

Institution: Queen's University Belfast		
Unit of Assessment: UoA12		
Title of case study: Acceleration of Big Data Applications		
Period when the underpinning research was undertaken: from 2003 to 2018		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Roger Woods	Professor	1986 to present
Period when the claimed impact occurred: from 2013 to 2020		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact (indicative maximum 100 words)		
<p>Research into software for accelerating signal and data processing solutions has spun out from Queen's University as <i>Analytics Engines Ltd.</i> Analytics Engines Ltd. has developed state-of-the-art software that is applied across a diverse range of sectors. These include healthcare, trade, finance and digital infrastructure.</p> <p>Analytics Engines Ltd. has secured private investment of GBP[text removed for publication] and currently (2020) employs [text removed for publication] people. The company has created solutions used by over [text removed for publication] organisations, including The National Gallery London, and Innovate UK. The firm's solutions have allowed organisations to improve their data analytics capacity and to transform and modernise traditional processes.</p>		
2. Underpinning research (indicative maximum 500 words)		
<p>The ability to effectively harness new and evolving computing technologies is a key challenge for many signal and data processing applications. The main attraction of using novel computing technologies such as field programmable gate arrays (FPGAs, an integrated circuit designed to be configured by a customer or a designer for specified application) is that they offer a considerable cost benefit as users can optimise the hardware in a way not possible using conventional computing architectures. FPGA companies create intellectual property (IP) cores that allow designers to take advantage of previously implemented designs. However, a significant bottleneck existed that whilst companies have system models, IP cores and FPGA boards, designers still need to spend several months achieving an efficient implementation. Innovative QUB research successfully addressed this bottleneck.</p> <p>Led by Professor Roger Woods, the UoA made key advances in this area of accelerated FPGA implementation that are now used by Analytics Engines Ltd (formerly CapnaDSP). An innovative methodology based on a data flow programming approach led to a suite of prototype tools for rapid algorithmic to programme implementation on FPGA's, R[1], thereby reducing non-recurrent engineering design time. The work was matured through research funded by the UK Electro-Magnetic Remote Sensing Defence Technology Centre (EMRC DTC) and resulted in the development of a prototype software framework called Owen R[2],R[3] for the rapid implementation and optimisation of DSP systems on FPGA platforms.</p> <p>The EMRS DTC programme final report, S[1], noted, "One of the most successful Transducer Embedded Processing (TEP) projects has been the work of Queen's University Belfast with their project on rapid development techniques and tools for field programmable gate arrays (FPGAs). During the course of the DTC the team completed the development of a new FPGA design environment, and spun-out an exploitation company (CapnaDSP)".</p>		

Whilst the original FPGA acceleration work was initially applied to defence applications, it was decided to speed up the programming of FPGA hardware for a more diverse range of applications across a broader range of sectors that included manufacturing, service and culture.

The key to the programming speed ups required for these sectors came when we showed how to avoid the considerably lengthy place and route compiler design times associated with conventional FPGAs, **R[4]**. This was achieved by creating efficient high performance, scalable soft-core processor targeted processors which could then be programmed using a software compilation process as outlined in **R[5]**. This work later resulted in the development of an FPGA-based solution for Real-time Analytics on Fast Data Streams created by Analytics Engines Ltd. which has been successfully applied to options pricing for finance **R[6]** as part of work supported by the EC, grant number 610509 (NanoStreams). This was a collaborative project involving Credit Suisse, IBM Research, Analytics Engines Ltd. and Queen's University Belfast.

3. References to the research (indicative maximum of six references)

R[1] J. Mc Allister, R. **Woods**, R. Walke, D. Reilly, K. Colgan and Y Yi, "Design technologies for DSP algorithm implementation on heterogeneous architectures", (invited paper) Proc. of SPIE Advanced Signal Processing, Architectures and Implementations XIII, San Diego, USA Vol. 5205, 6-8 Aug. 2003, pp585-597. doi.org/10.1117/12.506954

R[2] R. **Woods**, J. McAllister, R. Hasson and S. Fischaber, "System level design flow for low latency sensors", Joint Annual Technical Conferences: Electro-Magnetic Remote Sensing Defence Technology Centre (DTC) & Systems Engineering for Autonomous Systems Defence Technology Centre (DTC), Edinburgh, June 2005.

R[3] J. McAllister, R. **Woods**, S. Fischaber and E. Malins, "Rapid Implementation and Optimisation of DSP Systems on FPGA-Centric Heterogeneous Platforms", (invited paper), Special issue on Samos05, Journal of Systems Architecture, Elsevier Inc., North-Holland, Vol. 53, No. 8, Aug. 2007, pp. 511-523. doi.org/10.1016/j.sysarc.2006.11.005

R[4] J. McAllister, R. **Woods**, R. Walke and D. Reilly, "Multidimensional DSP Core Synthesis for FPGA, (Invited paper), Journal of VLSI Signal Processing 43, 207–221, 2006, doi: [10.1007/s11265-006-7271-5](https://doi.org/10.1007/s11265-006-7271-5) have

R[5] F. Siddiqui, M. Russell, B. Bardak, R. **Woods** and K. Rafferty, "IPPro: FPGA based Image Processing Processor", IEEE Workshop on Signal Processing Systems, 20-22 Oct. 2014, Belfast, UK, pp. 1-6. doi: [10.1109/SiPS.2014.6986057](https://doi.org/10.1109/SiPS.2014.6986057)

R[6] M. Russell, U. I. Minhas, S. Kaloutsakis, P. Barber, R. **Woods**, G. Georgakoudis, C. Gillan and D. S. Nikolopoulos, "NanoStreams: A Microserver Architecture for Real-time Analytics on Fast Data Streams", IEEE Transactions on Multi-Scale Computing Systems, 4(3), July-Sept. 2018, pp. 396 – 409. doi: [10.1109/TMSCS.2017.2764087](https://doi.org/10.1109/TMSCS.2017.2764087)

4. Details of the impact (indicative maximum 750 words)

Analytics Engines Ltd was co-founded by Roger Woods (with support from QUBIS and investments (GBP[text removed for publication]) in 2014 from Crescent Capital to speed up production and exploitation of IP, **S[1]**, **S[2]**, **S[3]**, and allowing growth to [text removed for publication] people (2020). The company's turnover was GBP[text removed for publication] in 2019.

Analytics CTO said, "The company's inception in 2008 was the direct result of research carried out by Professor Woods and his team the technological breakthroughs developed in relation to Field Programmable Gate Arrays set the company up for important early successes." S[3].

The company was in 2019 cited as one of the 7 start-ups shaking up Ireland's data science scene, **S[4]** and has to date successfully developed data analytics software in the areas of health care, medical science, trade, finance and digital infrastructure.

One early achievement was the development for SAP (a large German software company with [text removed for publication] customers) of an FPGA-based acceleration solution which resulted in a [text removed for publication] times speedup when integrated with SAP's core product *HANA*, a relational database management system.

The SAP Cloud Architect stated, "This early work provided key learnings of the potential of FPGA acceleration for In-memory databases and was fundamental in SAP's continuing work in this area", S[5].

The Almac Group is a leading pharmaceutical research organization employing over [text removed for publication] people. Its bioinformatics pipeline is an essential component of the company's diagnostics development and consultancy services. Almac identified their Gap Statistic Function as a bottleneck in their workflow, requiring a run time of [text removed for publication] hours thereby limiting Almac's diagnostic capability. Analytics Engines developed an optimised direct drop-in replacement function to allow the GAP Statistic Function to be deployed over multiple, multi-threaded computing cores. The solution resulted in a [text removed for publication] reduction in runtime for the typical full Statistic Gap Function pipeline.

Almac state, 'The pipeline can now be set up to run with [text removed for publication] minutes of hands on time and results returned within [text removed for publication]. Depending on the complexity of the dataset and analysis, this saves [text removed for publication] hours of FTE per analysis and enables Almac to take a data driven discovery approach. The pipelines are now run reliably, reproducibly and repeatably with a full audit trail', S[6].

Coriolis Technologies aggregate global trade and finance data into one place through its 'MultiLateral' platform. This allows banks, politicians, and businesses to accurately identify who trades what with whom. In 2019, Analytics Engines supported the next development of 'MultiLateral' allowing ingestion of up-to-date trade data from the United Nations Comtrade Database, **S[7]**. Analytics Engines optimised the performance of the refinement algorithm by improving the debug cycle required to faithfully implement the algorithms and created an intuitive visualisation capability ensuring end-users can isolate specific data for in-depth analysis. The allowed leverage of performance, reducing time taken to refine data from [text removed for publication]. One process displayed an improvement over CPU's of up to [text removed for publication] times.

The CEO of Coriolis Technologies said, "I would recommend Analytics Engines for its intellectual capacity and drive to move a project from the original vision through to new levels of potential. The team at Analytics Engines has more than exceeded expectations", S[7].

London's National Gallery houses a 2,300-strong collection. Here a solution called Perspective allowed the Gallery to employ data analytics to create robust reporting on visitor experiences by harnessing and examining data from a disparate range of sources. This yielded augmented visitor experiences and improved visitor flow.

"Any time an issue came up that could have been a blocker, everyone at Analytics Engines was really quick to find solutions and find an approach that worked. That was the reason why we were able to launch the solution as quickly as we could.", Senior Manager Data and Insights, The National Gallery, S[8].

Analytics Engines have also delivered transformative solutions for a number of other organisations:

For Innovate UK (2017) Analytics data solution COBALT Grant Manager was used to reduce the time taken for initial processing of applications from [text removed for publication] to a few minutes. **“Being able to successfully deliver on our objectives has been very beneficial both internally for Innovate and for me personally.” Applications and Assessment Team Leader Innovate UK, S[9].** While the COBALT Rates Revenue solution, created for Belfast City Council, identified GBP[text removed for publication] in additional revenue from unpaid non-domestic rates.

Precision, **S[10]**, a solution developed for Altnagelvin Hospital, was able to increase team capacity by [text removed for publication] and deliver efficiencies and costs savings of over GBP[text removed for publication] per year.

These have allowed Analytics Engines Ltd. to deliver significant insights and successful outcomes for its customers.

5. Sources to corroborate the impact (indicative maximum of 10 references)

- S[1]** EMRS DTC programme final report
- S[2]** Crescent Capital press release: Analytics Engines secures £1m+ investment
- S[3]** Letter from Analytics CTO
- S[4]** 7 start-ups shaking up Ireland’s data science scene
- S[5]** Letter from SAP
- S[6]** Almac Case Study
- S[7]** Coriolis Technologies case study
- S[8]** National Gallery case study
- S[9]** Cobalt Grant Manager Innovate UK Case Study
- S[10]** Precision for Pharmacy Altnagelvin Hospital