Institution: University College London

Unit of Assessment: 11 – Computer Science and Informatics

Title of case study: xlinkit for fast, cheap, reliable banking with automated verification of over-the counter derivatives trading

1. Summary of the impact

The Software Systems Engineering Group at UCL developed and patented xlinkit, an approach that supports the validation of XML documents in general and over-the-counter (OTC) derivative transactions expressed in the Financial Products Markup Language (FpML) in particular. The widespread adoption of FpML (95% of financial market participants now use it for OTC transactions) has brought about a substantial reduction in market and credit risk for financial institutions, by reducing the time required to confirm derivative transactions from up to 10 days to at most one day. In the year to June 2012 about $440 trillion OTC transactions were executed worldwide. [text removed for publication]. Message Automation, which markets a product including tools based on that patent, has received £3 million revenue in the same period.

2. Underpinning research

The background of the research that led to xlinkit was Professor Wolfgang Emmerich and Professor Anthony Finkelstein's work on consistency management of structured and semi-structured software engineering artifacts. The consistency management of such documents required the representation of abstract syntax trees and graphs, the definition of validation rules to define static semantics and inter-document consistency constraints, and the construction of validation engines that can execute these rules.

The adoption of internet standards for managing semi-structured documents, most notably XML, opened the possibility to apply similar techniques to documents other than those developed during software development processes. The Document Object Model (DOM) defines how such semi-structured documents are represented in DOM trees, which are very similar in nature to abstract syntax trees. Thus from 1998, the UCL Software Systems Engineering Research Group began to explore whether the principles, methods and techniques for consistency management of software engineering artifacts could be realised more elegantly using the emerging family of standards on XML that were being defined at the same time by the World Wide Web Consortium (W3C), thereby making them applicable to a broader application area and semi-structured documents that are managed in a decentralised manner.

A decentralised setting necessitated the management of consistency relationships out of bounds from the documents that are being related. The emerging XLink standard of the W3C enabled the management of such out-of-bound relationships and the research focused on how such XLink relationships could be defined and created in an effective and efficient manner.

xlinkit defines a first order rule language, which combines universal and existential quantification with boolean logic operators over path expressions defined using the XPath standard. Through further work, researchers under the supervision of Professors Emmerich and Finkelstein then developed several denotational semantics to indicate how the xlinkit language can be interpreted. A first interpretation shows how the language can be used to define whether two distributed semi-structured documents are consistent with each other [1]. A second semantics defines how this language can be used to infer the out-of-bound links that capture consistency relationships between elements in two semi-structured distributed documents [1]. A third interpretation defines how the language can be used for two distributed documents that are inconsistent with each other to calculate all possible modifications that render them consistent again [3]. The initial application of this research was to demonstrate how to manage the consistency of software engineering documents [2,4].

Once the wide applicability of the basic research on consistency management using XML technologies became evident, UCL protected the IP of the underlying research through patenting it

in the US and UK [6]. UCL then created a spin-out company called Systemwire, appointed a CEO to this spin-out and moved to develop a commercial implementation of the research results. This implementation became available in early 2002.

During spring 2002, UBS, UCL and Systemwire proposed the creation of the FpML Validation Working Group to the International Swaps and Derivatives Association (ISDA), which was submitted in June 2002 [7]. ISDA accepted the proposal and the FpML Validation working group was created in autumn 2003. It was chaired by Christian Nentwich, Wolfgang Emmerich's PhD student and had wide industry participation from BNP Paribas, Deutsche Bank, Barclays Capital, UBS and JP Morgan. The Validation working group then used the xlinkit language called Constraint Language in XML (clix) to formulate consistency rules for derivative transactions defined using the FpML standard [5].

The principal researchers were Professor Wolfgang Emmerich (Lecturer in Computer Science, now Professor of Distributed Computing, at UCL since 1997) and Professor Anthony Finkelstein (Professor of Software Systems Engineering since 1997).

3. References to the research

References [1], [2] and [3] best demonstrate the quality of the research.

[1] C. Nentwich, L. Capra, W. Emmerich and A. Finkelstein (2002). xlinkit: A Consistency Checking and Smart Link Generation Service. ACM Transactions on Internet Technology, 2(2):151-185. http://doi.org/btnt4z

[2] C. Nentwich, W. Emmerich, A. Finkelstein and E. Ellmer (2003). Flexible Consistency Checking. ACM Transactions on Software Engineering and Methodology, 12(1):28-63. http://doi.org/bt87v2

[3] C. Nentwich, W. Emmerich and A. Finkelstein (2003). Consistency Management with Repair Actions. In Proc. of the 25th Int. Conference on Software Engineering, Portland, Oregon. pp. 455-464. ACM Press. http://doi.org/c6z7j3

[4] C. Nentwich, W. Emmerich and A. Finkelstein (2001). Static Consistency Checking for Distributed Specifications. In Proc. of the 16th Automated Software Engineering Conference, Coronado Island, CA. pp. 115-124. IEEE Computer Society. http://doi.org/fhphxv

[5] D. Dui, W. Emmerich, C. Nentwich and B. Thal (2003). Consistency Checking of Financial Derivative Transactions. In M. Aksit, M. Menzini and R. Unland (eds), Objects, Components, Architectures, Services and Applications for a Networked World. Lecture Notes in Computer Science. Vol. 2591. pp. 166-183. Springer Verlag. http://doi.org/bh5m8d

[6] US patent 7,143,103 granted 2006 to UCL for consistency management of distributed documents. UK Patent 9914232.5. Available on request. http://patentscope.wipo.int/search/en/detail.jsf?docId=US41646661

[7] B. Thal, W. Emmerich, S. Lord, D. Dui, and C. Nentwich, FpML validation proposal by UBS, UCL and Systemwire. June 2003 http://www.fpml.org/documents/proposals/valid/proposal-fpml-validation-1.0.pdf

4. Details of the impact

Since 2008, the adoption of FpML by the financial services sector has become widespread, with 95% of the financial market participants who deal in over-the-counter derivatives now using it at some stage in their trading process [a], benefiting from reduced costs and risks in their trading. Moreover, 22% of the non-financial market participants, such as vendors, implement the FpML validation rules defined with xlinkit. These firms have seen new revenue streams open for providing tools and services for FpML validation.

The current Version 5.3 of the FpML Standard that is available for these market participants to use free of charge was released in October 2012. It now defines some 500 validation rules for a large number of equity, interest rate, credit, energy and foreign exchange derivatives. The first version of FpML to include validation rules was Version 4, which was released in April 2004. It had included some 15 validation rules for interest rate derivatives. These validation rules help clarify the

meaning of derivative transactions defined in FpML and provide precise and unambiguous means for market participants who use FpML to electronically trade derivatives to validate the correctness of these transactions.

The validation rules are included in the normative part of the standard, which means that the financial market participants that have adopted FpML will have to comply with these validation rules in their FpML messages. MessageAutomation provides a reference implementation of these rules using its xlinkit technology, which continues to be included in Version 5.3 of the FpML standard as an informative reference. As such it has **informed the adoption of electronic processing between 2008 and 2013**.

The **key beneficiaries of this impact are financial services institutions who trade in over-the-counter derivatives**. ISDA found the volume of these transactions in the 12 months to July 2012 was $440 trillion, about 200 times the annual GDP of the UK [b]. These participants benefit from the clarity and unambiguity introduced through the validation rules defined using UCL's consistency-checking technology.

The ability to check whether a trade meets all relevant constraints automatically and therefore with minimal cost leads to a **significant reduction in the time it takes to confirm these transactions,** with fewer operations staff required. Financial market participants are exposed to market and credit risk during the period between a trade being agreed and its confirmation. This is why the time required to confirm trades is used as a key indicator of the operational efficiency of market participants in the ISDA's annual Operations Benchmark Surveys.

The state of practice in derivatives processing at the beginning of the REF impact period is characterised in the 2007 ISDA Operations Benchmarking Survey [c]. The survey shows the distribution of confirmation delay, with between just 56-88% (depending on asset class) of trades being confirmed on the day after the trade had been agreed. Even after five days only 79-98% of trades had been confirmed. The 2007 survey did not distinguish between electronic and manual confirmations, and stated that many market participants were only planning the adoption of FpML for electronic confirmation in the near future. It is the manual confirmation processes, which include manual validation of these trades, which delay the confirmation.

The impact of the widespread adoption of FpML during the REF period is demonstrated by the 2013 ISDA Operations Benchmarking Survey [d]. ISDA found a **significant level of adoption of electronic confirmations** for different classes of OTC derivatives. The 2013 survey shows that the adoption rate of electronic confirmations for all market participants was 92% for interest rates derivatives, 100% for credit derivatives, 76% for equity derivatives, 82% for currency derivatives and 77% for commodity derivatives. It then shows that confirmation occurred on the same day for between 75-85% of the transactions, depending on asset class and that for all but credit derivatives 100% of the confirmations had been sent the following day. For credit derivatives 98% were confirmed the following day and 100% the day after. The survey also states that the time for manual confirmations takes between six and ten days depending on asset class.

Thus the substantial introduction of electronic confirmation with FpML, which can be validated automatically, has **reduced manual effort and brought down the time required to confirm derivative transactions from up to 10 days to at most one day**. This reduction means there is also a **substantial reduction in the period during which a financial market participant is subject to market and credit risk** because a contract is not yet confirmed. Given the value of these transactions confirmed by the FpML surveys, this risk reduction is very significant.

Some financial market participants have stated these benefits publicly. In a press release issued on 25 April 2010, Citigroup announced its adoption of FpML and stated "**Benefits include ease of validation for correctness and completeness of data, ease of processing, ease of deployment and lower processing costs**" [e]. In 2007, the Society for Worldwide Interchange of Financial Transactions (SWIFT), announced the adoption of FpML for derivative messaging on its SwiftNet and confirmed validation as one of its benefits. The first FpML message was traded and

validated on SwiftNet in July 2008, enabling firms that use their products to **reduce costs and risks**. A senior vice president at SwiftNet's client Brown Brothers Harriman said: "The primary benefit we have achieved is **improved operational risk management**… Manually keying in instructions is fraught with risk of errors, where incorrect information could go into an accounting system and be used to strike a NAV [net asset value] for a fund." [f]

Many financial market participants have implemented the FpML validation rules in a proprietary manner. In addition, there are at least six commercially available implementations of the rules. One of these implementations was built by Systemwire, the UCL spinout. Systemwire's FpML validator became ISDA's reference implementation, which has informed a number of FpML implementation projects between 2008-2013 that were required to achieve the benefit of reduced trade confirmation times [g].

In 2004, Systemwire was acquired through trade sale by Message Automation, a London-based specialist in financial trading systems. Message Automation still markets the implementation of the FpML validation rules in a product called Validator, part of its futureLANDSCAPE solution. This enables the financial community to significantly reduce operational risk and cost by imposing market standard and internal controls on the quality of data moving around an organisation. The CEO of Message Automation says: "The Validator tool was launched in 2008 as part of the Message Automation solution set which has been adopted by several leading international financial institutions. These include HSBC, Lloyds Banking Group, Nomura, Credit Suisse, Royal Bank of Canada, Fidelity Investments, Deutsche Bank and RBS. The futureLANDSCAPE solution set has generated in excess of £3 million of revenues for Message Automation Ltd., with a significant percentage in the form of exports." [h]. [text removed for publication]

5. Sources to corroborate the impact

[a] ISDA User Survey 2011, which confirms 95% FpML adoption levels
http://www.isda.org/media/press/2011/pdf/isda-fpml-user-survey.pdf

[b] ISDA Press Release 2012 confirms size of OTC Derivative Market is $440 trillion
http://www2.isda.org/attachment/NDQzNg==/Market%20Analysis%20-%20Year-end%202011%20Release%20FINAL.pdf

[c] Page 7, ISDA Operations Benchmarking Survey April 2007.
http://www.isda.org/c_and_a/pdf/ISDA-Operations-Survey-2007.pdf

[d] Pages 9-10, ISDA Operations Benchmarking Survey April 2013.
http://www2.isda.org/attachment/NTUzOQ==/OBS%202013%20FINAL%200425.pdf

[e] Citigroup's use of FpML: http://www.fpml.org/news/press042501.html

[f] SwifNet's use of FpML, including quote from Brown Brothers Harriman. See
http://www.swift.com/news/derivatives_solution?lang=en

[g] http://www.fpml.org/tools/validator/index.html indicates that the reference implementation of FpML validation is at http://messageautomation.com/validator.html

[h] Statement from the CEO of Message Automation confirms the acquisition of Systemwire by Message Automation, the benefits to the financial community of the validator product, the extent of adoption of the validator product by financial market participants and the revenue generated by the futureLANDSCAPE solution. Available on request.

[i] [text removed for publication]