Institution: University of Leicester

Unit of Assessment: UoA 11 Computer Science and Informatics

Title of case study: Underpinning successful UK-based innovation in security alarm systems

1. Summary of the impact

Expertise in mobile and location-aware web applications has underpinned the development of a revolutionary new security alarm system. Collaboration with an SME created, for the first time, a system to alert customers in real-time, via sensor-triggered cameras and phones. The impact of this collaboration has been to transform a UK company from a distributor of hardware to a leading innovator in security. More than £1 million of the company's £1.9 million turnover for 2012 was directly attributed to sales of the new system, now operating at more than 800 sites, providing improved security and cost savings - for example through preventing metal theft - for commercial, transport, ecclesiastical and construction sites across the UK.

2. Underpinning research

The expertise in context-aware (and specifically mobile, location-aware) web applications and services was acquired through research in context-aware collaborative systems and web service selection at Leicester conducted within two larger research projects, *Sensoria* and *InContext*. Briefly, *InContext* developed a platform and methodologies for context-aware computing while *Sensoria* was concerned with methodologies and tools for software engineering of service-oriented systems. The projects were led by **Heckel**, **Fiadeiro** and **Reiff-Marganiec,** and employed 5 RAs (Bocchi, Ehrig, Paoli, Hong, Yu).

Information about the context of an application, user or device, such as their location, current or future activity, or capability, can be used to select users or services for particular tasks, adapt the communication channels used between participants, or even the functionality provided at a point in time. For example, workers can be assigned tasks based on their location or expertise, or when a mobile device experiences low bandwidth, more demanding (e.g., video streaming) services may be deliberately degraded or disabled.

To support such scenarios, context information needs to be collected and stored, updated, shared and acted upon systematically. For this purpose, the *inContext* project developed a service-oriented architecture [4] based on a context store which, using a representation of the data in semantic web formats, allowed interaction with (software or hardware) sensors as well as client components as services. It furthermore employs automatic selection mechanisms to decide on appropriate services to be used. Specific contributions from Leicester included the modelling of Data [1] and the development of the service selection mechanisms [2,3], while the project partners were concerned with implementation (HP, Microsoft, Ecosoft), consideration of team structures (TU Vienna) and Querying of Semantic Structures (Deri).

Sensoria considered specific software engineering aspects for service systems, most pertinent and related to the effort by Leicester are the reengineering and related validation. The majority of service-oriented applications arise from reengineering existing software, where services are identified and extracted, replacing an existing user interface by a web service interface. A corresponding methodology and process has been developed [5]. Validating the quality of service-oriented applications requires new approaches of testing, one of which has been explored and reported accordingly [6].

3. References to the research

Grants:

"InContext: Interaction and Context Based Technologies for Collaborative Teams", IST-2006-034718, EUR 2,497,264 (Leicester: EUR 309,564); May 2006 - January 2009. Grant holders for UoL: J L Fiadeiro, R Heckel, S Reiff-Marganiec

"Sensoria: Software Engineering for Service-Oriented Overlay Computers", FP6-IST-2005-16004; €8,158,000 (Leicester: €742,380); September 05 – February 10. Grant holders for UoL: J Fiadeiro, R Heckel, S Reiff-Marganiec.

Publications (Leicester authors underlined)

[1] Kamran Taj Pathan, Stephan Reiff-Marganiec, Yi Hong: Mapping for Activity Recognition in the Context-Aware Systems Using Software Sensors. DASC 2011: 215-221. doi.ieeecomputersociety.org/10.1109/DASC.2011.56

[2] Hong Qing Yu, Stephan Reiff-Marganiec: Automated Context-Aware Service Selection for Collaborative Systems. CAiSE 2009: 261-274. dx.doi.org/10.1007/978-3-642-02144-2_23

[3] Hong Qing Yu, Stephan Reiff-Marganiec, Marcel Tilly: Composition Context for Web Services Selection. ICWS 2008: 785-786. dx.doi.org/10.1109/ICWS.2008.98

[4] Hong Linh Truong, Schahram Dustdar, Dino Baggio, Stephane Corlosquet, Christoph Dorn, Giovanni Giuliani, Robert Gombotz, Yi Hong, Pete Kendal, Christian Melchiorre, Sarit Moretzky, Sebastien Peray, Axel Polleres, Stephan Reiff-Marganiec, Daniel Schall, Simona Stringa, Marcel Tilly, Hong Qing Yu: inContext: A Pervasive and Collaborative Working Environment for Emerging Team Forms. SAINT 2008: 118-125. doi.ieeecomputersociety.org/10.1109/SAINT.2008.70

[5] R Correia, C Matos, R Heckel, M El-Ramly: Architecture Migration Driven by Code Categorization. ECSA 2007, LNCS , Springer, 115-122 (2007)

[6] R Heckel, Leonardo Mariani: Automatic Conformance Testing of Web Services. FASE 2005, LNCS, Springer, 34-48 (2005)

4. Details of the impact

Video Domain Technologies (VDT) Direct Limited, based in Mansfield, approached the UoA in 2009 after being advised by a growth consultant to investigate university collaboration as a source of expertise. Engagement has since taken various forms, including a University-funded Innovation Partnership involving several members of the UoA in technical consulting activities (S. Reiff-Marganiec, R. Heckel, Emilio Tuosto in 2009-10) and three Masters (MSc) projects co-supervised by R. Heckel in 2010-12.

The initial focus of the products developed focused on the commercial rather than residential use where they provide for curtailing of losses (e.g. the theft of copper cables on rail lines or lead on churches). Traditional alarm systems involve the use of land-based servers which are situated in physical buildings and monitored at computer screens. The monitoring is often carried out by security company staff who lack "on-the-spot" knowledge of what they are looking at and therefore find it difficult to accurately interpret video footage.

The collaboration has led to the development of novel alarm system software called **WebEye**. The software enables the company to offer an alarm system (Videofied) which has several advantages over traditional systems. Uniquely, the alarm system consists of a network of battery-operated video cameras which are triggered by motion sensors to capture a 10-second video clip when movement is detected. The video footage is then remotely transmitted to a web-based system received by WebEye software. Internet servers receive the video and forward it to the customer, using a web-based application chosen by the customer – Browser, purpose built app, text message, email, Facebook or LinkedIn, for example. The recipients of the message are able to

view the video footage, assess whether a crime is taking place and take action if appropriate, within seconds of the motion being detected.

The academics enabled the product to be developed by informing the design of the system, consulting on the technologies used in its implementation, providing training to enable the company to take up the advice and supporting the development of more innovative aspects in MSc projects underpinned by Heckel's expertise in designing, reengineering and testing web-based and service-oriented systems and Reiff-Marganiec's expertise in context-aware systems and services.

The work has informed the WebEye project in particular in view of the location-based delivery of alarms to mobile clients, which requires monitoring their locations based on the GPS sensors of these devices and deciding which client (serving a mobile security guard) is best placed to receive the alert, as well as in the service-oriented architecture of the application itself.

Managing Director of VDT had identified the potential for a web-based alarm system but the company lacked technical expertise to deliver the business idea. He said: "There is no doubt in my mind that WebEye would not have been developed without the University of Leicester expertise. We would not have taken the first steps and we wouldn't have had the confidence to invest in this idea.''

The company is the first to market with this new system and there are two novel and patented aspects:

1. *Progressive alarm delivery* – a cloud-based platform allows for the use of mobile technologies for delivery of the alarm. This enables the alert to be delivered to customers on the move, via their mobile phone, in a progressive manner using different technologies, ie persistent connection, push notification, sms, email, twitter, dependant on recipient response or the lack of it.

2. *Alarm response monitoring* – provision to monitor whether the recipient has actioned the alert. The second point is of particular importance and interest to insurance companies who are keen to establish what remedial action has been taken following the triggering of an alarm. Most alarm systems operate on a "send and forget" basis, whereas the novel systems continues to use different methods of communication – e.g. email, social media, text alert – until an alarm is acknowledged by the recipient.

The new product has found a market need driven by an epidemic of copper thefts across the UK over the past 10 years. Cabling at telephone exchanges and electricity substations, church roofs and even manhole covers are targeted by thieves. In 2011, experts estimated the total annual cost to the UK of copper theft had grown to £770 million with emergency services, transport services and online business security being undermined, as a result of railway lines and telephone networks being routinely disabled by thefts. In 2011, Chief Superintendent Eamonn Carroll of British Transport Police described the theft of copper cable as "the next biggest priority after the terrorist threat. The disruption and the problems it can cause are immense".

More than £1 million of the company's £1.9 million turnover for 2012 was directly attributed to sales of the new system. The VDT chief executive said that the key market sectors currently using the WebEye alarm system were the rail, ecclesiastical and construction markets. There are now 800 WebEye alarm systems operating in these sectors – 600 of them paid for, with the other 200 operating on a demonstration-basis. These systems are delivering cost, effectiveness and efficiency benefits for customers including Network Rail, the Ecclesiastical Insurance Group, Bloor Homes and Taylor Wimpey.

The residential market (total 25 million homes in the UK) for WebEye is now being targeted by a network of 30 installers in the UK. Agents for WebEye have also been employed in the US, Australia, New Zealand and Ireland to exploit commercial markets. As of July 2013, global security providers Securitas were using the WebEye system in 15 test sites in the US.

5. Sources to corroborate the impact

Chief Executive of Video Domain Technologies (VDT) Direct Limited