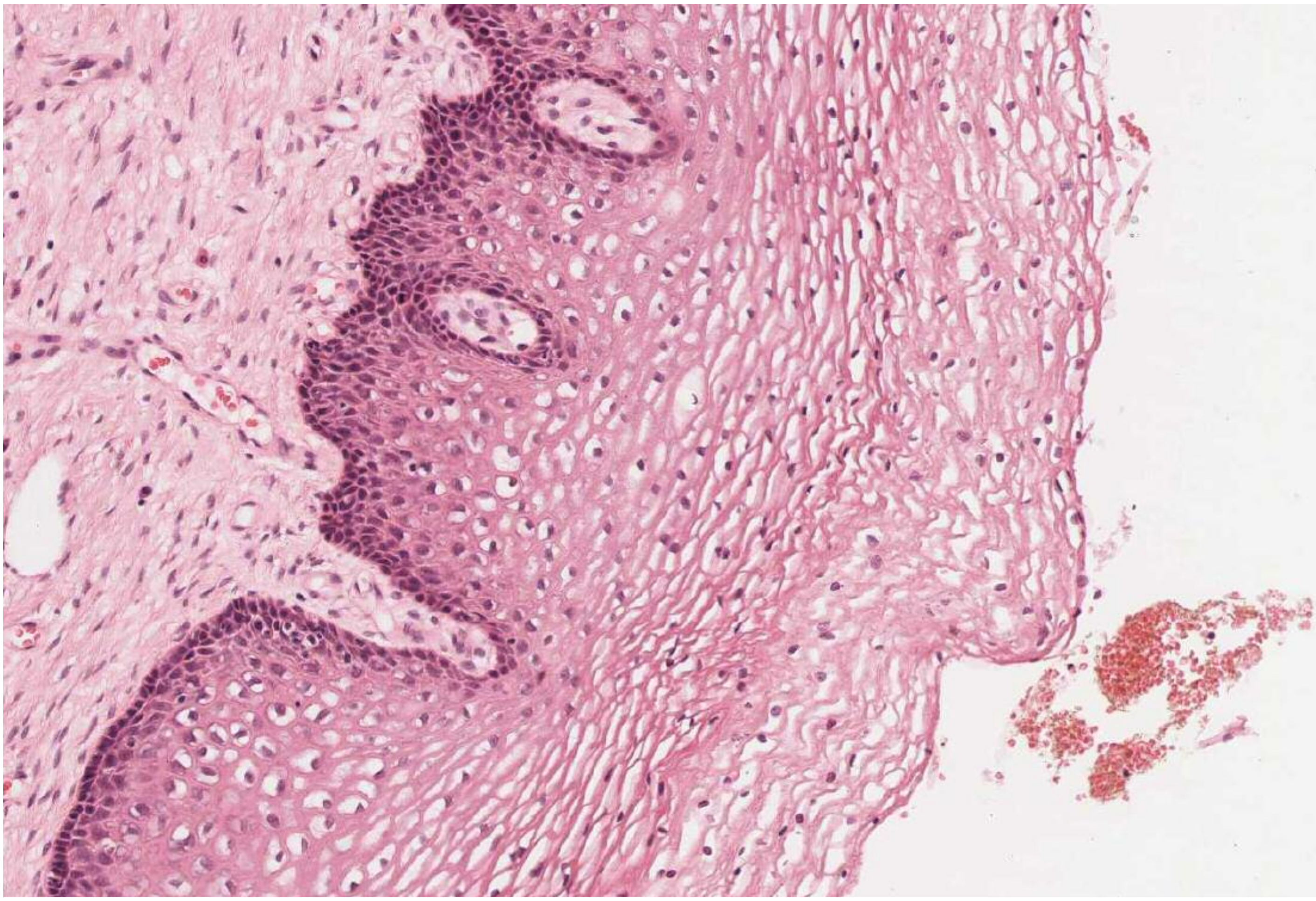
Why SGI?

By avoiding the previous limitations of FPGAs, SGI's RASC™ (Reconfigurable Application-Specific Computing) approach presents multiple benefits for the ECIT teams. "Because RASC can access memory at really high speeds, in your design you can focus your attention on the problem you want to solve, rather than on how to get around the limitations of the hardware you're using," explains Professor Crookes.

"The other big advantage is that because it's scalable, you can have access to very large memory and don't have to worry so much about things like synchronising access to different memory banks. This too means that you have one less thing to think about when you're designing your system.

"We want to be able to migrate from an HPC cluster to RASC, so another nice thing about the SGI architecture is its excellent shared memory model, which means the cluster's view of memory can be the same as that of the RASC, and so we can communicate much more easily between the two. We can also move the processing from the cluster onto the RASC without physically changing the memory structure. If you couldn't do this, you'd end up with two separate environments with different libraries.

"For problems of a serious size one of the issues with FPGAs is the memory interface. What most people have focused on in the past is the processing, but that's actually the easy bit. What we're finding is that one of the most significant design issues is the memory model. SGI have done a lot of forward thinking on this, and made it much more possible to get a standard memory model that saves a lot of development time. It's already proving its worth in the HPC arena, and I think that for the same reason, for what we'd call 'significant' systems, we can expect it to more



Small section of a cancer scan – Cervical Histology

than double the speed of our total systems development.

"Another thing RASC enables us to do that we couldn't do before is to have a 'hybrid' implementation where part of an application will run on an FPGA, and part on the high performance cluster – hence maximising the use of our resources. The FPGA is very good at certain things, and we can use this to free up the rest of the cluster for doing things with the data for which the processors are better suited. This creates the types of extra options that SGI are calling 'multi-paradigm computing'."

Looking to the future, Professor Crookes and his team will be using RASC with their SGI® Altix® server and Silicon Graphics Prism™ visual computing solutions to develop a variety of specialist applications and tools. "A lot of supercomputer vendors are now offering FPGA facilities and components, and we're working in conjunction with a world leader in high performance scientific libraries to develop FPGA implementations of these same libraries. This will mean that the user, without having to change their code, can run it on a mixture of FPGA and HPC, or even switch seamlessly between the two. SGI gives us the ideal platform for developing the tools that are necessary to do this," concludes Professor Crookes

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