Institution: UNIVERSITY of WEST LONDON

Unit of Assessment: 11 | COMPUTER SCIENCE and INFORMATICS

Title of case study:

Development of model-driven software methods that support knowledge-based, process-driven (mobile) service oriented architectures

1. Summary of the impact

This case study reports the impact on businesses and practitioners of model-driven software architecture research, workflow-based application development, and intelligent computing through a series of connected JISC, Knowledge Connect projects, and, especially, Knowledge Transfer Partnerships.

Key impacts for software companies, related to their software development processes and products, include the adoption of the model-driven architecture approach, showing:

- Improved software development processes for workflow-based and mobile applications.
- Early adoption of software product lines (SPLs).

Integration of intelligent computing in the form of data mining and decision support in software processes and products.

2. Underpinning research

Dr Samia Oussena laid the foundation for the reported impacts in 2005. She has primarily driven the research since then. From 2005 to 2010 Professor Balbir Barn and Professor Tony Clark helped consolidate research of model-driven software architectures (MDA) by establishing the Centre for Model-driven Software Engineering. In 2011, Professor Thomas Roth-Berghofer joined the centre, adding case-based reasoning and explanation-aware computing expertise. The key research driver in the centre is application-oriented and model driven software engineering closely linked with industry.

This case study focuses on knowledge transfer: mobile applications, workflow-based applications, and intelligent applications. These build upon a stream of successful JISC-funded projects for support in HE, namely CoVaRM, MPLAT, REMORA and, P-SPEX.

2.1 Mobile applications

MPLAT (Placement Learning and Assessment Toolkit) and REMORA (Mobile Applications in the Wild) demonstrated the strength of the software architecture methods in the HE learning and teaching environment, as well as its suitability for mobile application development. This convinced Mammoth Graphics Ltd. to work with the UoA in a number of projects. The first was a Knowledge Connect project to develop an iPhone app for the "Tour de France" that established the foundation for the development domain specific languages (DSL) for mobile platforms. A KTP proposal for the development of an engine for the DSL and consultancy on mobile application development followed. This led to PhD research on SPLs for context aware mobile applications.

2.2 Workflow-based applications

The roots of workflow-based applications in the Centre can be found in the JISC-funded projects CoVa and CoVaRM. The Course Validation Reference Model set out to explore the potential automation of elements in the course/programme validation process. SPLs and model-driven software development for the development of enterprise portals were introduced at **Arc Technology Ltd**. in a KTP (2010-12).

Arc Technology Ltd. and the submitting unit, recently started a second KTP, which aims to introduce context-aware mobile workflow management into their new product for managing student attendance and reporting within an HE environment (2013-15). One of the centre's recent PhD graduates, Anna Kocurova, joined Arc where she is applying her research in content-centric collaborative workflow management for mobile devices.
Two Knowledge Connect projects also introduced workflows and business process modelling to SMEs: **Lifeline Learning Inc**. (2009) developed a model-driven approach to learning workflows for foreign language tuition; **Wizzbike Ltd.** developed the use of Business Process Model and Notation.

2.3 Intelligent applications

MCMS (2008-10), a JISC-funded project, investigated the use of Data Mining to support student learning by detecting situations where early intervention could help retain students. In a Knowledge Connect project with **Mobsventures Ltd** (2009), the centre applied social networking and data mining to help develop and re-architect a social networking platform that matches users against opportunities provided by the public sector.

Linking University Course Information (LUCI) (JISC, 2011-13) applied the centre's expertise to link course data information and additional peripheral information, such as transport, location, and labour market, in a Linked Data format. This complements another JISC-funded project, Student Internship Programme (SIP) (2011-13), on internship/work experience, with both taking an Enterprise Architecture approach.

Our most recent KTP is with **MBS Survey Software Ltd.** (2013-15) and focuses on developing a software system that helps build 3D models from point cloud data through applying intelligent computing, where the point could data is acquired with a laser scan survey of building exteriors/interiors.

3. References to the research

Key Researchers:

- Dr **Samia Oussena**, Reader in Software Engineering, 2005-present, PI of all projects (except CoVa, CoVaRM, P-SPEX, MBS)
- Professor **Balbir Barn**, Professor in Software Engineering, 2005-8: MPLAT, REMORA, P-SPEX, CoVa, CoVaRM
- Professor **Tony Clark**, Professor in Software Engineering, 2008–10: Mammoth Graphics, Mobs Venture, Lifeline Learning, Wizzbike, MCMS
- **Hyonsook Kim**, RA/PhD student, 2008–13: MCMS, LUCI, SIP, Lifeline Learning, Wizzbike
- **Anna Kocurova**, RA/PhD student, 2008 –13: Lifeline Learning
- Professor **Peter Komisarzuk**, Professor in Computing, 2010-present: LUCI, SIP, Arc Technology.

- **Dean Kramer**, RA/PhD student, 2007–2013: REMORA, Mammoth Graphics, Mobs Venture
- **Neil Mather**, KTP Associate/PhD student, 2008-13: Arc Technology
- Dr **John Moore**, Senior Lecturer in Computing: REMORA, MCMS
- Professor **Thomas Roth-Berghofer**, Professor in Artificial Intelligence, 2011-present: MBS Survey Software
- **Liz Sokolowski**, Senior Lecturer in Computing: LUCI

References to the research:

- Kramer, D., Kocurova, A., Oussena, S., Clark, T., & Komisarczuk, P. (2011, December). An extensible, self contained, layered approach to context acquisition. In Proc. of the Third Int. Workshop on Middleware for Pervasive Mobile and Embedded Computing (p. 6). ACM.

- Kim, H., Zhang, Y., Oussena, S., & Clark, T. (2009, November). A case study on model driven data integration for data centric software development. In Proc. of the ACM first int. workshop on Data-intensive software management and mining (pp. 1-6). ACM.

- Kocurova, A., Oussena, S., Komisarczuk, P., & Clark, T. (2012, June). Context-aware content-centric collaborative workflow management for mobile devices. In COLLA 2012, The Second Int. Conference on Advanced Collaborative Networks, Systems and Applications (pp. 54-57).

- Kramer D., Clark T., Oussena S. (2011). Platform Independent, Higher-Order, Statically Checked Mobile Applications. The Int. Journal of Design, Analysis and Tool for Circuits and Systems.

- Barn, B. S., Dexter, H., Oussena, S., & Sparks, D. (2007). SOA-MDK: Towards a method development kit for service oriented system development. In Advances in Information Systems Development (pp. 191-201). Springer US

- Oussena, S., & Barn, B. (2009). Layered process models: analysis and implementation (using MDA principles). Eleventh International Conference on Enterprise Information Systems

4. Details of the impact

Knowledge Connect projects

(2009) Mobsventures Ltd. The project aimed to take Slenky, a social networking system for young people, and produce an updated design incorporating the necessary components utilising intelligent matching and moderation. The project provided the company with an example of how a scalable open source solution could be included in their commercial platform. The project provided a core engine that could be taken by Mobsventures Ltd. and used as the basis of commercial implementation.

(2009) Lifeline Learning Inc. The project achieved adaptive processes on a smaller scale, by using a hybrid approach involving the development of an adaptive sequencing engine for use with an open source application and social networking system. The application and the associated knowledge allowed Lifeline Learning Inc. to become more flexible in its delivery and more attractive to prospective students. The significance of the system was its potential to provide a semi-automated, personalized learning environment using open source products, which goes some way to addressing the problem of 'doing more with less' in a small business.

(2009) Mammoth Graphics Ltd. Prior to the project, Mammoth had developed media applications exclusively for television and web-based users. However, the creative industry trend began to produce media applications that work on mobile devices such as the iPhone and the Android

phone. Mammoth wanted to create a new business line by developing a mobile technology offering to complement the television graphics output. The project resulted in the production of an iPhone application involving interactive 3D data displays. As a consequence of the project, Mammoth started to expand its business by delivering applications on multiple mobile devices, seeking to offer products and services that can work together.

(2010) Wizzbike The key learning points for the company were the requirement to think clearly about their business processes and to spend considerable time in cleaning up the data behind the business, notably within the EPOS (electronic point of sale) database that underpinned the retail sales and service. The project provided the company with a good understanding and control of their systems and processes and launch an effective new website with real-time stock control.

Knowledge Transfer Partnerships (KTPs)

(2010-12) Arc Technology Ltd. Although the requirements of HEIs (Arc Technology Ltd clients) have some commonality, there are variants that need to be addressed and is traditionally left to the customisation stage. The project demonstrated the benefit of integrating SPL techniques to the development of customer portals. This has led to the company adopting both, product lines and model driven development, to their other products. Some ARC legacy systems have already been partly rewritten and KTP associate Neil Mather is now employed at Arc and enrolled at UWL on an MPhil.

(2010-13) Mammoth Graphics Ltd. The project has allowed Mammoth Graphic to create a new line of business in the second screen market, which enables content consumers with a mobile device to interact with what they are watching on a TV show. Mammoth has excellent contacts within the television industry and has exploited these for its new capability. The project also helped to improve their competitiveness and has acted as the catalyst for Mammoth to enter new markets and develop capabilities in the second screen market.

(2013-15) Arc Technology Ltd. The outcome of the project is expected to increase the company's profile and cement its lead position within its market place, by establishing a new line of business within ARC in mobile applications and development of a new revenue stream. The main technological innovation that will be exploited here is to harness contextual data provided by mobile devices in order to provide a personalised, adaptive and, anticipatory workflow system.

(2013-15) MBS Survey Software Ltd. The partnership will enable MBS to deliver a product that makes 3D models from point cloud data effectively and efficiently. This will serve to increase the company's profile within the sector and in turn boost its position within the market place.

5. Sources to corroborate the impact

- Managing Director, ARC Technology Ltd.
- Managing Director, Mammoth
- Managing Director, WiZZBiKE
- CEO, Mobsventures Ltd