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Collaborative Technologies for Mobile Workers and Virtual Project Teams

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COLLABORATIVE TECHNOLOGIES FOR MOBILE WORKERS AND VIRTUAL PROJECT TEAMS

By
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A dissertation thesis submitted in partial fulfilment of the requirements for the award of
the Engineering Doctorate (EngD) degree at Loughborough University

July 2009

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Emma, who married me.

Finally, my present compliment of children: Molly, Nancy, Finbarr, and Martha whom I am sure will never read this.

ABSTRACT

Information Technology is advancing at a frightening pace. Cloud computing and its subset, Software as a Service (SaaS), are rapidly challenging traditional thinking for enterprise-level application and infrastructure provision.

The project-centric nature of the construction industry provides an environment where the utilisation of SaaS is commercially appropriate, given its ability to provide rapid set-up and predictable costs at the outset. Using project extranets, the construction industry has been - unusually for it as an industry sector - early-adopters of this cloud computing model. However, findings from the research highlight that there is a gap in the information and documents that pass from the construction phase into the operational phase of a building.

This research considers examples of the SaaS IT model and how it has been used within a construction and facilities management industry context. A prototype system was developed to address the requirements of facilities management work order logging and tracking process. These requirements were gathered during detailed case studies of organisations within both the construction and facilities management sectors with a view to continue the use of building-specific information through its full life-cycle.

The thesis includes a summary of the lessons learnt through system implementation within the construction-contracting organisation Taylor Woodrow, and it concludes with an IT strategy proposal that was developed based on a cloud computing model.

KEY WORDS

Collaboration, Project Extranets, Mobility, SaaS, Cloud Computing, Document Management, Content Management, Internet, Construction Industry, Virtual teams

PREFACE

The research presented within this thesis constitutes the requirements of the EPSRC-supported Engineering Doctorate (EngD) programme run by the Centre for Innovative and Collaborative Engineering (CICE) at Loughborough University.

The Engineering Doctorate is a four-year postgraduate award intended for the UK's leading research engineers who want a managerial career in industry. It is a radical alternative to the traditional PhD, being better suited to the needs of industry, and providing a more vocationally oriented doctorate in engineering.

The EngD is examined on the basis of a thesis supported by peer-reviewed publications or technical reports. One journal paper and two conference papers support this thesis. Specific detail on the research can be found in papers presented in the appendices of this thesis, whilst the preceding chapters of the discourse provide the reader with a broader overview of the work undertaken throughout the period of the research.

USED ACRONYMS / ABBREVIATIONS

3G	3 rd Generation Wireless Communication Technology
AEC	Architectural, Engineering and Construction
AJAX	Asynchronous JavaScript and XML
ASP	Application Service Provider
BAA	British Airports Authority
BEng	Bachelor of Engineering
BT	British Telecommunications
CAD	Computer Aided Design
CICE	Centre for Innovative and Collaborative Engineering
CMS	Content Management System
CRM	Customer Relationship Management
DETR	Department of Environment, Transport and the Regions
DSSS	Direct Sequence Spread Spectrum
DTI	Department of Trade and Industry
EDMS	Electronic Document Management System
EngD	Engineering Doctorate
EPSRC	Engineering and Physical Sciences Research Council
FM	Facilities Management
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global Systems for Mobile Communications
HSDPA	High-Speed Downlink Packet Access
ICT	Information and Communication Technologies

IE	Internet Explorer
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
IPR	Intellectual Property Rights
IS	Information Systems
ISBN	International Standard Book Number
ISP	Internet Service Provider
ISSN	International Standard Serial Number
IT	Information Technology
KM	Knowledge Management
LAMP	Solution stack of software: Linux, Apache, MySQL, and PHP/Perl/Python
MSc	Master of Science
MIT	Massachusetts Institute of Technology
MRT	Mobile Repair Technician
NCCTP	Network for Construction Collaboration Technology Providers
O&M	Operation and Maintenance
PC	Personal Computer
PDA	Personal Digital Assistant
PFI	Private Finance Initiative
PHP	PHP: Hypertext Pre-processor ¹
R&D	Research & Development
RFI	Request for Information
RFID	Radio-frequency Identification
RFQ	Request for Quotation

¹ PHP is a recursive acronym that stands for PHP: Hypertext Pre-processor

ROI	Return on Investment
SaaS	Software as a Service
SLA	Service Level Agreement
UAT	User Acceptance Testing
UK	United Kingdom
URL	Uniform Resource Locators
Wi-Fi	Wireless Fidelity
WLAN	Wireless Local Area Network
XML	eXtensible Mark-up Language

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LIST OF PAPERS

“The limits of my language mean the limits of my world.”

Ludwig Wittgenstein (1889-1951)²

The following papers were produced in the course of the research undertaken for the Engineering Doctorate.

Papers labelled one to three are included in the appendices, and are submitted in partial fulfilment of the award requirements.

PAPER 1

McAndrew, S.T., Anumba, C.J., Hassan, T., and Duke, A.K. (2004). Overview of Application Service Provider's for the UK AEC Industry, *Proceedings of INCITE 2004: International Conference on Construction Information Technology: World IT for Design & Construction*, February 18-21, 2004 Langkawi, Malaysia, pp.427-435, ISBN 9832724171

PAPER 2

McAndrew, S.T., Anumba, C.J., and Hassan, T. (2003). Towards Wireless Web-based Facilities Management, *Proceedings of the Second International Conference on Construction in the 21st Century - Sustainability and Innovation in Management and Technology (CITCii)*, December 10-12, 2003 Hong Kong, China. Paper 85, pp.529-534, ISBN 9889737019

PAPER 3

McAndrew, S.T., Anumba, C.J., Hassan, T., and Duke, A.K. (2005). Potential use of real-time data capture and job tracking technology in the field, *Facilities Journal*, Emerald Group Publishing Limited, Vol. 23 No. 1/2, 2005, ISSN 0263-2772.

² Tractatus Logico-Philosophicus (1922) p. 148

1 BACKGROUND TO THE RESEARCH

1.1 INTRODUCTION

“Research is to see what everybody else has seen, and to think what nobody else has thought.”

Albert Szent-Györgyi (1893-1986)³

This chapter provides the background to the research undertaken to fulfil the requirements for the award of an Engineering Doctorate (EngD) of Loughborough University. The subject domain is explained, together with the overarching aim and objectives of the research, and how these contribute to the industrial context. The thesis is structured to provide the reader with a logical progression through the constituents of the research.

1.2 THE CONSTRUCTION INDUSTRY’S APPROACH TO INFORMATION TECHNOLOGY

“The Britain that is going to be forged in the white heat of this revolution will be no place for restrictive practices or for outdated methods on either side of industry.”

Harold Wilson (1916-1995)⁴

Abukhder *et al* (2004) traces the use of IT in construction, citing early usage in the 1970’s for designers utilising computer-processing power to help solve technical design problems. With the advent of the personal computer (PC) brought the automation of routine administrative tasks, together with accounts, payroll and human resource management packages being developed. Evolvement of design programs brought the advent of Computer Aided Design (CAD) packages that gave designers and architects far greater flexibility and capacity to

³ Hungarian Biochemist & Winner of the 1937 Nobel Prize for Physiology or Medicine <http://www.imaginginformatics.ca/research>

⁴ Speech at the Labour Party Conference, 1 October 1963

assess design alternatives. The upshot from these advances were reduced design times and increased quality in the designs produced.

With similarities drawn from Thomas Edison's pioneering harnessing of grid-based electricity, Carr (2008) compares the provision of electricity to that of computer processing power through Internet Protocol (IP) network infrastructure. It is the development of this network, and the proliferation of the Internet in the 1990's that has provided the footings for collaborative use of systems between virtual teams who are not located in the same office or even within the same organisation.

Collaboration takes place in every phase of the construction process, with the success of projects often measured on the effectiveness of collaboration between the parties involved. Bad collaborative channels often contribute to claim-ridden contracts, and do not provide a pleasant working environment for the people involved.

The project-centric nature of construction means that these virtual project teams are created, and are expected to perform to a high level – collaboratively – often given very short lead times. The application of leading-edge technology, therefore, has a key part to play in facilitating this, but, as many organisations have found to their detriment, without effective planning, implementation and utilisation of available technologies, great opportunities for cost and time savings have not been realised. Quality, in terms of reduced re-work, is another critical area that can be affected by the effective use – or not - of collaborative technologies. To this end, Stephenson & Conheeney (2004) recognised that construction organisations need to address new ways to use IT, increasing flexible access to people, and thus reducing the need for information intermediaries.

For the past few decades, the construction industry has attempted to work in a more collaborative manner, with information technology cited as an enabler to this end (Egan,

1998). Much discussion was generated from Latham's report of 1994, which highlighted the importance of collaboration between teams, and the report went as far to challenge the industry to utilise information technology to improve operations, and try to reduce building project's costs of up to 30%. However, technology to support collaboration was only emerging at this time. At the time of Egan's *Rethinking Construction* report in 1998, the industry was seeing websites promoting services for construction, albeit if the majority were no more than online 'brochure-ware' (Wilkinson 2005). Egan (1998) was correct to recognise that ICT was not a panacea for greater efficiency, but rather should be regarded as a support tool for cultural and process improvements.

Traditionally, the construction industry is notoriously conservative when implementing new technology and, potentially attributable to the low margins derived from construction projects, the risk of wasting investment in relatively unknown and unproven technology often signals the death-nail to many innovative proposals.

1.3 THE RESEARCH CONTEXT

1.3.1 ENGINEERING AND PHYSICAL SCIENCES RESEARCH COUNCIL (EPSRC)

'Rethinking Construction Innovation and Research', a review of Government research and development policies and practices by Sir John Fairclough (2002), estimated the total amount of public funding afforded to the construction industry over the 10 years from 1992 stood between £50 and £70m annually. One of the primary recipients of this funding is the Engineering and Physical Sciences Research Council (EPSRC). The EPSRC support the engineering and physical sciences research base, including engineering and production management, primarily in Universities. As an organisation, it aims to:

- a) Develop new knowledge;
- b) Train new people for industry, public and non-governmental organisations and for research careers; and

- c) Build public trust and confidence in the benefits of new technology and scientific discoveries.

The EPSRC are the primary sponsors and promoters of the Engineering Doctorate programme through an approved list of Centres. Loughborough University hosts the Centre for Innovative and Collaborative Engineering, and is one of a small number of Centres that include the construction sector as a speciality.

1.3.2 THE INDUSTRIAL SPONSOR - BT

British Telecommunications plc (BT) provided the industrial sponsorship for the research undertaken and presented in this thesis. British Telecommunications plc (BT) is a wholly owned subsidiary of BT Group plc and encompasses virtually all businesses and assets of the BT Group. BT Group plc is listed in stock exchanges in London and New York.

As a business, BT is one of the world's leading providers of communications solutions and services operating in 170 countries. BT's principal activities include networked IT services, local, national and international telecommunications services, and higher-value broadband and Internet products and services. BT consists principally of four lines of business: BT Global Services, Openreach, BT Retail and BT Wholesale (See Figure 1).

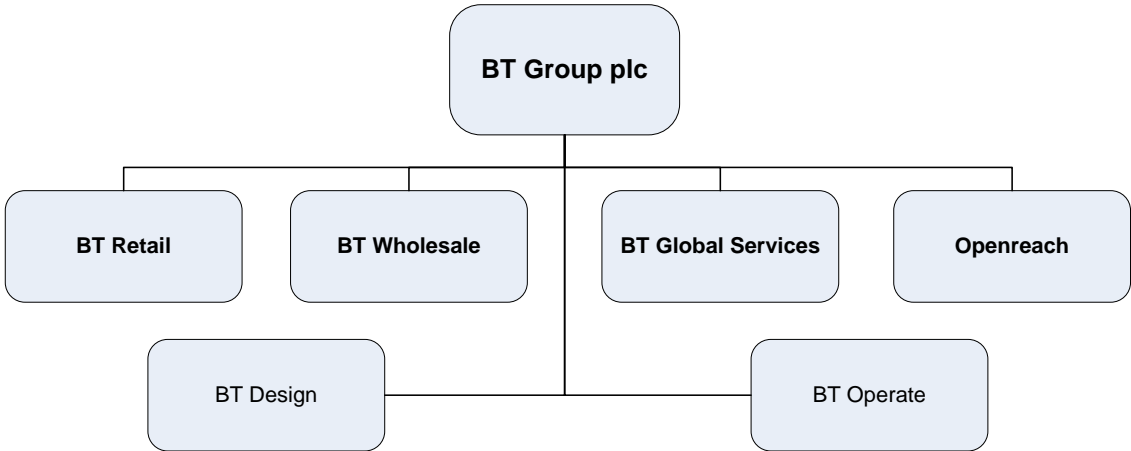


Figure 1 - BT Group plc 'Family tree' (Adapted from www.btplc.com)

BT Retail - serves business and residential customers and is the prime channel to market for other BT businesses.

BT Wholesale - runs BT's networks and provides network services and solutions to other communication companies.

BT Global Services - BT's global managed services and solutions provider that serves multi-site organisations worldwide (formerly BT Ignite and BT Syntegra).

BT Design - BT Group's IT design and delivery business.

BT Operate - deploys and runs communications services for customers over BT's core network and systems.

BT Exact / One IT – consultancy and internal IT resource for BT Group.

Openreach - owns, maintains and develops the access network that links homes and businesses to the networks of Britain's communications providers.

Given BT's strong heritage in telephony and technology services in the UK, they have extensive exposure to the construction and facilities management sector, such that they probably provide one or more services, in some form, to every organisation operating within that sector.

In 2000, BT shouldered the total £10bn cost of the 3G licenses that mmO2 use now. Figure 2 shows the decrease in value of the UK and Germany 3G licenses when re-valued in 2003, dropping £6bn from their original cost three years earlier.

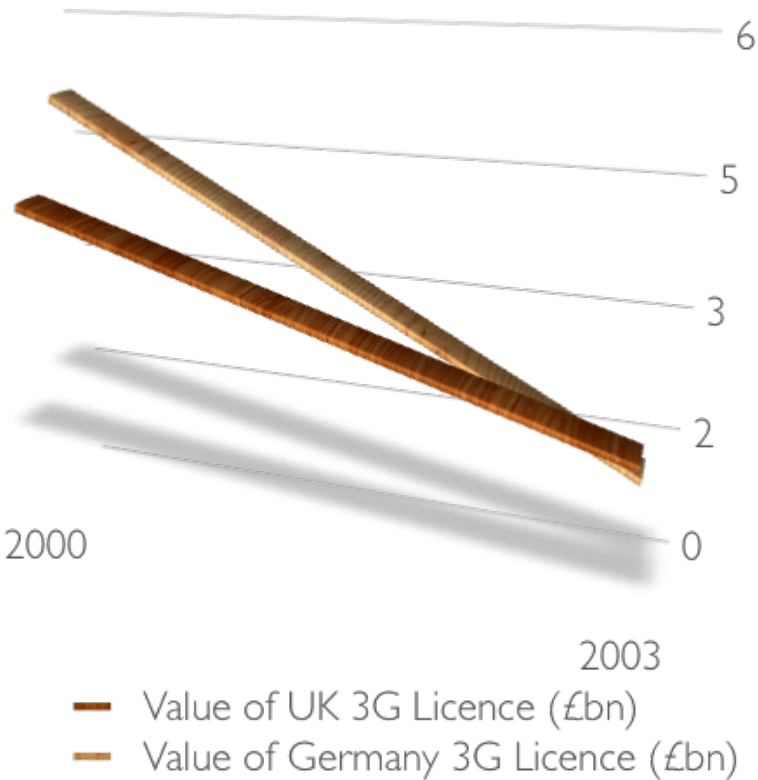


Figure 2 - Value of 3G licenses purchased by BT (2000 to 2003)

At the same time as the 3G-license purchase, BT’s yearly research and development budget was in the order of £500m. The heavy investment in mobile telephony licenses meant a change in the way BT Group funded its activities and, as a result, BT Exact were forced to self-fund most of their research and development. This change of business strategy had an effect on the emphasis of the research being undertaken, and meant that BT was eager to investigate other avenues of revenue generation. Therefore, the focus of the research evolved to include the field of facilities management as this was an area that BT Retail had identified as potential channel for new service delivery. BT Retail aspired to provide ‘Total FM’ to its clients, and so would be in a stronger position if they could offer value-add propositions such as the wireless web-based work logging and tracking system prototype, subsequently developed as part of this research project.

1.3.3 THE COMPARISON ORGANISATION – TAYLOR WOODROW CONSTRUCTION

"You have, in fact, literally built the foundation of our cities, built the foundation of many of our industries, much of our commerce, much of our new development in energy and much of our public services, and you've done it because you have always believed in excellence and you believed in delivering what you said you'd deliver, and you believe in quality..."

Margaret Thatcher (b. 1925)⁵

In 1921, 16-year old Frank Taylor borrowed £100 to build two houses in Blackpool. Too young to form his own company, his uncle Jack Woodrow lent his name to the business and Taylor Woodrow was born. Today, Taylor Woodrow Construction is a leading provider of construction, facilities management and engineering services for corporate clients in the UK and selected markets overseas.

In November 2004, the author joined Taylor Woodrow and was closely involved in a number of projects and operational activities that relate closely with the research undertaken for the previous four years at BT. Therefore, an opportunity was presented to compare and contrast the theory, hypothesis and prototype developed during the research period with those activities undertaken in a fully-functioning IT department of a major contracting and facilities management organisation.

More recently, the company has been involved in a number of mergers and acquisitions. Most notably, in July 2007, Taylor Woodrow plc and George Wimpey plc merged to form Taylor Wimpey plc., which at the time created the largest house-builder by volume in the UK. In September 2008, VINCI PLC acquired Taylor Woodrow Construction from Taylor Wimpey plc.

⁵ Speech inaugurating Taylor Woodrow's Research Laboratory, 13 July 1979
<http://www.margaretthatcher.org/speeches/displaydocument.asp?docid=104112>

1.3.4 THE AUTHOR

The author began under-graduate studies at the University of Sheffield in 1993, where he embarked on a three-year BEng course in Civil & Structural Engineering.

In 1996, he commenced a one-year MSc (Eng) in Construction Management at the University of Birmingham, where, as part of his degree submission he completed a dissertation comprising of an ethnographical study of Irish sub-contractors.

Following the MSc, the author joined Severn Trent Water's Engineering division as an assistant engineer, initially responsible for part of the design of a large-scale main linking the supplies of the two regions that serve the company's entire catchment area. At Severn Trent, he developed a Lotus Notes-based database that held information pertaining to the land and landowners that the link main spanned. This database was subsequently used at the construction phase of the £21m project, and its development spurred the author on to consider how ICT might assist in improving existing processes within the construction sector.

In October 2000, the author joined BT as a research engineer, holding this position until October 2004. Based predominantly at BT's research and development labs in Martlesham, Suffolk, he was a member of the Communications Applications development team of BT Exact. Within this role, he gained insight into some of the research projects undertaken on behalf of BT as part of their then £500m yearly budget for research and development.

In October 2004, the author joined Taylor Woodrow as an analyst responsible for project collaboration within the organisation. Responsible for both the document management and project extranet systems used within the organisation, he was also closely involved with a number of implementation projects including 'MRT Mobile', which contributed as a case study to the DTI part-funded COMIT project (Bowden 2005). In February 2007, the author was promoted to the position of lead business systems analyst, responsible for gathering

requirements from the business, and then translating these to functional specifications for the design of new IT systems. Later in 2007, following the merger of Taylor Woodrow with George Wimpey, the author undertook a number of project management roles; implementing a new hardware and operating system to the business; a new cloud computing, fully Web-based email system; a new document and content management system to consolidate disparate systems and file stores holding unstructured documents within the organisation.

1.4 SCOPE OF RESEARCH

This research study is primarily concerned with the subject domain of collaboration between members of virtual teams, including those of mobile workers in the construction and facilities management sectors.

The initial research focuses on the principles of the web-based hosted model for applications, whilst the prototype developed in the later stages builds on these principles and demonstrates how these can be extended to incorporate the business processes of the mobile facilities management operative.

1.5 STRUCTURE OF THESIS

This thesis provides a documented reference for the research undertaken in partial fulfilment of the requirements for the award of an Engineering Doctorate (EngD) of Loughborough University, and is presented in the following chapters:

Chapter 1 introduces the research project and provides an insight into the research context of the project. The chapter includes a synopsis of the published papers completed during the course of the research.

Chapter 2 elaborates on the aim of the EngD project, its specific objectives, and covers how the tasks undertaken contribute towards achieving these objectives.

Chapter 3 presents the adopted research methodology, covering the justification for its adoption and the methods used to achieve specific objectives.

Chapter 4 covers the research undertaken, with reference to the project’s aims and objectives.

Chapter 5 covers the findings and implications of the research within the sponsor’s organisation and the broader industry.

Appendices A to C contain the three peer-reviewed published papers that support this research. These papers form an integral part of this thesis, and so should be read in conjunction with the preceding chapters.

1.6 SYNOPSIS OF PAPERS

Title	Journal / Conference	Status	Description	Appendix
Paper 1 Overview of application service providers for the UK AEC industry	Conference World IT in Construction Conference - Langkawi, Malaysia: 18 –21 February 2004	Published	This paper concentrates on some of the current ASP products targeting the UK architecture, engineering and construction (AEC) industry and highlights the issues surrounding their practical use and effectiveness on projects.	A
Paper 2 Towards Wireless Web-based Facilities Management	Conference Second International Conference on Construction in the 21 st Century - Sustainability and Innovation in Management and Technology (CITCii), 10-12 December 2003 Hong Kong	Published	This paper highlights and discusses the possibilities of wireless Web-based solutions within FM and touches on some of the different wireless standards that exist.	B
Paper 3 Potential use of real-time data capture and job tracking technology in the field	Journal Facilities Journal, Volume 23, No. 1 / 2, 2005, pp. 31-46, Emerald Group Publishing Limited, ISSN 0263-2772	Published	This paper discusses the scope for improving the delivery of FM services through the use of wireless Web-based communications infrastructure, delivered via an application service provider (ASP) business model.	C

Table 1 - Synopsis of papers

1.7 SUMMARY

The first chapter has provided a general introduction to the research project subject domain, setting the research within the industrial context.

The structure of the thesis was presented, and a synopsis of the papers that were published in the course of the research was provided. The second chapter covers the aim and objectives of the research project in detail, and includes the justification of the research.

2 AIM AND OBJECTIVES

2.1 INTRODUCTION

The construction industry trend towards the use of virtual organisations and collaborative or concurrent engineering practices is creating a greater demand on individuals and groups to communicate more effectively.

The transient nature of these organisations, and the small size of many of the players involved can lead to high risk, high expense investment decisions on the level and nature of IT and communication. In this environment, there exists the potential for 3rd party organisations to provide generic services that can be tailored to individual project needs. The number of companies offering application-hosting services is growing. This model could be extended to include the provision of collaboration services such as product data management, directories, on-line conferencing environments and knowledge management. Engineering organisations out-sourcing the provision of these services would be able to choose the exact level of support and security required.

In order for a 3rd party organisation, such as BT, to operate within such a model, a level of understanding of the needs of organisations in this environment is required. This should be in terms of general needs, i.e. the development of new and existing practices, and the identification of specific tools to support those practices. Knowledge of how these tools can be effectively delivered in an integrated way is also required.

2.2 THE OVERARCHING AIM

The aim of the project is to develop a technology strategy to address the communication needs of engineering, construction and facilities management organisations in a collaborative engineering environment based on the principle of software as a service.

The research aims to strike a balance between the academic purpose of the study, and the business need expressed by the industrial sponsor, and construction industry and technology providers to the industry in the broader context. Over the period of the research, business focus and priorities have progressively evolved and, so had to the aim, objectives and methodology of the project. Nevertheless, the common theme of project collaboration through the implementation of appropriate technology remained consistent.

The outcomes of the research should aim to improve both the synchronous and asynchronous collaboration of individuals and groups. They should not represent a revolutionary change from the point of view of the organisation and the user. Instead, they should attempt to facilitate evolutionary change and place the adopting business in a stronger position.

2.3 THE INDIVIDUAL OBJECTIVES

In order to achieve the aim of the research, a number of specific objectives of the project were set, the overview of which are:

- An investigation into the current state of the art in communication and collaborative technologies for industrial/engineering applications, focussing on the practical applications of technology, particularly those in use in virtual organisations;
- A determination of the communication and collaboration requirements of organisations and individual parties within those organisations. To develop an understanding of how to support the management of processes within organisations. (Creative analysis of these results will produce generic requirements from a number of different organisations).
- An identification of barriers to the successful adoption of collaboration technologies - both of a technical and social nature;

- A formulation of practical solutions that will address the requirements identified; (These should focus on how a 3rd party technology supplier such as BT could provide a range of collaboration technologies that can be tailored to the specific needs of organisations whilst being hosted and supported by the 3rd party).
- A critical comparison of presented theory and solution prototypes with the perspective of an IT department of an operationally-active construction organisation; and
- Development of recommendations and IT strategy for organisations operating in the construction and facilities management sector.

2.4 THE JUSTIFICATION OF THE RESEARCH

The transient nature of some of the SaaS vendor organisations presented, and the small size of many of the players involved, can lead to high risk, high expense investment decisions on the level and nature of IT and communication. In this environment, there exists the potential for 3rd party organisations to provide generic services that can be tailored to individual project needs. A number of companies presently offer application-hosting services; however, this model could be extended to include the provision of enhanced collaboration services such as product data management, directories, on-line conferencing environments, email, calendaring and knowledge management. Construction and engineering organisations out-sourcing the provision of these services would be able to choose the exact level of support and security required. Any collaborative solution should not be limited to that addressing the feasibility, design and construction phases of a building. SaaS has a part to play in the operating and maintenance phase of any building and, as such, facilities management providers should embrace the technology like their construction brethren.

In order for a 3rd party organisation, such as the sponsoring company BT, to operate within such a model, a level of understanding of the needs of organisations in this environment is required. This should be in terms of general need, i.e. the development of new and existing practices, and the identification of specific tools to support those practices. Knowledge of how these tools could be effectively delivered in an integrated way would also be required in any solution offering.

2.5 THE RESEARCH TASK BREAKDOWN

Table 2 shows the task breakdown for each of the research objectives. Further detail on the tasks is presented in the research methodology section in chapter 3.

Table 2- Research tasks

Objective – Review of related work
With a view to addressing the communication needs of construction and engineering organisations in a collaborative engineering environment, it is necessary to identify and analyse the products and tools currently available in the marketplace.
Tasks
<ul style="list-style-type: none"> • Identification of appropriate collaborative technologies including Application Services Providers (ASP), Web Portals, Groupware, Electronic Document Management Systems (EDMS), intranets, extranets, conferencing, email, etc. • Identifying the key elements of construction project collaborative systems such as document management / repositories, cost management, project planning, design tools, specification generating tools, facilities / asset management, RFI, RFQ, procurement, etc. • Contribution through workshops, working with BT Retail, to develop ASP-based solutions for large construction clients of BT such as Carillion and Sir Robert McAlpine. This has included contribution on contract bids formation and demonstration of novel technologies such as satellite-delivered broadband

Objective – Requirements Capture
The requirements capture phase of the research takes the aim and objectives, and aligns these to development of solutions.
Tasks
<ul style="list-style-type: none"> • Case study of BAA’s collaborative working set up on the Heathrow T5 development design • Case study of Severn Trent Water’s approach to collaborative working on their major £21m ‘Birmingham Security of Supplies’ link main project • Case study of O’Shea contractors and their realigning of future IT requirements • Identification of suitable subject organisations so that there can be suitable variation of organisation types, insuring that a broad range of FM requirements is covered. Three organisations were studied; one from the banking sector; one from the health sector and one academic establishment. • Development of structured questionnaire to bring to the facilities managers in the chosen organisations. The questionnaire and interview will aid discovery of the current levels of wireless technologies, if any, being utilised within the organisations, as well as identifying the main information requirements. Analysis of these results will suggest at which point would wireless technology and SaaS add value. • Write-up and publication of a report detailing the three case studies with conclusions specifying the industry information requirements within FM and suggestions, if any, of application of wireless technologies together. This should be undertaken with the approach of integrating the benefits of an SaaS with the complimentary benefits of wireless Internet connectivity.

Objective – Development of solution
The prototype developed draws upon the results of the requirements capture phase.
Tasks
<ul style="list-style-type: none"> • Research wireless technology, particularly concentrating on the varying versions on the market and the impact of each. Highlight the benefits and shortcomings of each variant. • Produce [internal] technical paper explaining the technical background wireless data

<p>technologies and produce an overview of the different types, e.g. 802.11x, Bluetooth, GPRS, 3G, etc. available currently.</p> <ul style="list-style-type: none"> • Identify technical barriers to the implementation of a wireless solution. Make predictions based on desk study of publications from leading research organisations and manufacturer roadmaps on the likely success of each wireless technology variant. • Produce a detailed system architecture for a wireless Web-based service that addresses the information requirements identified in the preceding tasks.
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<p>Objective – Evaluation</p>
<p>Evaluation of the prototype developed involved the data collection and analysis of user reaction and feedback from demonstrations.</p>
<p>Tasks</p>
<ul style="list-style-type: none"> • Produce a map detailing the evaluation criteria for standard ‘wired’ delivery of SaaS and identify the strengths and weaknesses. • Produce a wireless-centric solution plan for the existing communicative paths within a standard SaaS model. • Critically examine the benefits and shortcomings at each of these paths for using wireless and make recommendations accordingly. • Consult with FM personnel in the previously targeted organisations and present a theoretical plan for an SaaS wireless Web-based FM service. Consultation at this phase is imperative so as to highlight any industry-specific logistical or socio-cultural issues that could deem a future solution unworkable or impractical.

<p>Objective – Dissemination and implementation of findings</p>
<p>Required to facilitate the effective dissemination and exploitation of results.</p>
<p>Tasks</p>
<ul style="list-style-type: none"> • The writing of technical papers for publication in refereed journals and / or peer-reviewed conferences. Emphasis will be placed to targeting those journals and

- conferences that are highly regarded in the construction and facilities management sector.
- Creation of an Internet-based Website to not only publicise the findings of the report, but also to act as a source of information on the technologies and principles researched.
 - Contribution towards the hosting of lectures within the Department of Civil & Building Engineering at Loughborough University. Presentation of wireless technology-based themed lecture to final year undergraduates.

Objective – Comparison to real-life system implementation
Where appropriate, the findings of the study are compared and contrasted with projects run within an operating construction contractor, Taylor Woodrow. Theories presented, and the prototype developed is considered within the context of an IT service department.
Tasks
<ul style="list-style-type: none">• Present previously authored research proposals to peers within Taylor Woodrow and evaluate relevance with that of their existing service offering.• Develop a different IT strategy to encompass more cloud computing / SaaS-based systems wherever appropriate.

3 ADOPTED METHODOLOGY

3.1 INTRODUCTION

Research methodology refers to the principals of methods, rules, and postulates employed by a discipline (Creswell, 1997). Unsurprisingly, the appropriate selection of research methods critically influences the success and validity of the overarching research (Steele, 2000; Fellows and Liu, 2008). This chapter provides a brief overview of some of the research methodologies that are available, and then provides the reasoning behind the choice of methods made.

3.2 METHODOLOGICAL CONSIDERATIONS

Yin (2004) encapsulates research design as the logical sequence that connects the generated empirical data to the initial research objectives of the study and, ultimately, to its conclusions. Along with the five data collection methods presented by Yin (1994), namely: archival analysis, case study, experiment, history and survey, Steele (2000) adds two more methods of action research and process modelling to the five presented by Yin (1994). Adetunji (2005) describes how by the combination of qualitative and quantitative research methods, of which the above seven fit into, the concept of triangulation is adopted. Triangulation can be viewed as not only providing validation to research, but also providing a deeper and wider understanding of the subject matter (Olsen 2004).

3.3 RESEARCH METHODOLOGIES

Research methods can be classified in a number of ways, with one of the most common distinctions being between qualitative and quantitative methods.

Qualitative research methods tend to be considered a ‘soft’ approach to data gathering. Qualitative research aims to seek out the ‘why’, and not the ‘how’ of the research topic through the analysis of unstructured information. Qualitative methods do not rely on statistics or numbers, which is the domain of quantitative research methods.

This section reviews different research methodologies, and includes a brief description of each.

3.3.1 LITERATURE REVIEW

Johnston (1953) recounted the wry observation of Wilson Mizner that to steal from one author was plagiarism, but to steal from many was research. As a method of research, an analogy of passing on the baton could be used to describe the flow of information and findings from previous research undertaken, to the inception of new research projects. It can be argued that academia bemoans the dissipative nature of some areas of industry that maintain or persevere with business processes that are inefficient or inefficacious just because 'that is the way we always do it'. Academic research must then also ensure that it does not fall into the trap of reinventing the wheel, but should use the literature review as a vehicle exhibiting the following characteristics:

- A logical flow of ideas
- Current and relevant references
- An appropriate referencing style
- Correct use of terminology
- An unbiased and comprehensive view of previous research on subject

In essence, a literature review provides the theory base that the rest of the research can build upon. It should demonstrate how the research being reported relates to previous research and,

if possible, how it gives rise to particular issues, problems and ideas that the current research addresses (Denscombe, 2007). Cooper (1988) contrasts the purpose of the literature review from not reporting on new primary scholarship itself, but more as a database of reports of primary or original scholarship, seeking to describe, summarise, evaluate, clarify and/or integrate the content of primary reports. Without this step, Cooper argues, researchers cannot expect to construct an integrated, comprehensive picture of the world.

Within this research, a comprehensive literature review was undertaken to determine the current state-of-play of application service providers within the construction sector. This study considered the material published by the provider's themselves, but also case studies published in collaboration with the construction organisations who presented their experience of implementations. The literature review approach in the early stages of the research project provided useful qualitative analysis, highlighting common nuances and issues across previous implementations.

3.3.2 CASE STUDIES

Rather than using large samples and following a rigid protocol to examine a limited number of variables, case study methods involve an in-depth, longitudinal examination of a single instance or event: a case. Case studies provide a systematic way of looking at events, collecting data, analysing information, and reporting the results. As a result, the researcher may gain a sharpened understanding of why the instance happened as it did, and what might become important to look at more extensively in future research. Case studies lend themselves to both generating and testing hypotheses (Flyvbjerg 2006).

Another suggestion is that case study should be defined as a research strategy, an empirical inquiry that investigates a phenomenon within its real-life context. Case study research means single and multiple case studies, can include quantitative evidence, relies on multiple sources

of evidence and benefits from the prior development of theoretical propositions. Case studies should not be confused with qualitative research as they can be based on any mix of quantitative and qualitative evidence.

By taking a case study approach and only focussing on a smaller set of studies, one could be accused of taking a generalist approach. Gummerson (1991), commented on the lack of scientific weight and general applicability of conventional research methods that a case study approach provides. He did concede, “However in certain area they represent the only possible research strategy”. Craig-Smith (1991), argued that ‘the principle criticism of case studies in research is that they are unrepresentative. Theoretical conclusions derived from case studies cannot be considered valid unless the cases can be demonstrated to be typical of the phenomena under investigation.’ However, in a corporate context, the value of case studies and reference sites for IT implementation is significant. The view of Soy (1996), who maintained that case study research excels at allowing an understanding of complex issues, and can extend experience to what was already found in previous research. Denscombe (2007) highlighted the major benefit of a case study approach, whereby focussing on one or a few instances allow the researcher to deal with the subtleties and intricacies of complex social situations. This point is particularly relevant when considering the subject area of this research as it is important to study the softer, non-technical, issues that influence the successful adoption of new technology in organisations.

3.3.3 ACTION RESEARCH

Kurt Lewin, a professor at MIT, first coined the term “action research” in about 1944, and it appears in his 1946 paper “Action Research and Minority Problems”. In that paper, Lewin (1946) described action research as “a comparative research on the conditions and effects of various forms of social action and research leading to social action” that uses “a spiral of

steps, each of which is composed of a circle of planning, action, and fact-finding about the result of the action”.

McNiff (2006) defines action research as a form of enquiry that enables practitioners everywhere to investigate and evaluate their work, and considers it an increasingly popular form of professional learning. It is a reflective process of progressive problem-solving led by individuals working with others in teams or as part of a "community of practice" to improve the way they address issues and solve problems. Action research can also be undertaken by larger organisations or institutions, assisted or guided by professional researchers, with the aim of improving their strategies, practices, and knowledge of the environments within which they practice.

McNiff (2006) presents the action-reflection cycle, which encompasses the complete ‘observe – reflect – act – evaluate – modify – move in new directions’ process as represented in Figure 3.

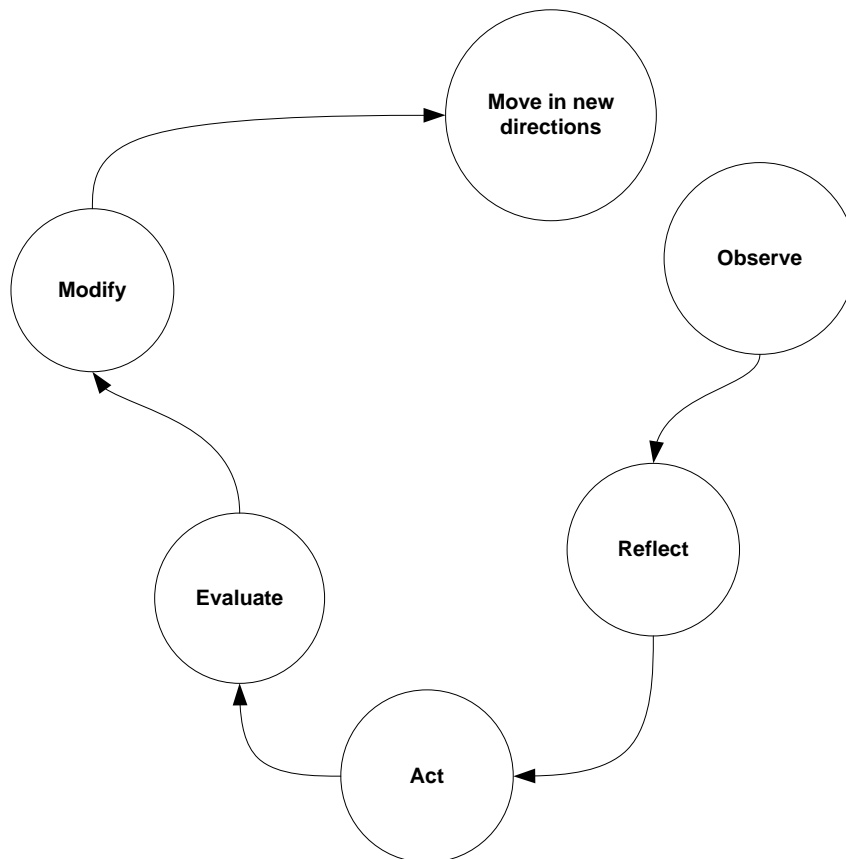


Figure 3 - 'An action-reflective cycle' adapted from McNiff (2006)

The cycle is an on-going one as soon as one reaches a provisional point where the situation is considered satisfactory, this point itself raises new questions and so the cyclical process begins again; almost a form of continual improvement; *Kaizen* in Japanese business culture (Imai 1986).

Action research is distinctive in that it is typically undertaken by practitioners rather than a professional researcher (McNiff 2006). The term 'insider researchers' is coined, and this is a good description of the type of research undertaken by research engineers on the EngD programme. The insider researcher considers themselves as part of the situation and questions if the current methods could be improved on from what might just be considered a 'satisfactory' viewpoint; the action researcher is immersed in the research setting (Coghlan & Brannick 2005).

With consideration to one of the underlying objectives of the engineering doctorate programme, the research undertaken in this project encompasses a greater degree of action research than might be found in traditional research projects. By being placed within an operating organisation, the researcher is able to meter the potential effect of findings and recommendations against the existing processes, procedures, and policies of that organisation. To achieve innovative, yet practical and workable solutions, it is essential that reality cannot stray too far from any theory presented.

Where possible, the research undertaken within this project has been compared and contrasted with what could be implemented either by a third party technology provider such as BT, or within a construction organisation such as Taylor Woodrow.

3.3.4 PROTOTYPING

Derived from a Greek word meaning ‘archetype’ or ‘original’, a prototype can be considered a typical instance of a category that can compare against other less representative instances.

Prototyping is used as a cost effective method of developing a solution from theory that can be critically examined as a proof of concept.

Once a prototype is created, one can undertake usability testing, which can incorporate user acceptance testing if the prototype is suitably developed, and close to a final version. By the method of prototyping, one can quickly determine what parts of the system or interface work well, and what parts are unsatisfactory.

Development of a prototype was deemed most appropriate for the wireless Web-based FM service, as it could be easily demonstrable to practicing FM professionals within their working environment. It cannot be underestimated the benefit of presenting something the interviewees could hold and probe, compared with the alternative of presenting a flat-text

theory-based proposal. The interaction with a test system created a two-way discussion on the topic and hopefully more insightful comments as a result.

3.3.5 TRIANGULATION

Derived from the surveying process for mapping out an area, triangulation can be used as a way of assuring validity of research results using a variety of research methods and approaches. Denzin (1978) described one form of triangulation – methodological triangulation - as involving more than one method to gather data. Triangulation involves the use of both qualitative and quantitative approaches and allows the researcher, for example, to develop their theories qualitatively and then test quantitatively (Khalfan, 2001).

3.4 RATIONALE FOR RESEARCH METHOD SELECTION

The research undertaken to achieve the stated aim (section 2.2) was conducted utilising a combination of research methods. **Error! Reference source not found.** presents the objectives of the EngD project and the primary and supporting research methods adopted to satisfy these.

Table 3 - Rationale for research method selection

Objective	Research Methods				
	Literature Review	Case Studies	Action Research	Prototyping	Triangulation
<p>Review of related work</p> <p>An investigation into the current state of the art in communication and collaborative technologies for industrial/engineering applications, focussing on the practical applications of technology, particularly those in use in virtual organisations;</p>	P	S	S		

Objective	Research Methods				
	Literature Review	Case Studies	Action Research	Prototyping	Triangulation
Requirements Capture The requirements capture phase of the research takes the aim and objectives, and aligns these to development of solutions.		P	S		
Development of solution The prototype developed draws upon the results of the requirements capture phase.			S	P	
Evaluation Evaluation of the prototype developed involved the data collection and analysis of user reaction and feedback from demonstrations.		P	S		
Dissemination and implementation of findings Required to facilitate the effective dissemination and exploitation of results.				P	
Comparison to real-life system implementation Where appropriate, the findings of the study are compared and contrasted with projects run within an operating construction contractor, Taylor Woodrow. Theories presented, and the prototype developed is considered within the context of an IT service department.		P			S

Key

P = Primary method

S = Supporting method

A literature review was used as the primary research method to assess the current state of art in communication and collaboration technologies in the AEC sector as a number of successful implementations had been documented in case studies, and published for wider consumption.

Functional and technical specifications produced as marketing collateral by the application vendors was also studied, so that the relative benefits and limitations of each of the provider's offerings could be assessed. Complimentary to the literature review was the undertaking of a small number of case studies on organisations of differing size and exposure to collaborative technology.

Detailed case studies were undertaken to fulfil the requirements capture stage of the research project. Detailed business analysis undertaken during the case studies provides the opportunity to perform process mapping and gap analysis. The findings from the case studies formed the functional requirements that were used in the prototype development.

Using the requirements gathered through detailed case studies, a solution was proposed to address the findings from Paper 3 (Appendix C). The method of prototype development was chosen as the most appropriate in order to provide a demonstrable solution back to the case study subjects for evaluation. The prototype was developed based on the functional requirements set out in the findings of the preceding case studies, but also by utilising best practice of mobile browser based development.

Once completed, the prototype was presented back to the case study participants of the initial exercise. The evaluation was based on a working demonstration of the prototype followed by a detailed interview, the topics of which are covered in section 4.6.

To gain a perspective from an IT provision standpoint, the method of triangulation was used, whereby the developed prototype was compared and contrasted with a non web-based mobile solution used at Taylor Woodrow.

3.5 SUMMARY

This chapter has provided detail and discussion on the research methodology undertaken for the engineering doctorate project. The framework of how the research was conducted was examined, together with justification of why a multi-methodological approach was employed.

The following chapter outlines the research work undertaken and the outcomes derived from the use of the adopted research methods.

4 THE RESEARCH UNDERTAKEN

4.1 INTRODUCTION

This chapter presents the research that was undertaken to meet the aim and objectives of the Engineering Doctorate project cited in chapter 2. The research was conducted in accordance with the methodology set out in chapter 3. Where reference is made to the appended published papers, the reader is advised to read these papers in their entirety, and then return to overview covered in this thesis.

4.2 MAP OF RESEARCH DEVELOPMENT

Figure 4 presents the high-level project activities cross-referenced with time and employer. It presents the progression through the subject matter studied, and shows the crossover between construction and operating phases of projects, and how the research developed across these.

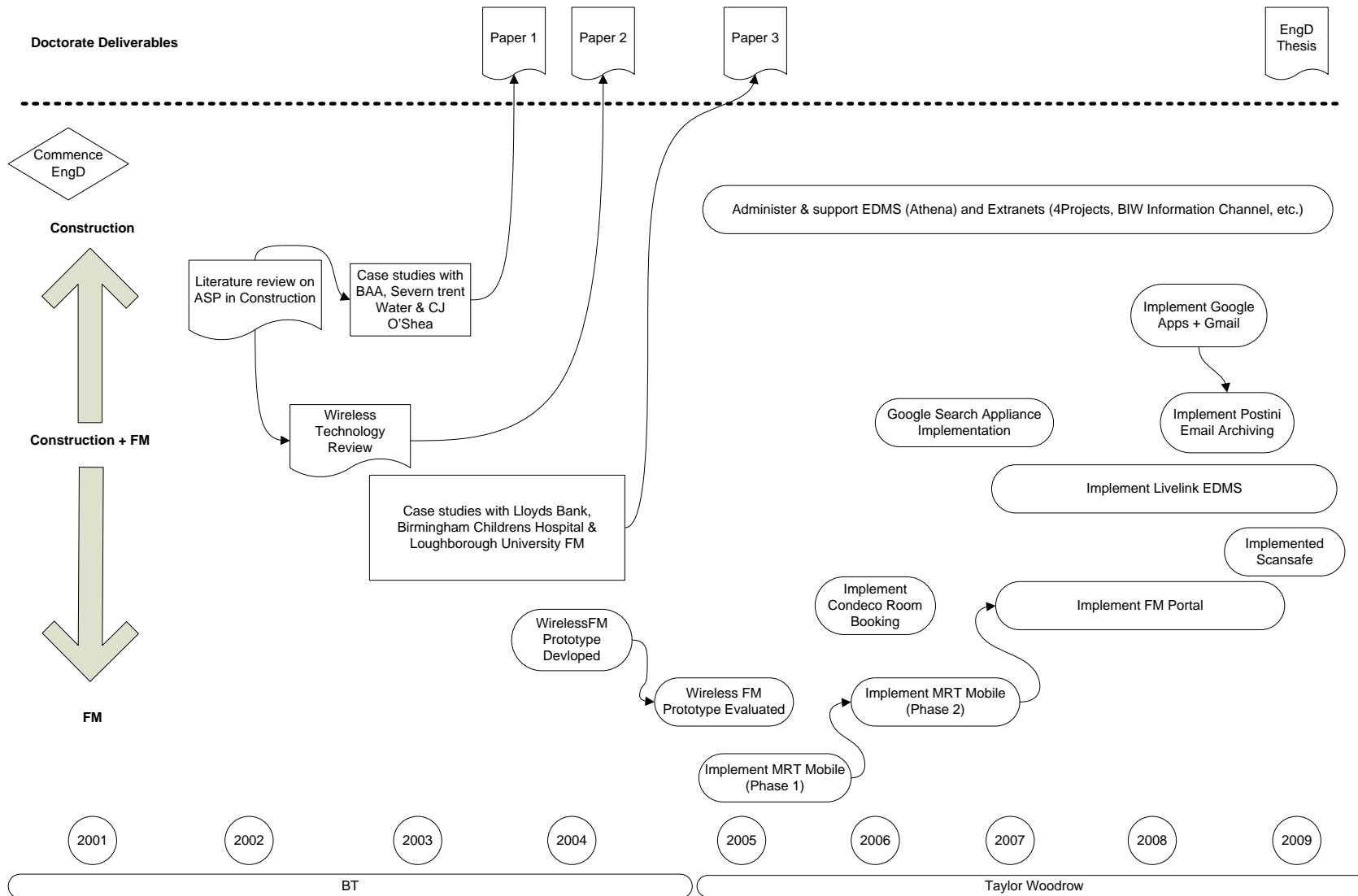


Figure 4 - Research and activities undertaken

4.3 THE RESEARCH TASKS IN CONTEXT WITH PREVIOUS WORK UNDERTAKEN

A literature review was undertaken to determine the current market of application service provider's targeting the construction industry. From this study, a report entitled 'Application Service Providers for the AEC Industry' was produced internally for the consumption of BT Retail. This internal report contributed to the research undertaken prior to BT choosing BIW Technologies as a technology partner to sell to their existing, and potential new clients, in the sector. Figure 5 shows the public-facing customer page on BT Retail's Website for the BT 'Build Business' proposition that the author created.

BT | [Homepage](#) | [At home](#) | **In business** | [About BT](#) | [Search/site map](#) | [Contact us](#)

Popular destinations
[Call Pricing Rates](#) Go


Quick search:
 Go

[Advanced search](#)
[Product Index](#)
[Privacy Policy](#)
[Terms & Conditions](#)
[Help](#)

Home > Solutions > Build Business

Build Business

Today's construction projects are complex and demanding, often involving many organisations and a huge volume of information. Effective collaboration requires excellent communication. This plays a key role in ensuring that projects are won profitably, and delivered on time and within budget.



How can you achieve successful collaboration?

On any large project, increased collaboration through the use of integrated technology can bring real value but requires:

- A reputable and reliable applications provider
- Critical information that is secure, verifiable, and available whenever needed - throughout the project and for many years beyond
- A well managed and future-proof collaborative environment.

So, what is the answer?

BT offers a complete turnkey solution that is also extremely flexible - you can opt for the whole package, or just select the components you need.

- It encompasses applications, connectivity, and all the hardware required to create a 'hassle free', collaborative project environment.
- The package can be tailored to meet the needs of any company involved in complex projects and work programmes.
- BT acts as the single point of contact for ALL your collaborative needs, ensuring a co-ordinated, efficient and continuous service.

Key reasons why you should choose BT as your favoured partner

- **Experience** - BT already has vast experience in the field of collaboration. We know what to do - and what not to do!
- **Investment** - Over the past ten years, BT has invested over 312 billion in the creation of the world's most robust, reliable, scalable and secure networks and network services.
- **Commitment** - A high quality service depends on lasting commitment. BT will design your network end-to-end, based on your precise needs - however demanding those may be.

Build Business is a secure service from BT. It enables organisations to harness the power of the Internet so that they can collaborate rapidly, easily and effectively with their clients and with members of a project team - irrespective of their location.

If you would like to find out more please contact your account manager.

Additional Information


<p>Product Brochure</p> <p>Build Business</p> <p>This document can be viewed using adobe acrobat reader. If you have trouble opening these files, or alternatively if you want to download acrobat reader 5 please click here.</p> <p>Click here to download file.</p>	<p>Related Solutions</p> <p>Subscription Computing</p> <p>Provide core business applications to the whole organisation without the hassle of maintenance or the expense of buying it yourself.....</p> 
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Figure 5 - BT Build Business product page on BT.com

The internal report was then reviewed and amended, forming part of the paper entitled ‘Overview of application service providers for the UK AEC industry’ presented to the World IT in Construction Conference - Langkawi, Malaysia in February 2004 (see Paper 1 - Appendix A).

The report included a review of the main ASP vendors who were targeting the UK construction market with collaborative tools. Summaries of each offering were presented, and a discussion as to their potential continued success was offered.

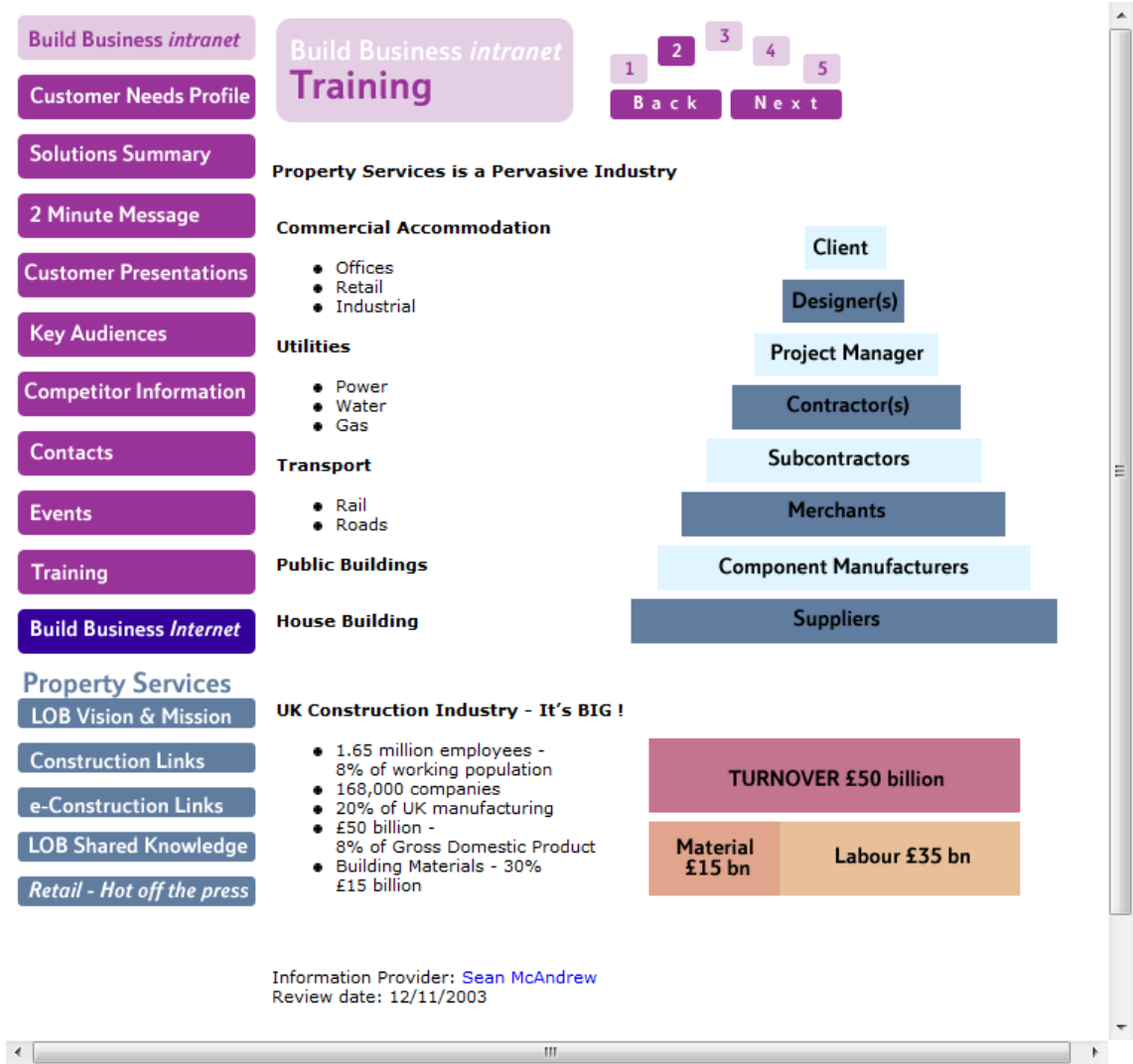


Figure 6 - BT 'Build Business' training resource created for account managers

4.4 REQUIREMENTS GATHERING

Part of the requirements capture element of the research involved liaison with a number of construction organisations, each with differing levels of experience with collaborative IT systems and methods. These case studies were undertaken to provide background on the appropriateness and maturity of application service provision in the construction industry at that point-in-time.

4.4.1 CASE STUDY – C J O’SHEA

C J O’Shea are civil engineering contractors working mainly within the M25 boundary of London with an operating turnover, in 2001, of approximately £20M. They are a relatively small construction organisation who were in the process of realigning their IT needs for the future. The type of work undertaken by C J O’Shea broke down as follows:

- Concreting sub-contractor (40%)
- Building main contractor (40%)
- Non-mechanical plant hire (20%)

Discussion with the contractor highlighted their heavy reliance on back-office systems rather than any utilisation of any Internet-based collaborative applications or services. As a small contractor they were keen to keep expenditure in new IT hardware to a minimum, and they expressed a preference that any system sought would benefit the company if it could integrate closely with the Microsoft Office suite of software. The reasoning behind this approach was partly a training requirement, i.e. much less needed if users were presented with a familiar interface, but also from a reluctance to ‘experiment’ with other less proven applications.

4.4.2 CASE STUDY – BAA HEATHROW AIRPORT TERMINAL 5

On an entirely different scale to the needs of C J O'Shea were those encountered by BAA (British Airports Authority) and their partners on the planning and design of the then proposed Terminal 5 at Heathrow Airport in London.

BAA had created an office where the majority of parties involved with the design of the new terminal had moved their teams to co-locate with each other.

On a visit to the offices at Heathrow, the author was exposed to the tools and concepts that were being implemented on the design phase of the Terminal 5 project. Integration between communicative systems and the document management system was identified as lacking slightly in sophistication. At that time, plans were in place on the Terminal 5 project to adopt the latest version of Documentum. The version that was being utilised did not have a Web-based interface, and workflows were not generated from the mail client being used.

4.4.3 CASE STUDY – BIRMINGHAM SECURITY OF SUPPLIES LINK MAIN (SEVERN TRENT WATER)

The author undertook interview with site personnel on a visit to the site of the 26km long large diameter link main proposed to join both East and West regions of the Severn Trent Water supply network. The project presented an ideal model for remote collaborative working owing to the spread-out aspect of the construction site, and the absence of fixed and permanent IP network telemetry available. The Security of Supplies project also presented the utilisation of an intranet-based database system using Lotus Notes and the logistical difficulties of accessing this for site-based staff when working away from the main design office, which as based some distance away in Warwick. The project highlighted aspects of inter-team collaboration, as opposed to inter-project ones. The main contractor for the project, Birse Pipelines, had no access into the project space held in the Severn Trent-hosted Lotus

Notes system. It was identified that there were no formal channels in place between the parties for the exchange of information electronically.

4.4.4 CASE STUDIES – FM ORGANISATIONS

Detailed case studies were undertaken at three distinct organisations to fulfil the FM requirement of the requirements gathering. In 2004, three organisations and their approach to work order logging, tracking and reporting were studied. The resultant paper ‘Potential use of real-time data capture and job tracking technology in the field’ (see Appendix C – Paper 3), suggested that there was scope for a Web-based system driven by wireless network technology within FM.

Providers of facilities management services have identified the requirements of their clients to provide for ‘real-time’ solutions to monitor performance in the field. Russell (2004) stated that provision of this level of functionality provides the ‘gateway’ to qualification from both existing and new clients. From an FM provider’s point of view, a major objective is to meet the SLAs (Service Level Agreements) set with the client. However, providers realise that without an automated real-time solution for work order tracking and reporting, they are often unable to provide evidence of how they have performed, or able to give a point in time status report to their clients.

From a regular employee’s perspective, an automated real-time system provides the functionality to track the progress of a fault they may have logged, without the need to call a helpdesk and attempt to ascertain an update from an operative who is not directly involved with the actual work being undertaken.

The case studies investigated the current practice operated by three organisations selected from different business sectors, namely commerce, healthcare and higher education.

Compared to the industrial revolution, which duration spanned centuries, the ‘Information Revolution’ emerged all around the world and within a single generation. Its influence is such that the Internet has spread to some of the least developed regions of the globe (Sun and Howard, 2004).

4.5 PROTOTYPE DEVELOPMENT

This development and evaluation piece of research originates from the case study noted in section 4.4.4 which was subsequently published in *Facilities* journal as ‘Potential use of real-time data capture and job tracking technology in the field’, and is provided for reference in Paper 3 (Appendix C). Amongst the recommendations within the paper was to develop a prototype system based on the findings and requirements gathered from the case studies.

4.5.1 PROCESS OF PROTOTYPE DEVELOPMENT

Analysis of application service providers, presented in Paper 1 (Appendix A), highlighted a number of common traits amongst offerings targeting the construction sector. With relevance to the development of this prototype, these included:

- being browser-based;
- being accessible over the Internet;
- delivering results from a relational database; and
- providing a simple, yet intuitive graphical user interface.

Therefore, the design of the prototype system was initially based on these criteria and developed further to provide a better experience for use through a mobile device.

Business process requirements were gathered from the work undertaken with the three case study organisations, and presented in Paper 3 (Appendix C).

4.5.2 SYSTEM ARCHITECTURE

The developed prototype was essentially an implemented functional subset of the functional model. The subset allows for a baseline level of interoperability, and was designed such that any future development will not require an excessive overhaul, i.e. the basic principles could be carried through to a scalable solution within an organisation.

4.5.2.1 Application Service Provider (ASP)

Explained in broad terms, application service provision is the management of a software application as a service, delivering solutions to end-users organisations from remote data centres via the Internet or private networks on a rental model basis.

Predictable pricing, lack of up-front capital expenditure and the ability to deploy rapidly are identified by Chamberlin (2002) as being the obvious business benefits of the ASP model.

In terms of quality assurance, job tracking and management tools hosted via ASPs can provide complete audit trails of document or content accesses, changes and workflows recording the date, time and user involved. The transparency of this method of auditing should promote good working practice, as well as providing integrity of data and information that can be archived and be readily accessible for the client in the future, say for the purpose of billing.

In addition, the benefits of using application software via ASP may also include:

- More reliable data communications,
- Less risk of implementation delay or failure owing to the users increasing experience with the ASP tool,

- New applications and features of existing systems can be developed and deployed without the need to invest heavily in having to train new skills, or be reliant on rolling out a new client-based application install to a device or computer,

4.5.2.2 Front-end presentation and back-end database considerations

Initially, the use of Flash files (.SWF) for front-end presentation was considered as the graphical user interface (GUI) is scalable, and so can be deployed across different platforms without loss of usability. The final version of the demonstrator did not incorporate Flash due to the added programming complexity involved, but its use in any future developed system could be considered.

To deliver a dynamic information feed and flexibility for presenting over different device types, Web design best practice promotes the separation of content from the layout on a Web page. This can be achieved by programming with XML, or alternatively by using open source PHP scripts a similar benefit can be derived without having to develop XML schemas from scratch. PHP handles data in a similar way and XML can be integrated into a back-end application design at a later stage.

PHP was chosen as the desired programming script and MySQL was chosen as the relational database management system that served the back-end processes. MySQL is open source and runs as a server providing multi-user access to a number of databases. MySQL is used in web applications and acts as the database component of the LAMP software stack. Its popularity for use with web applications is closely tied to the popularity of PHP, which is often combined with MySQL. Several high-traffic web sites, including Flickr, Facebook, Wikipedia, Google (though not for searches), YouTube use MySQL for its data storage and logging of user data. Other databases such as Microsoft SQL and Oracle, which are more

traditionally found in corporate hosting environments, could be considered as replacements for MySQL should this be required.

4.5.3 USER HARDWARE SELECTION

Originally designed for HP iPaq but demonstrated on Mobile Pocket PC-based Orange SPV M2000. The M2000 supported both WLAN and GPRS, and so could be used on wireless networked sites as well as on the road utilising mobile telephony provider networks such as Orange, O2, T-Mobile and Vodafone.

A 'standard' Pocket PC was chosen as opposed to a ruggedised version. This decision was mainly down to cost, as ruggedised Pocket PC's typically cost £1,500, i.e. up to 5-times the amount of a standard mobile-enabled device.

At the time of the prototype development, no devices were available with 'persistent' memory. The implications for this, as those with Pocket PC owners will testify, is that when the device loses its charge it will power down and perform a 'soft reset' on awakening. The soft reset wipes all locally held data on the device, and the user must then perform a restore from a previously made backup, if one exists that is. As the prototype system is based on an SaaS model, it is unaffected should such a reset take place as it does not rely on any client-installed software other than an ubiquitous browser. The use of browsers are typically unaffected by soft resets as they are included in the base build of virtually all PDAs.

4.5.4 KNOWLEDGE MANAGEMENT (KM)

Paper 1 (Appendix A) highlighted that application service provider systems catering for the construction sector do not address the needs of the client, say, after the construction phase has been completed and the operations and maintenance phase commenced. Information on assets, and changes to the built environment, are seldom fed back into project extranets and so

the prototype was designed to offer some knowledge management functionality that could be utilised in future construction projects. This would prove useful in a 'lessons learned' perspective, and so was incorporated in the prototype system design.

Considering the two types of knowledge, tacit and explicit, the prototype system was designed to harness elements of the workers tacit knowledge. Explicit knowledge, such as operations and maintenance (O&M) manuals, can be stored in corporate electronic document management systems (EDMS), or on project extranets. However, the capture and presentation of tacit knowledge has traditionally posed an issue for organisations.

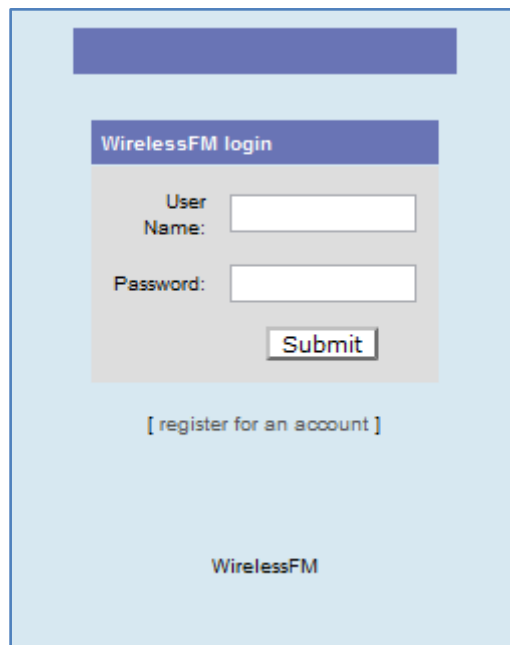
In addition to the core functionality of incident logging, tracking and reporting, the system has a 'knowledge base' function whereby notes can be stored, mapped to incident categories, and searchable for future use.

Some of the thinking behind the incorporation of a KM feature, such as adding certain incident detail to the 'knowledge base', is so that technicians in the field contribute, through their regular daily work, to a system that can be drawn upon on future jobs by themselves and their peers. Many handheld-based systems often concentrate solely on passing data in the most efficient manner through a structured, process-driven, form. However, the user of the system feels little ownership of the data he or she is 'processing' and cannot always see the attributable business benefit for themselves, even though the greater business logic behind automating the system may be obvious. Therefore, any technical solution implemented must provide the mobile user with something that is relatively easy to use, and does not increase their work payload.

4.5.5 USABILITY

On the topic of Web site usability, Krug (2000) describes usability as meaning that something works well: that a person of average (or even below average) ability and experience can use

the thing – whether it is a Web site, a fighter jet, or a revolving door – for its intended purpose without getting hopelessly frustrated. Figure 7 shows the layout of the WirelessFM login screen as seen on a PDA.



The image shows a screenshot of a PDA screen displaying a login form. The form is titled "WirelessFM login" and is set against a light blue background. It contains two input fields: "User Name:" and "Password:". Below these fields is a "Submit" button. At the bottom of the form area, there is a link that says "[register for an account]". The "WirelessFM" logo is centered at the bottom of the screen.

Figure 7 - Pocket PC login screen for WirelessFM prototype

The user interface is clean, and without Web-page elements such as vast images and frames which do not translate well to the small screen. The interface was designed using the scripting language PHP, and the back-end server code was adapted from an open source IT issue ticketing application.

4.5.6 USER FEATURES OF SYSTEM

- Ability to modify profile
- Attach files to jobs raised
- Send private messages to other registered users
- Set severity of a raised job
- Take and reassign ownership of jobs

- Update or comment on jobs
- Choose to send a response whilst updating or closing jobs
- Move raised jobs to other groups queues
- Search database for matching search strings

4.5.7 USER ACCEPTANCE / EVALUATION

A programme of thorough user acceptance testing would be required before the prototype could be considered for implementation within a live production environment; however, feedback from demonstration of the WirelessFM prototype system was very encouraging. Section 4.6 covers the evaluation topics discussed with the case study subjects. The feedback from these questions were then analysed and used to refine the final version of the prototype.

The FM professionals, two from each of the three organisations, who were part of the study were involved in an interactive demonstration of the system. They were shown how to log a work order on their own PC via www.wirelessfm.org, and then they were walked-through accessing that same work order on the PDA. The login credentials created allowed for them to log the work order as a supervisor, allocate to a particular technician, and then check that technician's job queue on the PDA.

4.6 EVALUATION TOPICS

The evaluation of the prototype system was broken down into eight topics for discussion with the case study subjects:

- How well did the prototype system address the aims and objectives?
- Possible prohibiting factors to adoption
- Areas for development / improvement

- User interface
- Benefits over a paper-based process
- Training / learning issues
- Technical considerations
- High-level evaluation

The evaluation sessions with the subjects were taken immediately after they had been demonstrated and participated in a working session using the system so that the experience was fresh in their memory.

4.6.1 HOW WELL DID THE PROTOTYPE SYSTEM ADDRESS THE AIMS AND OBJECTIVES?

In order to evaluate the success of the prototype system developed, the solution demonstrated to the case study subjects was cross-referenced with the aims and objectives of the system defined in the Paper 3 (Appendix C).

The topic was broken down into the following discussion areas with the subjects, and a summary of these discussed in Section 4.7:

- Would the system provide appreciable benefits to facilities managers?
- How positively would the system be received by the FM operatives in the field?
- Was there enough detail, such as categories, contained in the job ticket screens?
- How easily can incident-reporting users track the status of their incidents?
- Does the system require more or less access security, i.e., the data being transferred holds information of some criticality or, conversely, the existing security provision makes the system unwieldy on a mobile device?

4.6.2 POSSIBLE PROHIBITING FACTORS TO ADOPTION

Taking the assumption that the prototype met the functional requirements of the business processes previously considered, the subjects were asked if there were any other factors that could affect the potential use of the system within an operational environment. Items discussed included:

- Whether WLANs were used within their organisations at present, and whether there was a clear policy, possibly for security or safety considerations, against their use?
- The cost of the Pocket PC handsets were prohibitive?
- Whether they envisaged issues with obtaining on-going support from the internal IT provider within their organisation?
- Whether the cost of application hosting would be prohibitive, or whether providing this through an external 3rd party went against their IT policy?

4.6.3 AREAS FOR DEVELOPMENT / IMPROVEMENT

Rather than simply start by asking the subjects for areas they thought could be improved on the prototype, the evaluation discussion led by identifying some areas that could be an issue. These were used for two purposes; One, to spark discussion around thinking of system improvements, but also to validate whether the following areas were valid concerns in the system design:

- Integration with back-end systems
- Improved user interface for Pocket PC
- Memory caching if out of signal area
- Would the ability to add a file, such as an image taken from the inbuilt camera on the PDA, be a useful function?

4.6.3.1 User interface

A key element of user acceptance testing is to evaluate the effectiveness of the user interface. In systems that are presented through smaller screens such as the Pocket PC, this study is critical as it often the differentiator to success or the unpalatable alternative. The following areas of evaluation were covered with the subjects:

- First impressions of the system layout on the Pocket PC screen
- Is the system straightforward to use?
- Is the interface easy to navigate?
- How intuitive is the user interface?

4.6.3.2 Benefits over a paper-based process

The case study leading in to the prototype development, presented in Paper 3 (Appendix C), highlighted that all three organisations relied, to various degrees, in a paper-based process for handling the recording and tracking of work. To assess the potential benefits of the prototype system, the subjects were asked to compare and contrast the system against that of the paper-based process they were familiar with. Topics for discussion included:

- Opinion of real-time tracking
- Time saving estimate over paper-based process
- What benefits, if any, does a paper-based system have over the prototype?
- Are there any direct money-saving benefits that can be identified?

4.6.4 TRAINING / LEARNING CONSIDERATIONS

The prototype system had been designed to have a clear and intuitive user interface, but as it is presented as a system to replace a currently paper-based process, the issue of change management should not be underestimated amongst potential users. To assess the potential

training requirement for using the system within the subjects own organisation, the following topics were discussed:

- Comparison to other system currently used within the organisation (not necessarily ones used for the same or similar purposes)
- Familiarity with web browser
- Will users be able to remember the URL and their login credentials?

4.6.5 TECHNICAL CONSIDERATIONS

In addition to assessing the functional capability of the prototype system, it was important to consider IT infrastructure and hardware issues that may affect the delivery of the service of the application. History suggests that areas such as Internet connectivity and hardware speed and performance improve constantly to meet demands of consumer and business. The prototype system had been designed to be device agnostic and accessible using whatever mode of Internet connection was available. By taking this approach, these inevitable improvements to devices, browser applications and connectivity should only provide a better user experience on the prototype system going forward. Nevertheless,

- Connectivity
 - Page render speed on Pocket PC
 - Page render speed on desktop/laptop
 - Latency – lag between page refresh
 - Reliability of connection
- Hardware
 - Durability of test device

- Battery life
- Ergonomics
- Screen resolution / clarity
- Opinion on additional features contained on the device, i.e. calendar, contact list, phone, etc.

4.6.6 HIGH-LEVEL EVALUATION

- How appropriate is the prototype for use in your organisation?
- What is your overall rating of the system?
- What aspect of the prototype impressed you most?
- What aspects of the prototype fell short of your expectations?
- In their opinion, what are the key benefits of using the system?
- Would they consider using the system in the future?

4.7 FEEDBACK

A valuable part of the prototype evaluation exercise was the collation of feedback from the subjects demonstrated the system. Without exception, the facilities managers who participated in the case studies and prototype evaluation all agreed that the system would provide appreciable benefits to facilities managers if implemented across their organisations. It was acknowledged that a test deployment across operatives within their organisation would be the best method to gauge user acceptance from the FM operatives in the field. The subjects explained that probably the correct level of detail was included in the job screens, but that this would need to be tailored to match existing terminology and categories specific to their organisation. The ability to track the status of any job in real time and without the intervention

of a third party, such as administrative staff back in the office, was seen as a definite process improvement and potential cost and time saving benefit. In terms of information security, the subjects responded that they did not envisage any major areas of concern with respect to the type of data passing through the system, however the banking organisation representative qualified this by saying that location-specific information may have to be addressed differently for sensitive facilities such as data centres.

The following sections contain some of the system design points that should be considered if the prototype was to be developed further.

4.7.1 ADD EDIT FUNCTION POST-SUBMITTAL

It was recommended that the system should provide edit capabilities for the user, but not to the extent that allows for the manipulation of data. This could be achieved by allowing changes by the users after information has been submitted to the system, but before another user has been logged as viewing that information, and potentially working off it. System administrators could also have the facility to make minor amendments in the case of spelling mistakes or typos. The original version, submitted by the author, would be saved to the database for the purpose of audit, but it would only be the latest, corrected, version that would be visible on the live system to the standard user.

4.7.2 OPERATIVES OWN JOBS MADE MORE DISTINGUISHABLE BY DEFAULT

To more comprehensively alert operatives in the field to new work, it was suggested that jobs allocated to them personally, and not their team, were marked in some distinguishing way from their colleagues tasks. This functionality could be achieved by highlighting the users own tasks in a different colour, applying a label, or by

4.7.3 REFINE LAYOUT OF SUMMARY OF JOBS SCREEN

It was argued that operatives are not primarily concerned with whom the incident is affecting, and so would not necessarily benefit from having this information occupy a column on the summary of jobs screen. The contact information ascertaining to the affected person could be kept within the more detailed job detail screen that relates to that particular incident.

The Pocket PC screen 'real estate' is very valuable and site designers, who may be used to the generous proportions offered for designing for full size browsers, must rethink their approach. The Pocket PC screen offers 240 x 320 pixels to present a single screen. This area is reduced further when the URL and tools bars are added to the viewable area. According to w3schools⁶, the most common PC screen resolution for browsing the Internet is 1024 x 768 pixels with 57% of Internet users, a further 17% browse the Internet using even higher resolutions.

4.7.4 CONSIDERATION FOR LEFT-HANDED USERS OF PDAS

The evaluation exercise highlighted an accessibility issue encountered by left-handed people using PDAs. Holding the stylus in ones left hand does obscure the screen when using the scroll bar in applications. These scrollbars, by default, within Windows Mobile are located on the right-hand side of the screen. Another design consideration bias towards the right-handed majority is the position of the stylus in its storage socket on the right hand side of nearly all Pocket PC PDAs.

⁶ http://www.w3schools.com/browsers/browsers_display.asp

4.8 DISSEMINATION


The wide dissemination of results is an important objective of the research project, and this has been achieved through the published papers, presentations at international conferences and themed lecture to undergraduates at Loughborough University.

In addition to the published papers and conference presentations, an Internet-facing site was developed by the author to present the EngD research project (see Figure 8). Within the website was the facility for those interested to request access to the prototype system – a true representation of cloud computing.

Figure 8 shows the dissemination page from the WirelessFM portal and includes citations and links to the published papers as well as other information relating to the research project and Centre for Innovative and Collaborative Engineering (CICE) at Loughborough University.

The research undertaken by the author was of great interest to Taylor Woodrow and, as such, it and the author has significantly contributed to the organisation's IT strategy for the period 2004 to 2008.


Wireless Web-based Facilities Management Service



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Dissemination of findings


Refereed Journal Papers



"Potential use of real-time data capture and job tracking technology in the field"
 Published in 'Facilities' Journal. Emerald Group Publishing Limited, ISSN 0263-2772 (Facilities, Vol. 23 No. 1/2, 2005). McAndrew, S.T., Anumba, C.J., Hassan, T., and Duke, A.K.


Refereed Conference Papers

"Towards Wireless Web-based Facilities Management"
 Proceedings of the Second International Conference on Construction in the 21st Century - Sustainability and Innovation in Management and Technology (CITCii), December 10-12, 2003 Hong Kong . Paper 85, Pages 529-534, ISBN 988-97370-1-9



Download - Powerpoint presentation (275 KB) given to CITCii Conference, Hong Kong, 10th December 2003

"Overview of Application Service Provider's for the UK AEC Industry"
 Proceedings of INCITE 2004: International Conference on Construction Information Technology: World IT for Design & Construction, February 18-21, 2004 Langkawi - Malaysia. Pages 427-435, ISBN 983-2724-17-1



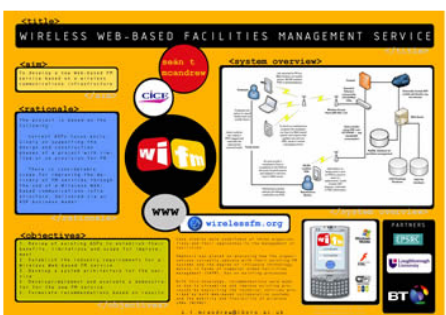
Download - Powerpoint presentation (143 KB) given to INCITE 2004 Conference, Langkawi, Malaysia, 20th February 2004

Conferences attended

Second International Conference on Construction in the 21st Century - Sustainability and Innovation in Management and Technology (CITCii), December 10-12, 2003 Hong Kong

INCITE 2004: International Conference on Construction Information Technology: World IT for Design & Construction, February 18-21, 2004 Langkawi - Malaysia

Centre for Innovative Construction Engineering (CICE) Open Day 2004



Click on the above image to view the wi-fm poster (pdf) presented at the 2004 CICE Open Day. The day was held at the Burleigh Court Conference Centre, Loughborough University on Wednesday 19th May 2004.

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Figure 8 - WirelessFM dissemination page on portal

5 CONCLUSIONS & IMPLICATIONS

5.1 INTRODUCTION

This chapter summarises the findings of the research and discusses the implications on the industrial sponsor, the comparison organisation and the wider FM and construction sector.

5.2 REALISATION OF AIM AND OBJECTIVES

Table 4 - Summary of findings

provides a summary of how this research has satisfied the project objectives, with the findings discussed further in the subsequent chapter sub-sections.

Table 4 - Summary of findings

Objective	Findings	Evidence			
		Paper 1	Paper 2	Paper 3	Thesis
To undertake an investigation into the current state of the art in communication and collaborative technologies for industrial/engineering applications, focussing on the practical applications of technology, particularly those in use in virtual organisations	Initial application service provider’s offerings were quite simple with limited capabilities. The leading provider’s in this technology space were BIW Technologies, ASITE, 4Projects and Causeway Technologies.	P			S
To determine the communication and collaboration requirements of organisations and individual parties within those organisations. To develop an understanding of how to support the management of processes	Existing processes for work order job logging and tracking were identified as wasteful in terms of time taken to complete, inaccuracies due to double-entry keying of information and lack of real-time status updates	S	S	P	S

Objective	Findings	Evidence			
		Paper 1	Paper 2	Paper 3	Thesis
within organisations	on job progress				
An identification of barriers to the successful adoption of collaboration technologies - both of a technical and social nature	Successful implementation of systems require capable network infrastructure to provide support for document transmission and responsiveness for users. Enterprise pricing models mitigate against project concerns against cost.	P	S	S	S
A formulation of practical solutions that will address the requirements identified	A mobile web-based application was demonstrated to improve on existing, predominantly paper-based, processes across 3 organisations studied		S	P	S
A critical comparison of presented theory and solution prototypes with the perspective of an IT department of an operationally-active construction organisation	The prototype system developed shared many of the features identified as improvements on existing processes with the comparison organisation's system. The prototype system, being web-based, is device and platform agnostic, thus providing greater flexibility and potentially longevity				P
Development of recommendations and IT strategy for organisations operating in the construction and facilities management sector	Benefits of cloud computing provides organisations with innovative technology without the cost and risk of capital expenditure on hardware. Solutions are scalable and flexible as hosting provision is not location-specific.				P

Key:

P Primary evidence
S Supporting evidence

5.3 THE KEY FINDINGS AND CONCLUSIONS OF THE RESEARCH

The study of application service providers for the UK AEC industry, presented in Paper 1 (Appendix A) concluded that the early applications offered into the AEC industry collaborative space were quite simple with limited capabilities. The findings suggested a future trend towards more integrated solutions, incorporating more functionality, search facilities and security.

The following vendors and their collaborative application offerings were identified by the study as currently being perceived as the leading contenders in the UK construction market:

- BIW Technologies
- ASITE
- 4Projects
- Causeway

The problems of collaborative working from remote sites should be a firm consideration when planning any system as there are still shortfalls in the quality and capacity of connection to the Internet. This point was confirmed when analysing support issues relating to extranet usage at Taylor Woodrow. Certain tasks on site, such as compiling snagging lists or identifying defects, could be completed utilising mobile devices such as PDAs, but application service provider's need to do more work to support these devices with their products. The AEC industry as well as the software vendors targeting it should look to the technologies that are rapidly becoming ubiquitous in the field of mobile communications and try to embrace the benefits brought with enhanced functionality.

5.3.1 WIRELESS FM PROTOTYPE DEVELOPMENT

The overarching aim of the prototype development research was not to push technology onto reluctant users, but to improve an existing work process that is inefficiently handled through ‘traditional’ labour-intensive paper-based methods.

The study found that a new wireless Web-based service for FM systems would be considered useful. Although notoriously slow adopters of new technology, there was an acceptance by the facilities managers interviewed that a wireless Web-based approach would improve current practice, especially with respect to real-time job reporting and tracking and in the determination of FM operative working time utilisation.

The development of the prototype system was well received, and the three organisations questioned thought that an FM system based on the principle of SaaS, and accessible via mobile data-enabled devices, would improve the current manual and paper-based processes found within the industry. Figure 9 shows the portal developed to provide access to the prototype system and disseminate findings from the research.

In conclusion, the following could be considered the benefits of an SaaS system on wireless and hand-held devices:

- Platform independent, i.e. resistant to the issue of rapidly changing hardware;
- No need to roll-out client installs to users devices; and
- All devices effectively on the same version, considerably easier to troubleshoot.

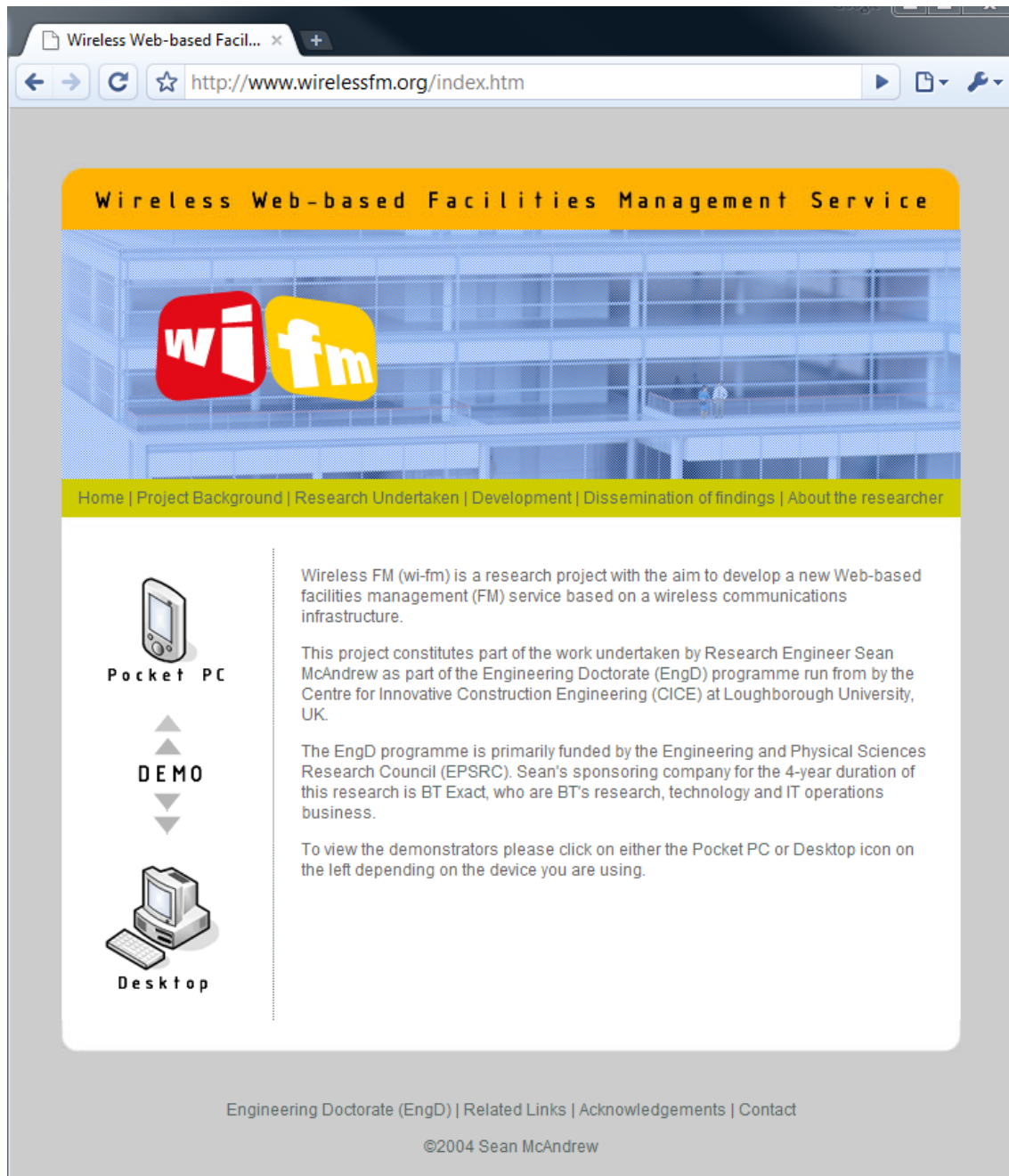


Figure 9 - WirelessFM prototype portal

5.4 THE CONTRIBUTION TO EXISTING THEORY OR PRACTICE

“Good ideas are two a penny. They only become valuable when someone implements them. Then they become innovation.”

Ian Pearson – BT Futurologist

The work undertaken utilises current wireless technologies and has developed an innovative solution to support mobile workers within an engineering business environment. The research draws upon the cloud computing principle of hosting services. It covers not only how this model can be successfully used through the design and construction phases, but also how it can be carried through into the operations phase and used by facilities management operatives in the field.

5.4.1 FULL PROJECT LIFE CYCLE

The research has attempted to bring closer the use of systems across the building life-cycle, from construction through to facilities management. Traditionally, organisations who undertook facilities management were not those who embarked on heavy civil engineering-based construction. Organisations such as Carillion and Taylor Woodrow are redressing that tradition and offering a one-stop-shop for construction and FM needs. Taylor Woodrow's PFI work on the new St Helens, Knowsley & Whiston hospitals are testament to this.

5.4.2 COLLABORATIVE SYSTEM DESIGN PRINCIPLES

From the initial study of ASPs for the construction industry (Paper 1, Appendix A), and the subsequent work with the WirelessFM prototype development, the following collaborative system design principles should be considered:

- Provide a system with open access to documents within the business
- Ensure that documents exist in one place only once
- Have an owner, audience and status
- Simple to understand and easy to use
- Culturally appropriate and resilient to change

- Re-use structures wherever possible
- Most valuable data has metadata

5.4.3 THE MOVE TO CLOUD COMPUTING

Introduced in Paper 1 (Appendix A), and utilised in a broader IT strategy developed at Taylor Woodrow, the move to a cloud computing model has reached the construction sector. Although an almost amorphous term within the IT world, Kavanagh & Pescatore (2008) define cloud computing as “a style of computing where massively scalable IT-related capabilities are provided “as a service” using Internet technologies to multiple external customers.”

According to Rosenberg (2009), cloud computing can be broken into the following segments:

- Infrastructure-as-a-Service - operating system hosting with dynamic provisioning and theoretically unlimited resource scaling. A leading example is Amazon's EC2⁷
- Platform-as-a-Service - no infrastructure required hosting to develop and deploy applications. Examples here include Force.com⁸, Heroku and Google App Engine⁹
- Software/Application-as-a-Service - where applications are delivered via a web browser. These examples include Salesforce.com, NetSuite and Gmail¹⁰

With respect to the terms ASP and SaaS, there does not seem to be any material difference, just a re-branding of terminology over time, with the latter acronym the current favourite with vendors and commentators alike.

“The next sea change is upon us”

⁷ Amazon Elastic Compute Cloud (Amazon EC2) <http://aws.amazon.com/ec2/>

⁸ Force.com <http://www.salesforce.com/platform/>

⁹ Google Apps Engine <http://code.google.com/appengine/>

¹⁰ Google Apps for business <http://www.google.com/apps/intl/en/business/index.html>

Bill Gates (b. 1955)¹¹

Carr (2008) quotes the chairman of Microsoft giving a warning to his organisation of the threat from 'utility' computing, which threatened to erode its traditional business. Gates conceded that software was no longer something that people had to install on their computers, but that it was evolving into a utility service supplied over the Internet.

From Paper 1 (Appendix A) the following are some of the benefits of a cloud computing based SaaS system:

- Scalable
- WYSIWYG - What You See Is What You Get
- Predictable cost
- Rapidly deploy-able
- Platform and device agnostic

The following are aspects of SaaS that should be considered before implementation:

- SaaS systems do not always give the 'feel' of a client-installed application, and this can be off-putting for users. Web 2.0 advances with AJAX are providing users with a client-rich feel and so, with improved Internet connectivity, this issue should reduce with time
- Total system control is not absolute as it would be with a self-hosted system.
- Practical considerations such as access controls for organisation leavers

¹¹ Part of 'Internet Software Services' memorandum sent to Microsoft's top managers and engineers on 30 October 2005

In consumer life, cloud computing is rapidly becoming ubiquitous. Taylor Woodrow has embraced this shift more than most in industry – not just the construction industry - by implementing solutions such as Gmail and Google Apps for its entire corporate workforce. The flexibility, scalability and reduced cost of services such as Gmail has allowed them to bring email accounts to employees and sponsored students who otherwise may not have been catered for in a rigidly self-hosted system.

5.5 THE IMPLICATIONS/IMPACT ON THE SPONSOR

BT has attempted to provide systems tailored to the construction industry to compliment their ‘traditional’ product set of voice and, more recently, data provision. Following on from the findings of the study of application service providers targeting the UK AEC industry, BT entered into an exclusive commercial agreement with BIW Technologies, whereby they would market BIW’s extranet offering – *BIW Information Channel* – as part of their own product set. In addition to highlighting BIW as a strong technology provider in this field, there was an aspiration by both parties, BT and BIW, to work together to develop the offering further. This approach provided BT with the opportunity to provide an all-in-one packaged offering of application provision with the network infrastructure that is essential for the extranet to be utilised effectively. This approach, as effectively both an infrastructure and application provider, gave BT an unique selling point that other extranet and network infrastructure providers did not possess.

The author was seconded onto the *BT Build Business* proposition team within BT Retail for a proportion of research period. Here, the author provided input into the product selection and overall development of the proposition. Figure 10 shows an intranet resource site developed by the author for the BT Retail account management and sales teams.

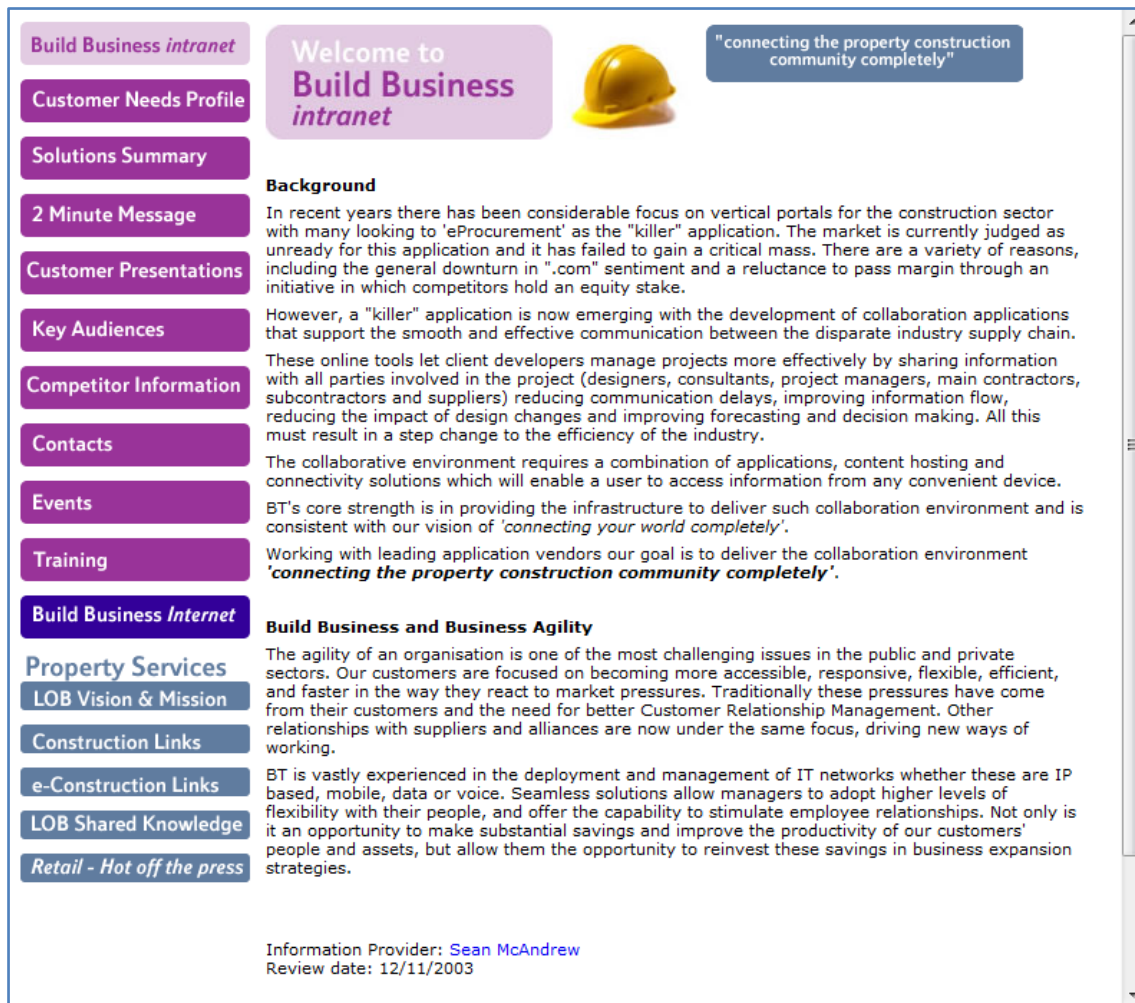


Figure 10 - BT 'Build Business' intranet resource

The work undertaken on the WirelessFM prototype also provided BT with a new perspective on an emerging part of their new business. At the time of the study, BT Retail were preparing to develop their in-house and out-sourcing skills so to provide a 'Total-FM' solution within their portfolio. BT had the vision to provide all hard and soft FM services to existing and new customers within the business sector. The potential implementation of a wireless Web-based real-time work order logging and tracking system would be seen as a technology differentiator within that sector. Taylor Woodrow, through its MRT Mobile project, found this to be the case.

5.6 THE IMPLICATIONS/IMPACT ON WIDER INDUSTRY

“Technology...the knack of so arranging the world that we need not experience it.”

Max Frisch (1911-1991)¹²

The findings and structured feedback from the development of the Wireless FM prototype was unanimously appreciated amongst the interviewees as a system that would potentially provide real improvement to the current process used within the three organisations studied.

When compared with the MRT Mobile project implemented by Taylor Woodrow, the benefits of having a hosted service, non-reliant on client-installed applications, was recognised as offering greater business continuity in the event of a battery running flat on an engineer’s PDA, which provokes a hard-reset of the device, wiping settings and data.

5.6.1 LEARNING FROM CLOUD COMPUTING SYSTEM IMPLEMENTATION WITHIN ORGANISATIONS

Why do great ideas and theories for project implementations often fail to meet expectations?

Generally, people are resistant to change. Innovators strive on change, and are spurred on by what they see as obvious improvements on current inefficient practice.

Construction organisations are project-centric and often this can mean that project teams can be 'greedy' for resources, whether it be staff, IT hardware and infrastructure, or support services in general. This greed could be interpreted by some as them not showing a bigger picture view of the organisation's overarching aims and objectives. In many respects, who could blame them? Project teams are tarred with the brush that is dependent on how commercially successful their project was. Whilst IT can undoubtedly be seen as an enabler, it

¹² Homo Faber (1957) pt. 2

can often be cited as a scapegoat for why some projects do not realise the successes that had been anticipated.

What one sees in sales demonstrations are not often what is delivered in IT projects, at least not often in the first phase of delivery. Cloud computing solutions often come with trial facilities which can be rapidly - and cheaply - configured.

5.6.2 USERS LIKE TO FEEL INVOLVED

At Taylor Woodrow, a legacy email system based on HP Openmail was replaced with bleeding-edge cloud computing solution offered up by Internet giant Google. The implementation of the new system was so rapid that some users felt that the system was forced upon them. It is strange to say this, but those users almost felt more comfortable if they were subjected to a slowly implemented self-hosted system with associated teething problems.

Contrast this response to the implementation of the Livelink ECM system two months later to the same workforce. Maybe because users were involved in the longer drawn-out taxonomy design sessions for the new EDMS implementation they actually felt more 'ownership' and, as a result, were far more forgiving to the glitches and service outages experienced with that system.

5.6.3 USERS NEED TO FEEL THEY HAVE BEEN TRAINED

The majority of employees have personal email accounts provided either by their home Internet Service Provider (ISP) or by one of the web-based email providers such as Microsoft's Hotmail, Google's Gmail or Yahoo mail. In the home and consumer environment, users do not expect to attend formal training sessions in the new web-based services they use, but rely on the principle that clearly laid out and easy to use websites propagate to the fore,

assuming the underlying service is solid. However, in a work setting, employees feel there is a requirement that any implementation of a new system should be delivered in tandem with a training course and, as such, many will only reluctantly enter into using the system if that criterion is not met. Taylor Woodrow implemented the new enterprise-wide email solution based on Google's Gmail in May 2008. The core functionality of Google Mail for enterprise is identical to the user as it is in the consumer offering of Gmail, yet a few people – those with personal Web-based mail accounts – seemed unable to transfer their skills from home to work.

5.6.4 TRAIN THE WAY TO USE AND NOT JUST THE TECHNICAL ASPECTS

Taylor Woodrow has an enterprise-level agreement with its extranet provider whose monthly charges are not directly related to usage, number of seats or number of extranets. Extranet provider's such as 4Projects have adopted their business plan in a way so as it does not financially punish those users of the systems who achieve high utilisation. Business analysts and implementation project managers within construction organisations should ensure that they are promoting use of the extranet within their organisation, and ensuring that users are using the system in the correct way. 4Projects now incorporates implementation and training sessions as part of their enterprise service offering to aid take up of extranet usage on construction projects, which contributes to this end. Within Taylor Woodrow, all new projects are able to utilise this service with no addition cost borne by the project itself. Vendors such as 4Projects have a number of added incentives for ensuring take-up within the construction projects, namely:

- Effective utilisation of the system means efficient use of infrastructure resources such as storage. For example, by promoting best practice use of extranet usage in terms of document management, storage costs could be reduced due to the higher likelihood

that files are only uploaded onto the system once and not needlessly replicated. If documents and drawings are categorised within well-structured taxonomies, then the time – and network bandwidth consumed – to find these files by the end-user is reduced.

- Increased dependency on their system within the organisation will make the proposition of moving to a competitor's product rather less palatable, owing to the potential increased cost for migrating substantial amounts of data between systems, and re-training the workforce.
- As a collaborative tool, extranets are utilised by numerous parties, and not just the organisation who has the agreement with the extranet provider and who is paying the fee. Therefore, an efficient well-structured extranet will act as ideal product placement for potential future sales within the sector. Again, dependency on particular systems may increase the chance of new customers deciding on an agreement with an extranet provider partly because they have previous work tied up in a system they may have only been a guest on in the past.

5.6.5 IMPLEMENTATION OF IT PROJECTS

Commercially speaking, IT departments are viewed as a cost centre; a drain on finances in a business; an unavoidable evil. In construction organisations, operational projects provide the revenue to the business and innovations are often borne from necessity. In the *Harvard Business Review*, Carr (2003) went even further to say that “IT Doesn't Matter”. In the fallout from this paper, Carr received many disparaging comments from the great and the good of IT providers. Steve Ballmer, Microsoft's chief executive, declaring it “hogwash”. In a retort, Carr (2008) explained that IT systems were not all that important to the success of an organisation. Whilst conceding they were necessary, he explained that systems had become ubiquitous to

the point where they no longer provided one company with an edge over its competitors. Advances in system development soon proliferated through to competitors, and, strategically speaking, Carr proposed that information technology had become inert, and was just another cost of doing business.

A cloud computing system can provide the opportunity for an organisation to implement systems without the heavy involvement of an IT department. They have their part to play in terms of providing the necessary network infrastructure, required client applications (browsers) and probably first and second line support, but in the absence of coding requirements, businesses may find that they can implement a system with just the basic measures of configuration. As with extranets, this shifts power from the IT department back into the business. Ideally, any project should be undertaken with representatives from IT and the business, with a competent business analyst and project manager to ensure that requirements are set and met by whatever is chosen and implemented.

5.7 CLOUD COMPUTING-BASED IT STRATEGY

The new IT systems implemented by the author within Taylor Woodrow Construction are shown in Table 5.

Table 5 - Systems implemented at Taylor Woodrow Construction 2004 to 2008

IT Service	Legacy system	New System	Date moved	Cloud computing Solution?
Collaborative document management	Athena	4Projects	Circa 2000	Yes
Room Booking	None. HP Openmail with Outlook 2000 interface used for internal booking	Condeco room booking (provided to FM clients for	2006	Yes

IT Service	Legacy system	New System	Date moved	Cloud computing Solution?
		Sheffield City Council & HM Government Buildings)		
Email	HP Openmail delivered through Outlook 2000 (no mobility support)	Google's Gmail	May 2008	Yes
Real-time document collaboration	None	Google Apps: Google Docs, Spreadsheets	May 2008	Yes
Calendar	HP Openmail delivered through Outlook 2000 (no mobility support)	Google Calendar	May 2008	Yes
Email Archiving	None	Postini	August 2008	Yes
Web filtering / Proxy servers	Internally hosted Microsoft ISA Servers	ScanSafe	November 2008	Yes
Enterprise Search	None	Google Search Appliance	2 nd instance installed August 2008	Self-hosted but with capability to search externally-hosted sources such as Gmail and Google Docs
External party FM call logging portal	No current IT solution due to existing FM	FM Web portal (bespoke	September 2008	Yes, the portal is

IT Service	Legacy system	New System	Date moved	Cloud computing Solution?
	system infrastructure (IBM MRO Maximo 4.1)	application)		externally hosted by an ISP.
Internal document, content and records management system	Athena, Novell file stores, bespoke content management system	Causeway ECM (Livelihood ECM) and Google Sites	July 2008	Causeway ECM (self-hosted); Google Sites (Yes)
FM work order management system (MRT Mobile project)	Manual, paper-based process	Taskmaster	Pilot late 2004; Full in 2005	Self-hosted
Customer Relationship Management (CRM)	Numerous, multi-versioned, unstructured Excel spreadsheets	Salesforce.com	Pilot late 2008	Yes

From Table 5 it is apparent that there is a strong move towards adopting a cloud computing approach to system implementation at Taylor Woodrow. In the role as lead business analyst at Taylor Woodrow, the author presented recommendations based on gathered requirements from the business and studies into the latest technologies available. Both traditional self-hosting and cloud computing were considered, and recommendations on each system made to the IT director and main board at Taylor Woodrow Construction. From recent study and experience of numerous system implementations, the IT director, Rob Ramsay, together with the author developed an IT strategy that placed the following criteria as fundamental in new system selection:

- Can an existing, possibly under-utilised system, meet the requirement?
- Who are the market leaders in this technology?
- Are there valid reference sites to study?

- As a construction and facilities management organisation, can we really provide the best hosting facility for the required system? Can our infrastructure provide the resilience, scalability and service support that the business requires?
- Is the new system supportable?
- How does the system integrate with our legacy systems and, more importantly, how will they integrate with the new ones going forward?
- Have we saved the business money in the short/medium/long term?
- Does it support mobile devices?
- Is it consultant-heavy in terms of implementation? Do not underestimate the risk and cost associated with this potential variance in quality.
- Can I get my data out (in a usable format) when I want to change provider?
- Operate a pilot as a proof of concept
- Undertake a thorough internal marketing exercise to state what you are doing and what benefits it will bring

5.7.1 HAS SAAS / CLOUD COMPUTING TAKEN OFF IN THE CONSTRUCTION INDUSTRY?

In some respects the software as a service IT model for collaborative working has actually taken off and been embraced more readily than in some other industry sectors.

Project collaboration extranets, such as those provided by the NCCTP¹³ partners, are becoming the de-facto standard for drawing and document sharing amongst clients, contractors, architects, consultant and suppliers in the AEC industry today. The NCCTP -

¹³ <http://ncctp.constructingexcellence.org.uk/default.jsp>

Network for Construction Collaboration Technology Providers - are a membership forum with secretariat provided by *Constructing Excellence*.¹⁴

Construction organisations may now wish to consider moving other systems to a cloud computing model in a similar way that Taylor Woodrow did with its email (Gmail), email archiving (Postini), web filtering (Postini/ScanSafe), proxy services (ScanSafe), customer relationship management (CRM)(Salesforce.com) and room booking (Condeco) requirements. Taylor Woodrow's venturing into this area has been bold, but it has realised significant cost savings, and has left them with leading-edge developed systems.

The first year set-up costs for Google Apps, incorporating Gmail, for the 1,800-head workforce was £45,000. To implement a Microsoft Exchange service, catering for the same headcount but without support for mobility, came in at over £1m when all infrastructure, licences and implementation costs were taken into account. When considering the addition of email archiving provided by Google through their summer 2007 acquisition of Postini, the first three-year cost for combined email and archiving came in under £250,000.

5.8 RECOMMENDATIONS FOR INDUSTRY/FURTHER RESEARCH

5.8.1 EXTRANETS ON MOBILE DEVICES

Application service providers in the AEC sector have not pursued as much development in the area of mobile connectivity from mobile devices as could have been expected. Further research could focus on if this perception is so, why it is so, and what factors are affecting the use of project extranets on mobile devices. Mobile browser technology has developed, separate from extranet application development, to a point where traditionally laptop / desktop-based systems such as 4Projects can now be accessed on Windows Mobile devices running the latest version of Opera, albeit with reduced functionality. This provides much

¹⁴ <http://www.constructingexcellence.org.uk/>

hope for the future as, together with the rapidly decreasing cost of 3G / HSDPA access, mobile access to these older systems will naturally, and almost organically, proliferate.

“I never think of the future. It comes soon enough.”

Albert Einstein (1879-1955)¹⁵

Browser development for Pocket PC and mobile devices is rapidly maturing. Programming using Java scripting, for example, was not an option when considering implementation of the prototype on mobile devices because the main browser offering – Pocket Internet Explorer from Microsoft – cannot support the language. Functions such as drop-down menus, which are commonly programmed using Java script, do not work in these browsers.

The next generation of browser, in particular Opera for mobile devices, supports Java scripts, and so opens up a great deal of functionality for Pocket PC that was not there previously.

New developments in ‘standard’ web technologies may also provide web programmers for mobile devices with more possibilities for their sites. Considering Web 2.0, AJAX is touted as the next ‘big thing’ and provides application-like feel and functionality through web pages. Until the advent of AJAX, the replication of rich and responsive design of applications was not possible. Fortunately, for designers of Pocket PC applications, AJAX can be utilised in browsers made specifically for the PDA environment, namely Pocket IE.

5.8.2 CONSIDER APPROPRIATE SYSTEMS FOR CLOUD COMPUTING

With respect to cloud computing, research could be undertaken to investigate what type of systems, within a construction organisation, are appropriate for this method of system delivery. More work could be undertaken to move elements of CAD packages, traditionally a thick-client application, towards a hosted model so that the collaborative working element is

¹⁵ Interview given on the *Belgenland*, December 1930

streamlined. It was often the case within Taylor Woodrow that clients would specify CAD-designed drawings in a specific file format, almost solely for the reason that was the format they always dealt with rather than whether it was the best format/package for the work being designed.

5.8.3 AGREE THE ‘COLLABORATIVE ARCHITECTURE’

Pisano & Verganti (2008) highlight a key point regarding collaboration in general, whereby organisations jump into relationships without considering their structure and organising principles - the collaborative architecture. This notion of formally agreeing an architecture before entering into relationships can be directly transposed to the use of collaborative IT systems between construction project parties. Ambiguity of roles and responsibilities will lead to inconsistent contribution from parties involved. Quite often, the contribution from smaller sub-contractors into a collaborative extranet is not fully considered at the outset, and whether down to budget, lack of influence or other factors, they are not always invited to participate in kick-off meetings or extranet training sessions.

5.9 CRITICAL EVALUATION OF THE RESEARCH

Whilst the Wireless FM prototype was demonstrated to operational facilities managers, there was not the opportunity to run a pilot program with a group of field technicians. This pilot would have proved useful in terms of user acceptance testing (UAT). Pilot phases of implementation projects are invaluable for identifying software bugs, refining user interface design, as well as addressing other hardware / infrastructure-related issues prior to a volume rollout into a business. However, feedback given during the operation and support phase of the MRT Mobile project at Taylor Woodrow showed that reliance on locally-stored data where devices can be lost or wiped after a dead battery, brought much frustration to their

users. The principle of having a device and location independent system, i.e. that provided by the WirelessFM prototype, would address this issue.

The principle of SaaS for the provision of work order tracking within facilities management was agreeable both with the group of facility managers involved with the research and those providing FM services at Taylor Woodrow. Security of data was noted as generally less of an issue with respect to the information connected with work order logging, i.e. reporting a faulty light bulb. However, Taylor Woodrow's MRT Mobile offering was designed with very high IT infrastructure security owing to some of the requirements of their clients. For example, locations of mobile phone antennae base stations need to be handled carefully, and not put into the public domain.

5.10 SUMMARY

In summary organisations within the construction and facilities management sector should consider the following with respect to their IT strategy:

- As an organisation whose primary objective is to profit with the construction and FM sector, can you really provide IT better than a 3rd party specialist?
- Can the system or service, or a number of, be consolidated into a single system provision?
- Is there any valid over-riding reason why the system cannot be hosted externally?
- In the event of an economic downturn, does your organisation have the capability to rapidly scale-down its costs – potentially IT – without loss of investment or crippling penalties?

- As an organisation, do you wish to be seen at the bleeding edge of technology innovation?

The research undertaken as part of the EngD programme with BT, and the comparison with Taylor Woodrow has highlighted the following as benefits of SaaS-based systems within a construction context:

- Applications are subject to on-going development, with frequent releases attending to bugs, but also delivering new functionality often at no extra cost
- They provide predictable cost and expectation of function at the outset, i.e. very much a 'What You See is What You Get' (WYSWYG) approach
- Highly scalable (both up and down)
- Unaffected by business-level changes such as mergers and acquisitions. For example, Taylor Wimpey actually used 4Projects as an integration project management and collaboration tools during its creation
- Location independent

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APPENDICES

APPENDIX A - PAPER 1

OVERVIEW OF APPLICATION SERVICE PROVIDERS FOR THE UK AEC INDUSTRY

FULL REFERENCE

McAndrew, S.T., Anumba, C.J., Hassan, T., and Duke, A.K. (2004). Overview of Application Service Providers for the UK AEC Industry, *Proceedings of INCITE 2004: International Conference on Construction Information Technology: World IT for Design & Construction*, February 18-21, 2004 Langkawi, Malaysia, pp.427-435, ISBN 9832724171

ABSTRACT

Collaboration takes place at every phase of the construction process. The success of projects can be measured on the effectiveness of collaboration between the construction parties involved. Bad collaborative channels often contribute to claim ridden contracts. Application service providers (ASPs) provide a platform for aiding collaborative working between members of virtual project teams. This paper concentrates on some of the current ASP products targeting the UK architecture, engineering and construction (AEC) industry as well as highlighting the issues surrounding their practical use and effectiveness on projects.

1.0 Introduction

Collaboration takes place at every phase of the construction process. The success of projects can be measured on the effectiveness of the collaboration between the construction parties involved. Bad collaborative channels often contribute to claim ridden contracts.

With a view to addressing the communication needs of engineering organisations in a collaborative engineering environment it is necessary to identify and analyse the products and tools currently in the market place. The methodology adopted for this research took the form of a literature review of current research and of products targeting the AEC industry.

The UK construction industry currently provides a tenth of the UK's gross domestic product, and employs 1.4 million people (Source: DTI 2003). However, research by Graves *et al* (1998) studying UK Government projects found that two thirds were over budget and three quarters experienced delayed completion. It has been suggested, that the utilisation of collaborative tools within the industry could lead to savings in the order of 10%, and with supply chain management savings could be double that.

One of the key performance indicators in the construction industry is building completion time. Web-based tools allow the developers representing clients manage projects more effectively by sharing information with architects, design engineers, contractors, and site managers. The codifying of project management workflow is highly time intensive in terms of learning and the expertise required to manage. Therefore, many clients now look to application service providers (ASPs) to manage Web-based inter-firm collaboration.

2.0 Application Service Provision

Application Service Provision is the management of a software application as a service, delivering solutions to end-user organisations from remote data centres via the Internet or private networks on a rental basis.

Predictable pricing, lack of up-front capital expenditure and the ability to deploy rapidly are identified by Chamberlin (2002) as being the obvious business benefits of the ASP model.

Table 1 - User perception – Pros and cons by Type of ASP (Source: Ovum 2000)

Type of ASP	Pros	Cons
Software vendors i.e. SAP and Oracle	<ul style="list-style-type: none"> • Thorough knowledge of applications and how to integrate them • Ability to customise applications • Financial security/comfort factor, if big company 	Reputation for poor help-desk support Higher cost, if big company
Specialist ASP i.e. BIW Technologies, BuildOnline, Business Collaborator, etc.	<ul style="list-style-type: none"> • Greater independence/more choice of applications available • More experience of integrating multiple applications from different software vendors • Better understanding of network delivery • More personal service • More price competitive 	Less financial stability/risk of business failure or merger

Project extranets differ from ASPs as the client, if so desired, may chose to host them. The client's firewalls, possibly the ones securing the organisation's own intranet, can be administered so that an extranet can be developed between consensual members of other organisations.

Each party involved in the process of a construction project looks at the same piece of information in different ways. For example, an architect will study a drawing for the design issues, whereas the engineer will consider functional aspects. The contractor will then study the same drawing and concentrate on the construction methods required together with an estimate of the predicted cost.

There seems to be a clear requirement for an effective collaborative product in this area. It should be client orientated. The client is the only participating member of the process who is present for every step of the process and, more importantly, is often there following construction.

The client is the party with the money to spend. Whatever the depth of knowledge or experience the client has with construction projects they should be able to monitor and record at every step along the construction process, and through into the operations and maintenance (O&M) period.

Effective utilisation of the Internet for collaboration on projects can provide two immediate and key benefits, namely:

- Reduction in wasted time,
- Improvement in the accuracy of information.

The utilisation of extranets and ASPs by construction personnel may be more of a cultural issue than a technology one. Education and training are critical factors in the successful implementation of applications such as extranets. Throughout the duration of a project many new members will come on board and therefore require new training sessions. In most probability, the members present at the initial training sessions provided by the extranet suppliers will make up only a small proportion of the total number who will be expected to use the extranet through the life of the project. A solution to overcome this problem could be the integration of a continuous and formal user-training package into the extranet application itself. Users should be encouraged to change their perspective with regard to the exchange of digital information.

The commercial advantages of using on-line project management tools are most notably demonstrated by the significant increase in speed of transfer of information of that of

traditional paper-based transmittals. As well as fast information transfer there is also the benefit of knowing that the information and documentation on the project site will be the most up-to-date versions. Both these factors will realise noticeable cost saving benefits if utilised effectively.

In terms of quality assurance project management tools hosted via ASPs can provide complete audit trails of document accesses, changes and workflows noting the date, time and person involved. The transparency of this method of auditing should promote good working practice as well as providing integrity of project data and information that can be archived and be readily accessible for the client in the future.

In addition, the benefits of using application software via ASP services may also include:

- More reliable data communications,
- Client having direct access to project information,
- Less risk of implementation delay or failure, owing to the users increasing experience with the ASP tool,
- New applications can be developed and deployed without the need to invest heavily in having to train new skills,
- Predictability of costs and packaged price, which can reduce the cost of ownership and management,
- Easier administration, with a single bill and point of contact,
- Opportunity to build, collate, and store health and safety information, as well as O&M manuals extracting key data from design through to construction phases,
- Can help initiate and foster better supply chain integration,
- The reuse of information in the post build period.

The AEC industry is notoriously inefficient and this is partly due to its reliance on paper-based workflows. Typical values of 1% to 2% are anecdotally quoted for the margins of profit

expected on UK construction projects. If those values are compared with that of construction cost savings of between 3% and 5%, which are quoted by the vendors of collaborative tools, then the current interest in them is explicable.

The aims of using on-line project management tools were summarised by Seddon *et al* (2001) as:

- Facilitating in the transfer of information,
- Making the latest documents/drawings available to everyone,
- Providing a complete record of the project,
- Removing the need to use the same or compatible systems,
- Cost savings.

A key element of an ASP should be in connecting everyone involved on a project, individuals and organisations, together into a virtual network to mirror the real-world networks that already exist.

Technology should provide the platform to provide more than just a project extranet but rather an application that can provide life-cycle integration. In essence, information should be created once electronically and reused wherever relevant throughout the entire life cycle of the asset. Figure 1 highlights the inconsistency of the current product set in the industry.

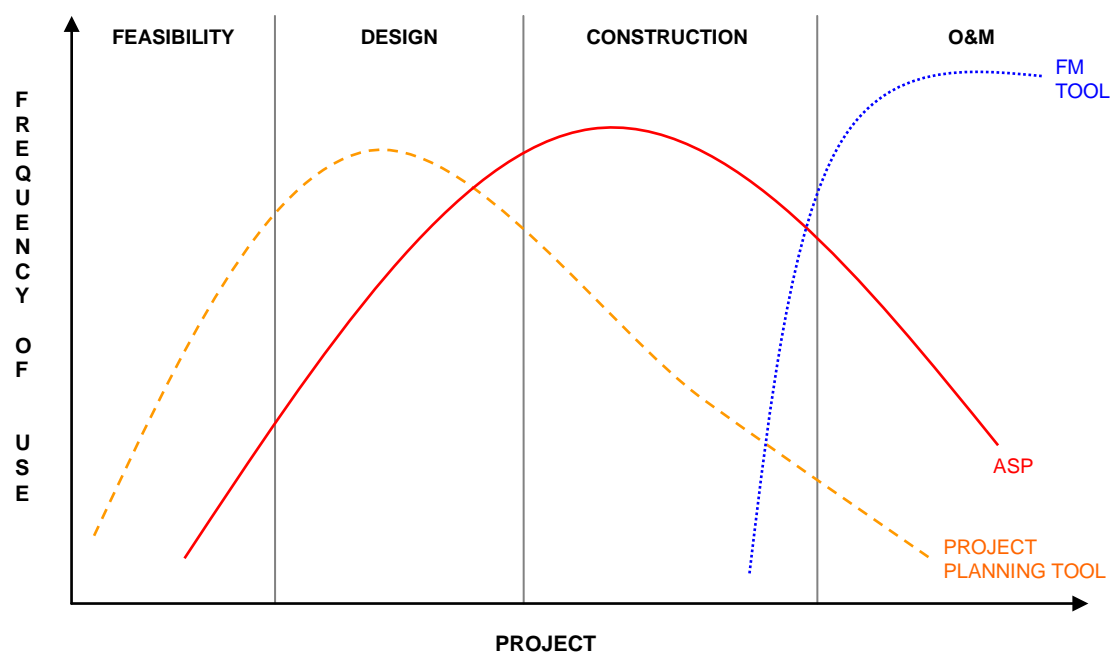


Figure 1 - Applications utilisation throughout project phases (Source: BIW Technologies)

3.0 Suppliers targeting the AEC market

As with most of Internet initiatives in the marketplace today the major exponents of ASPs emanate from the United States. However, with respect to prominent companies targeting the UK AEC industry it appears that at the moment this is predominantly the domain of those based the UK and Eire.

3.1 Start up application service providers

Many companies, encouraged by the hype surrounding the Internet, entered the on-line project management space with backing sought from venture capitalists. These companies have the benefit of low overheads and developing products suited for the Internet. Quite often the generic nature of their products lack alignment in addressing the key processes and requirements of a construction process.

3.2 Software developers

These are established companies who have served the construction industry with applications in the past. Organisations such as Oasys (part of the Arup group) and H R Wallingford have supplied design tools for the industry. Notable collaboration products have been developed by well-established US construction software companies such as Bentley [Viecon], Primavera and Autodesk [Buzzsaw]. UK construction companies such as Atkins, Ove Arup & Partners and Gibb are amongst those who have either developed their own software or adapted an existing product and have benefited from being able to utilise these in actual construction projects they were involved with.

3.3 Industry collaborations

Companies associated with the AEC industry have been coming together to work towards producing Internet-based applications that can primarily be utilised by the partnering companies, and if particularly successful, marketed as a product. A great deal of these 'collaborations' could be viewed mainly as a marketing and brand enhancing move to be seen to be innovative companies who are moving with the times.

However, it appears that many of the prominent industry collaborations, such as Mercadium, Arrideo and ASITE have fared as badly as the majority of the more infamous dot.com start-ups. It can be argued that this is, in part, due to trust issues associated with paying a fee to have data held/hosted by a competitor.

3.4 Information providers

Information providers such as Technical Indexes and Barbour Compendium have transferred their services from CD-ROM format to Internet based ones. This, in theory, will give them greater control on updates and also subscriptions as well as reducing material and postage costs.

Industry news providers have also developed services from existing publications. Emap, the publishers of the New Civil Engineer, Construction News and Architects Journal have created reciprocal Internet sites. More recently Emap have cemented a partnership with BIW Technologies and now actively promote their product – The Information Channel – through these websites.

Both the information providers and news providers have identified that demand for the information that they carry on their sites will lure companies to use their sites. In addition to their core services they are developing supplementary services such as the Information Channel, which, they hope, will represent an added value aspect to their offering.

Table 2 - Some of the Specialist ASP companies targeting the AEC industry

Company	Application Service Provider	URL
4Projects	4Projects.com	http://www.4projects.com/
Autodesk	Buzzsaw	www.buzzsaw.com
Bentley Systems Incorporated	Viecon	www.viecon.com/
Bidcom UK	Bidcom Collaboration Service	www.uk.bidcom.com
Bricsnet Incorporated	ProjectCenter	www.bricsnet.com
BIW Technologies	Information Channel	www.biwtech.com
BuildOnline	BuildOnline	www.build-online.com
Group BC	Business Collaborator	www.businesscollaborator.com
Cadweb	Cadweb	www.cadweb.co.uk
Citadon	ProjectNet Process	www.citadon.com
Causeway	Buildingwork.com - ProjectLink	www.buildingwork.com
Constuctware	Constructw@re	www.constructware.com
Enviros Software Solutions	Business Collaborator	www.businesscollaborator.com

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Hummingbird	DOCS Fusion	www.hummingbird.com
Open Text (technology featured in other ASP products)	LiveLink	www.opentext.com/livelink/
Ove Arup & Partners	Integration	www.integration.arup.com
Project Village Incorporated	Project Village	www.projectvillage.com
Ramesys	Ramesys	www.ramesys.co.uk
Sarcophagus Ltd	<i>the-project</i>	www.sarcophagus.co.uk
Web4 Incorporated	WebWorks	www.web4engineers.com

Table 3 - Overview of predominant ASPs targeting the UK AEC industry

	4Projects.com	Information Channel	ProjectsOnline	Business Collaborator	ProjectLink	Sarcophagus the-project
Owners	4Projects	BIW Technologies	BuildOnline	CODASciSys	Causeway	Privately-funded Limited Company
Established	1997	1995	1998	1997	1999	1998
Companies using product	900	2908	Unknown	Unknown	Unknown	Unknown
Individual Users	15,500 (80% active last 12 months)	25923	10000	15000	7000	7200
Market Share	14.9% (Compagnia data)	26.4%	11.5%	17.2%	8.0%	8.2%
Technology partners	N.A.	Emap (content provider), Asta, Allenda, Autodesk, Ramesys	n.A.	N.A.	Open Text Corporation, Arup	N.A.
Notable clients	Mott McDonald, Six Continents Plc., Marconi, Microsoft, BAA, Taylor Woodrow, Tesco, Birse	Sainsbury's, Ministry of Defense (UK),	Balfour Beatty, Kier, Balfour Beatty, Hines, Transco, Ballast		Kier, HBG (now BAM)	Asda Wal-mart
Future development areas	Improvements in terms of usability with new version (v5.3)	<i>i-components: "... 'intelligent components'. They can 'learn' about themselves as a project</i>			Asset Management	Working towards a common industry data exchange standard

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	4Projects.com	Information Channel	ProjectsOnline	Business Collaborator	ProjectLink	Sarcophagus the-project
		<i>proceeds"</i>				
Interopeability	4Projects will provide 3 rd parties with an API to allow integration using SOAP(Simple Object Access Protocol)/XML.	Interoperability with Ramesys Xchange Portal, Bovis Hummingbird DMS and SER drawing management system. All future development will be made on the Microsoft .Net platform	Provide a standard set of Application Program Interfaces (APIs) allowing for possible integration with other business applications. As well as being able to integrate with Microsoft Outlook and Exchange servers	Can connect to any application that is run on an ODBC (Open Database Connectivity) compliant database. This allows interoperability between applications that utilise SQL Server and Oracle.	The product Tradex may present opportunities for integrating other vendor applications into a single access and interface solution	Sarcophagus developed Doclink as a European research and development initiative for the EU funded Procure Contract.
Comments	Research undertaken by Compagnia (2003) suggests that the market will move towards the 4-Projects revenue model, namely that of an unlimited projects/usage/data storage space charging a monthly fee based on contract value	BIW Technologies (BIW) has a 26.4 per cent share of the UK market for construction collaboration systems, according to research undertaken by Compagnia (2003)	BuildOnline claim that their products are developing into a complete integrated solution. There appears to be brand recognition of BuildOnline throughout the	Atkins used the technology behind Business Collaborator for their offering (iProNet)	Causeway reputation is quite strong, particularly in the areas of cost control and estimating.	Small company which has been profitable for 2½ years

	4Projects.com	Information Channel	ProjectsOnline	Business Collaborator	ProjectLink	Sarcophagus the-project
			construction industry			

3.5 Differences between offerings

In some respect, the services offered by the vast majority of service providers are very similar with no one company offering the total solution. All provide central storage of documents in basic document repository formats as well as central communications sections. The scope of products offered can widen to include e-procurement, industry news feeds, reporting, drawing redlining, etc. Prices can vary quite considerably and the more flexible providers who can tailor their product to the users' requirements usually come at a premium.

Vendors have sought to sell value-adding products such as project planning software and online procurement marketplaces to differentiate themselves above the competition. BIW Technologies provide a comprehensive analytical design and planning tool with their PlanWeaver product, whilst BuildOnline have concentrated on setting up an online marketplace with their products TenderOnline and SupplyChainOnline.

4.0 Barriers to Adoption

In his paper, Paton (2002) concurs with the view that Internet-based solutions often resemble nothing more than glorified file-management systems, only managing text documents and small files that can be shared using conventional technologies such as e-mail. Paton (2002) suggests that collaboration needs better software; however, the importance of its implementation with the necessary capable network infrastructure is one of the key factors for success. Even technologies such as Broadband, which is being heavily marketed in the UK at present, cannot cope efficiently with large downloads but especially uploads which are typically set at a speed ratio of 4:1 respectively.

Research undertaken by Chamberlin (2002) for Gartner predicts that by the year-end 2004 e-business will drive the use of new network-exploitative services through the advances being

made in terms of scalability, extensive personalisation and superior network performance. The research touts this as heralding a new age of distributed architectures.

At present, however, the technological infrastructure is flawed to the point that the business benefits identified for ASPs cannot be fully realised, and often it is only sufficient to deliver basic services. This point is critically highlighted when considering the plight of the part of the virtual project team who are deployed out to site.

4.1 Lack of real-time analysis

Pena-Mora and Dwivedi (2002) highlighted in their research that Web-based project repositories offer no real time analysis tools to process the project information. The paper explained that the current tools, such as ASPs, offer no structural support for an efficient interaction among project personnel. The research also critically highlights the lack of support that site-based personnel receive in respect to accessing information and goes on to propose Collaborative Dynamic Project Management (CDPM) on multiple computing devices, with special reference given to handhelds and personal digital assistants (PDAs). However, examples cited in the research suggest the use of PDAs for viewing CAD drawings is fairly impractical and is a view concurred by Bowden and Thorpe (2002). The application of mobile devices such as PDAs may prove a more productive purpose in areas such as facilities management where simpler data collection and reporting can be exercised through the completion of forms, which lend themselves better to smaller, lower resolution displays.

4.2 Legal aspects

Carter et al (2002) and their eLEGAL study highlighted that communications often operate without contractual support. Typical construction contracts from Finland, Germany, Italy and the UK were studied by the research team gathering existing clauses and legal cases regarding the field of ICT. Whilst reference was made in these contracts to ICT the underlying message,

in the case of German contracts, that the only method for achieving legal admissibility was the use of a hand-written signature on a paper hardcopy. However, the study highlighted that whereas this may be the case it does not mean that legislation to support technology does not exist. It does, but the construction industry has not taken the necessary further steps to adopt it within its contractual practices. As the research piece concludes:

“The use of information and communication technologies is thus not necessarily contractually valid in current practice.”

Practical ramifications of this include affecting the validity of contractual notices issued by means of ICT, the validity of electronic communications, and the ownership of data and intellectual property rights.

4.3 Cultural

Professionals within the AEC industry have differing abilities and experience with using ICT. Engineers used to drafting drawings on CAD packages and utilising structural analysis programs will face a less steep learning curve than, say, a site-based contractor’s agent whose key communication tools may be their mobile phone and pen and paper.

4.4 Continuity of products

As collaboration, by definition, will be driven by individual projects there will be conflicts between clients, contractors, suppliers etc. and the collaborative product they choose. Client X may wish to run a project using product *alpha*, but Contractor Y may already be using product *beta* with another client. Re-training of staff using these different products would only be one of many problems. There may therefore be some compromise made where the simpler ASP propositions are implemented so that large learning gaps are not encountered by staff working from project to project.

4.5 Connectivity

Almost unanimously, users within the AEC industry cite slow connections as one of the foremost reasons why they do not utilise collaborative software to the levels it was intended. The transition from design office to site not only presents a different type of working environment it typically presents huge disparities in terms of network connectivity. As discussed, the roll-out of Broadband services in the UK can only facilitate the cause for low-cost high-speed connectivity for offices and sites but issues such as upload speeds need to be addressed.

5.0 Conclusions

Early applications have been simple and often with limited capabilities. The suggested future trend is towards more integrated solutions which will provide more functionality, searching capabilities and security of data.

In the UK the leading providers appear to be BIW Technologies, Business Collaborator, 4Projects, BuildOnline, Sarcophagus and Causeway.

One key element of emerging ASP products is the ability to integrate data types into a usable form in their application. AEC industry users should be confident that their choice of ASP vendor will not go bust with their entire project data hosted on their servers. If they should go bust, the information stored with them must be able to be retrieved and used in another application. Direct integration with other products, such as accounting packages, is the next step forward for collaboration software. Business Collaborator, for example, has the capability to integrate with Sage.

The problems of collaborative working from remote sites should be addressed. Shortfalls in the quality and capacity of connection to the Internet should be a high priority. Certain tasks

on site could be completed utilising mobile devices such as PDAs (O2 xda, Pocket PC, Blueberry Rim, Palm, Handspring, Psion etc.), wireless LANS (WLANs) (802.11x, Bluetooth, Piconode), GPRS (2.5 G) and UMTS (3G) mobile telephony. The appropriateness of these devices and their related technologies should be considered carefully before implementation on site. The AEC industry, as well as the software vendor's targeting it, should look to the technologies that are rapidly becoming ubiquitous in the field of mobile communications. The latest mobile phone handsets from Nokia and Sony-Ericsson incorporate most, if not all, of the technologies such as Java™ applications, Bluetooth®, GPRS and larger high definition colour displays. PDA manufacturers are adapting products to be 802.11b or Wi-Fi™ compliant.

“if it can go mobile – it will go mobile!”

Jorma Ollila (b. 1950)¹⁶

New data delivery methods should be investigated so that efficient storage and transfer can occur. This research would have particular relevance to remote site working where transfer speeds are often cited as the biggest frustration.

Use of ASP products on construction projects appears to be strongly driven by clients rather than any other party involved. Clients will typically accept the majority of the cost associated with the use of these products. However, to receive a fuller return on investment greater consideration should be made towards utilising data through the full project lifecycle, i.e. from inception, feasibility, design, construction and continuing into the operation and maintenance phase. Of the products on the market today none effectively sustain the continuity of information through into the O&M phase. It is at this time that the client will receive direct business benefits of having timely and accurate information to hand, i.e.

¹⁶ Chairman and CEO of Nokia Corporation, 27 August 2003

information coming direct from drawings and specifications created and updated through the design and construction phases. Leading ASP vendors such as BIW Technologies have recognised this and are investigating avenues of product development to exploit accordingly. Further research is needed in this area to incorporate the information and communicative needs within management of built facilities and ideally tie these in with the resources and information available from previous phases.

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APPENDIX B - PAPER 2

TOWARDS WIRELESS WEB-BASED FACILITIES MANAGEMENT

FULL REFERENCE

McAndrew, S.T., Anumba, C.J., and Hassan, T. (2003). Towards Wireless Web-based Facilities Management, *Proceedings of the Second International Conference on Construction in the 21st Century - Sustainability and Innovation in Management and Technology (CITCii)*, December 10-12, 2003 Hong Kong, China. Paper 85, pp.529-534, ISBN 9889737019

ABSTRACT

For many years, paper and clipboards were the “mobile” solution for getting critical information out of, and back into, Facilities Management (FM) software systems by the mobile operative. However, with the current frenzied uptake of all things wireless, and the increasing dependency on Internet and intranet-based information submission and retrieval systems, the time is nigh for facilities management to embrace both these technologies. The widespread utilisation of wireless web-based solutions should not be viewed as another attempt at adopting technology simple for the sake of it. Wireless web-based solutions could offer achievable benefits to facilities managers over manual, paper-based processes and the technology existing today has matured to such an extent that it is not uncommon for high-speed wireless networks sharing and distributing broadband connections through homes as well as businesses. This paper highlights and discusses the possibilities of wireless web-based solutions within FM and touches on some of the different wireless standards that exist.

Keywords

Facilities Management, Wireless, WLAN, 802.11, Web-based collaboration

1.0 Introduction

Employees who manage inventory, conduct inspections and undertake maintenance of critical assets are out wherever those assets may be located. These operatives are not performing work at their desks, but are out at the “point of performance” taking care of critical assets and materials.

Ideally, mobile workers need to interact with FM software at the point of performance, which is typically not in the vicinity of a computer workstation. Organisations rely on paper-based procedures to get information from FM software, record information on the form and then physically re-enter the information gathered into the system when back at their computer workstation.

However, with manual, paper-based processes several key challenges remained (MRO Software Inc., 2002):

- Higher than necessary amount of non-productive time due to time spent on paperwork and data re-entry.
- Lower asset reliability due to maintenance backlogs and lack of information at the point-of-performance.
- Less than optimal decisions made due to lack of complete, accurate, and timely information.
- Lack of definite accountability of critical equipment and material.
- Inability to track compliance with government, environmental, and safety regulations.

Research into the UK facilities management market (Burgess, 2002) stated:

"The key drivers in the market today remain the search for greater efficiencies and core business focus that lead to increased outsourcing, plus an increasing demand for flexibility. The latter is coming from both organizations and their employees, and is enabled by internet, wireless and broadband technology, such that the nature of FM is changing from a workplace to a people focused activity."

2.0 Web-based applications

The aims of using on-line project management tools were summarised as (Seddon et al, 2001):

- Facilitating the transfer of information.
- Making the latest documents/drawings available to everyone.
- Providing a complete record of the project.
- Removing the need to use the same or compatible systems.
- Cost savings.

The use of web-based collaborative tools in the construction industry is becoming commonplace and is seen as offering recognised business benefits such as the reduction in administrative time and resources and continuity of data from project inception through to the operations and maintenance phase (McAndrew *et al*, 2003).

The basic principles of Web-based collaboration can be applied to FM, and much of the valuable data created during design and construction, such as health & safety files and record drawings, should be readily available in electronic form for the Client on completion. It would therefore be sensible to suggest that more providers of web-based collaborative solutions for construction projects should aim for a similar variant of their offering be available for use by facilities managers and their operatives.

3.0 Wireless Technologies

Wireless technology is playing an increasing role in the lives of people throughout the world. In addition, ever-larger numbers of people are relying on the technology directly or indirectly. It has been said that (Keane, 2002):

“After 13 years of proprietary products and ineffective standards, the networking industry has finally decided to back one set of standards for wireless networking: the 802.11 series from the Institute of Electrical and Electronics Engineers (IEEE). These emerging standards define wireless Ethernet, or wireless LAN (WLAN).”

Research has indicated that 80 percent of online Europeans had interest in home networking activities (Fogg et al, 2003). The avoidance of the need for new cabling is one attraction of wireless LANs (WLANs) that rate highly with home consumers. It could be reasonably assumed that the same could be true for facilities managers who may be restricted or reluctant to implement extensive cable installations in older building or ones with limited leases.

Wireless communication of data is achieved by a number of different technologies such as GSM, GPRS, UMTS (3G), Bluetooth and Wi-Fi to name but a few. By far the most exciting prospect for the imminent future has to be the IEEE 802.11x series, within which Wi-Fi, or 802.11b, sits.

3.1 IEEE 802.11

The IEEE 802.11 series comprises of a number of different specifications, some complete and some still under development and without approvals. One of the key benefits 802.11 has over some of the other technologies is that, rather than being subject to operator tariffs of GSM/GPRS/UMTS networks, 802.11 can be rolled out like any other piece of IT hardware and used without incurring additional subscription and download charges. The limitations of distance of transmittal of data are mitigated against by the relative low cost of implementation

and high speed data-rate transfers that can be achieved as well as the unobtrusive method of installation, as mentioned previously.

At present three variants of 802.11, namely 54a, 11b, and most recently 54g, have products in the marketplace and have been ratified by the IEEE.

3.1.1 IEEE 802.11a

An IEEE specification for wireless networking that operates in the 5 GHz frequency range (5.725 GHz to 5.850 GHz) with a maximum 54 Mbits/s data transfer rate. 802.11a was previously known as 'Wi-Fi5' however WECA dropped this term in October 2002 due to consumer confusion. It is commonly referred to nowadays as 54a. The 5 GHz frequency band is not as crowded as the 2.4 GHz frequency, because the 802.11a specification offers more radio channels than the 802.11b. These additional channels can help avoid radio and microwave interference. In reality, maximum rates of less than 20Mbits/s could hope to be achieved. Whilst this improved transfer rate should prove to be more of a competition to wired networks, whose transfer rates are typically either 10Mbits/s or 100Mbits/s, the 802.11a standard is not backwardly compatible with 802.11b meaning existing users would have to upgrade their entire equipment. The 802.11a standard has also had a harder time gaining accreditation in Europe than its predecessor.

3.1.2 IEEE 802.11b or 'Wi-Fi'

International standard for wireless networking that operates in the 2.4 GHz frequency range (2.4 GHz to 2.4835 GHz) and provides a throughput of up to 11 Mbits/s. This is a very commonly used frequency. Microwave ovens, cordless phones, medical and scientific equipment, as well as Bluetooth devices, all work within the 2.4 GHz frequency band. The 802.11b standard uses DSSS (direct sequence spread spectrum). The fact that the 2.4 GHz frequency band is unregulated in the majority of countries has almost certainly aided it

success. Early efforts of different manufacturers were not always compatible with each other, but the creation of the Wireless Ethernet Compatibility Alliance (WECA) has provided the needed conformance and interoperability testing for products. Companies producing devices for the 802.11b standard aim to be granted the WECA *Wi-Fi CERTIFIED* label of approval.

3.1.3 IEEE 802.11g

Similar to 802.11b, but this standard provides a throughput of up to 54 Mbits/s. It also operates in the 2.4 GHz frequency band but uses a different radio technology in order to boost overall bandwidth. The 802.11g standard, or 54g, quotes possible transmission speeds of 54Mbits/s, which is up to five times the bandwidth of 802.11b, and has a greater range than 54Mbits/s rival 802.11a. More importantly, the licensing issues associated with 802.11a in the UK are not relevant to 802.11g as it operates in the same 2.4GHz spectrum as Bluetooth and 802.11b. The Radiocommunications Agency (RA) has been quoted as saying, with respect to 802.11g, ‘As long as it conforms with existing interface requirements, it doesn’t need a license.’ In July 2003 the standard was ratified by the IEEE.

Table 1 - Common varieties of IEEE 802.11

IEEE standard	Maximum Link Rate	Frequency Band	Notes
802.11	1 Mbits/s to 2 Mbits/s	2.4 GHz	First standard (1997). Featured both frequency-hopping and direct-sequence modulation techniques.
802.11a (Wi-Fi5)	Up to 54 Mbits/s	5 GHz	Second Standard (1999), but products not released until late 2000.
802.11b (Wi-Fi)	5.5 Mbits/s to 11 Mbits/s	2.4 GHz	Third standard, but second wave of products. The most common 802.11 equipment at the time of writing.
802.11g	Up to 54	2.4 GHz	5 GHz Recently standardised. Has the benefit of

	Mbits/s		backward compatibility with 802.11b.
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4.0 Benefits of wireless technology for FM

There are “hard” and “soft” benefits of mobility solutions (Redman, 2003). Improving accuracy and efficiencies are cited, and these hard benefits can be measurable and quantitative. Soft benefits such as responsiveness and employee satisfaction are high value but are not as measurable in terms of hard return. It is estimated that, through 2004, 75 percent of enterprises that implement mobile access to applications will fail to articulate mobility’s quantitative and qualitative benefits, and will be unable to prove a return on investment (ROI) (Redman, 2003).

Slow, labour intensive and error-prone are words that can describe data collection in the ‘traditional’ method of clipboards, datasheets and paper reference drawings (Shelton, 2003).

In the recent past, intermediate solutions using Windows CE run devices still required the user to come back from the point-of-service to their base and physically synchronise on a desktop machine. In this instance, the operative is using two machines in total but not utilising either to full potential. To compound the inefficiency the desk space left vacated when the user is out on site could be considered “dead” and, more often than not, it would be typical for their desktop to contain proprietary FM software in stand-alone form. The combination of a wireless Web-based solution in this instance should improve efficiency of this process and remove the inherent risks associated with stand-alone systems.

The utilisation of wireless connections will reduce contention issues where previously workers would not be working with the latest version of any file or piece of information until they physically synchronised, during which period another employee may have made a

change. However the stark benefit of using mobile devices that update instantly over a WLAN is the elimination of double-entry data submission which is all too commonplace in FM currently.

A summary of the benefits of utilising a mobile solution include:

- Improved employee productivity by the reduction of double-entry data submission.
- “Real time” data synchronisation.
- Better access to reference material at the point of performance and therefore aiding decision making.
- Provide access to corporate applications, e-mail and intranet.
- Aiding compliance with government, environmental, and health & safety regulations by improved quality control of data inputting.
- Accountability of and control over strategic assets and materials.
- Higher return on FM system and technical hardware investment.

5.0 Barriers to adoption

5.1 “Perceived” cost

From initial investigation, it appears that the majority of facility managers are reluctant to deploy wireless technologies for FM purposes. The major obstacle identified by the Centre for Facilities Management (CFM) at Salford University is that of cost. Companies too often look at IT investment in terms of how it will generate income and with the nature of FM it is seen as a cost centre rather than a revenue generator. The ROI is far harder to quantify accurately when analysing savings in terms of time saved by integrating IT solutions into FM processes.

To facilitate the core business many companies are considering, and a number have implemented, wireless connectivity solutions for their employees. The management of facilities can be viewed as more a cost centre as opposed to revenue generating, but it is essential to the working of a business nonetheless. Provision for wireless solutions solely for the management of facilities might be difficult to sanction in many companies, whether this is due to tight budgets for new technology provision, decision on IT spend taken outside FM departments or due to a lack of knowledge in the subject. Typically, it will be a combination of these factors. Therefore, in many instances it may be applicable for facility managers to identify areas of their work where wireless can play a part and then ‘piggy-back’ on the technology being used by core business. This piggy-back effect would significantly reduce the implementation cost that would be associated with a solely FM specific system, essentially “stealing” relatively small amounts of bandwidth for O&M and facilities tasks.

5.2 Security

The perceived lack of security of transmitting data over WLANs is almost always cited as the primary concern when considering implementation. It could be argued that to address the needs of facilities operatives the data being transferred would not hold the same allure as say that of company accounts or personal details of customers. Roaming hackers would less likely be interested in report data pertaining to the inability of a WC being able to flush than they would other sorts of data from other areas of the business. More developed variants of 802.11 such as 54a have improved security over that of 11b and 54g.

5.3 Loss of signal strength

IEEE 802.11b, speed decreases the further one moves from the access point. For example, when you are close to the access point, full 11 Mbits/s data rates should be achievable on the device. Move further away, and depending on environment, the data rate will drop to 5.5

Mbits/s. Move even further, and the data rate will drop to 2 Mbits/s, and finally to 1 Mbits/s. But getting just 1 Mbits/s throughput could be considered an acceptable performance level. 1 Mbits/s is faster than most ADSL and cable connections, typically 512 kbits/s, which means it is still a satisfactory high-speed transmission if you're sending and receiving e-mail, browsing the Internet or performing data entry tasks from a mobile device.

5.4 Interoperability

Concerns have been raised regarding the actual interoperability of different manufacturers' devices within the recently ratified 802.11g standard. In theory, the most common 11b products should work with the newer, and faster, 54g products making it backwards compatible. Something the 54a version lacks. However, it appears that hardware manufacturers of 802.11g devices have offered features outside of the standard and this has led to reports of incompatibility between 11b and 54g products.

6.0 Conclusions

Early adopters of wireless technology in facilities management should be aware of the licensing restrictions of some of the protocols; in particular, the higher speed 802.11a which up until February 2003 needed licenses to operate in the UK and was restricted to indoor use only. Since February, the UK Government has offered to relax the regulations regarding 54a to encourage operators to deliver new broadband services.

At present, the 802.11b standard is the most popular and best represented product-wise in the market, and is the standard used by Intel® in their recently released Centrino™ range. Home consumers have readily taken to the good value that the products represent whereas businesses are still sceptical of the WEP based security. With increased transmission speeds, and the possible compatibility with 11b, the 54g standard is rapidly gaining acceptance in the wireless marketplace and should topple 11b's position. Strategists suggest that 802.11g will

be largely an enterprise play over the next several years, due to battery and cost constraints. 802.11b will remain the standard of choice in the notebook PC segment until at least 2005 (Mawston et al, 2003).

Web-based applications supported by WLAN driven devices offers exciting opportunities for the management of facilities. Elimination of double-entry data submission can be achieved through a change in working processes and this will undoubtedly realise tangible reductions of non-productive time of mobile operatives. Quality of data, both which is drawn at the point of performance as reference material, and that which is fed back into FM systems will improve as a result of the removal of the extra layer of administration that the current method of paper and clipboard offers. Cost of implementation need not be a limiting factor in the implementation of WLANs. Many mobile devices currently being used by mobile operatives can, with relatively cheap modification and upgrades, be wireless-enabled to utilise the recognised benefits of WLAN technology. “Piggy-backing” on existing office WLANs can reduce these costs further.

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APPENDIX C PAPER 3

POTENTIAL USE OF REAL-TIME DATA CAPTURE AND JOB TRACKING TECHNOLOGY IN THE FIELD

FULL REFERENCE

McAndrew, S.T., Anumba, C.J., Hassan, T., and Duke, A.K. (2005). Potential use of real-time data capture and job tracking technology in the field, *Facilities Journal*, Emerald Group Publishing Limited, Vol. 23 No. 1/2, 2005, ISSN 0263-2772.

STRUCTURED ABSTRACT

Purpose

The purpose of the paper is to discuss the scope for improving the delivery of FM services through the use of wireless Web-based communications infrastructure, delivered via an application service provider (ASP) business model. This paper discusses the findings from case studies of three organisations and their approach to the management of facilities.

Methodology/Approach

The current state of play in terms of managing and tracking processes within the facilities management department of three different organisations. These case studies were chosen from distinct sectors, namely healthcare, higher-education and banking. Emphasis is placed on analysing how the organisations currently operate with their existing FM systems and the degree of influence technology has on existing processes. This was considered mainly in terms of computer-aided facilities management (CAFM) and computer-integrated facilities management (CIFM).

Findings

The study found that a new wireless Web-based service for FM systems would be considered useful. Although notoriously slow adopters of new technology, there was an acceptance by the facilities managers interviewed that a wireless Web-based approach would improve current practice, especially with respect to real-time job reporting and tracking and in the determination of FM operative working time utilisation.

Practical implications

Further work by the author is focussing on the development of a suitable demonstrator to illustrate the key concepts of a wireless Web-based FM service which will then be tested and evaluated. For further information visit the research project website at www.wirelessfm.org

Originality/value of paper

Hopefully stimulates discussion in the area of emerging wireless technologies that have the potential to streamline and improve current practices for the management of facilities, in particular that of real-time job reporting and tracking.

Keywords

Facilities management, Wireless LAN, Web-based services, Real-time reporting and tracking

1.0 Introduction

Facilities management (FM) employees who manage inventory, conduct inspections and undertake maintenance of critical assets operate ‘in the field’. That is to say they are not performing work at their desks, but are out on location taking care of critical assets and materials. Ideally, mobile workers need to interact with FM software in the field, which is typically not in the vicinity of a computer workstation. Organisations often rely on paper-based procedures to get information from FM software, record information on the form and then physically re-enter the information gathered into the system when back at their computer workstation. The weaknesses of manual, paper-based procedures in relation to the management of facilities were identified by MRO Software Inc. (2002) as:

- Higher - they require an unnecessary amount of non-productive time due to time spent on paperwork and data re-entry.
- Lower - they produce lower asset reliability due to maintenance backlogs and lack of information at the point-of-performance.
- Less - such procedures provide less than optimal decisions made due to lack of complete, accurate, and timely information.
- Lack - they provide a lack of definite accountability of critical equipment and material.
- Inability - they make it difficult to track compliance with government, environmental, and safety regulations.

Accessing information through freely available Web browsers is now ubiquitous both at home and in business. Gabriel (2003) suggests that to improve workflow and business processes, and to eliminate the amount of redundant data, more users, for example maintenance staff in

the context of FM, need to be involved directly with business information. The technology available today offers the opportunity to incorporate blue-collar workers, such as FM operatives, working in the field, to actively contribute to the organisation's knowledge base. Until now, such workers have had few opportunities to directly contribute to, or interrogate, an organisation's systems that hold vital information about its assets and facilities.

Improvements and innovation in hardware, software and network infrastructure is such that information such as computer-aided design (CAD) drawing and health and safety (H&S) information can be taken from the design and construct phases of projects and used directly in systems used for the management of facilities. However, previous research undertaken by McAndrew *et al* (2004) identified that collaborative tools currently being used in the architecture, engineering and construction (AEC) industry almost exclusively focus on the design and construction phases of construction projects. More often than not there is only limited, or sometimes no provision made for continuance into the operations and maintenance phase which is overseen by facilities managers. This delivers a fairly poor return on investment for the client, especially as they are typically the party that covers the cost of the implementation of collaborative tools up to handover. It therefore makes sense to suggest that clients should aim to exploit more fully the benefits of application service provider (ASP) systems.

By the nature of their work, FM operatives are mobile workers. This presents opportunities powered by wireless network technologies that would not be feasible by the implementation of hard-wired systems alone. If H&S and CAD files were available to FM operatives to interrogate in the field this would surely reduce time wasted in having to locate and find the relevant information from archives.

This paper discusses the scope for improving the delivery of FM services through the use of a wireless Web-based communications infrastructure, delivered via an ASP business model. The following section of the paper outlines the research methodology adopted and how this was implemented in the course of the study. The results are then presented for each of the case study organisations, broken down into the following key criteria: organisational overview, current FM practices employed, scope for IT usage, and identification of key problems. The discussion section compares and contrasts the organisations studied and their approach to FM. Finally, conclusions are drawn and recommendations made together with an insight as to how this research can be taken forward in the future.

2.0 Research methodology

The objective of the study was to investigate the current state of play in terms of managing and tracking processes within the facilities management department of organisations. It is acknowledged that automated data capture is extensively used for managing and tracking processes, but it is not immediately evident whether current methods are delivering the desired information, in a desired form, or in a timely enough manner for facilities managers. An appropriate approach for this type of research is to conduct case studies. To gain a sufficient amount of information for comparisons to be formulated, more than a single organisation needed to be considered. This study concerns the practices of three organisations chosen from distinct sectors, namely healthcare, academia and banking. The choice of these sectors was such that many different organisational facets could be covered, such as:

- Size of organisation – local to multi-national
- Type of organisation – commerce/healthcare/higher-education
- Location of facilities – single campus-based to multiple dispersed facilities

- Revenue generating (i.e. bank) or cost-centre (i.e. NHS hospital)

The case studies approach presents a snapshot picture of each organisation at the current time and provides a brief assessment of where each is at in their management of facilities. By considering three organisations from different sectors it is possible to identify similarities and differences between sectors. The intention was to identify best practice and highlight weaknesses in current working practices, in order to establish the scope for improvement. The choice of the specific organisations selected was influenced by the availability of, and access to, key personnel. In all three cases, this included the head's of department for the respective organisations. Prior to meeting key personnel, questionnaires were sent out to provide background on the research being undertaken and to gather numerical data and similar information which might be difficult or impractical to gather during the interviews themselves. In all cases the key personnel from each organisation had prepared answers for these questions and these proved useful documents to work from and explore further during the interviews. This method helped optimise the allotted interview time allowing the interviewer and interviewee explore the subject to a greater degree in a more organic way. Each interview lasted between one and two hours and all participants had no objection to a voice recording being made.

3.0 CASE STUDIES

3.1 Banking organisation

Organisation overview

The banking organisation has approximately 3,200 sites. Roughly 200 of these are head office sites, where most of the business elements are situated, including Data Centres and other components such as Treasury and Registrars. Of the rest, there are 800 smaller offices and approximately 2,200 branches.

The FM side of the banking organisation is not out-sourced, and is managed completely in-house. The organisation employs approximately 70-80,000 people, of which 230 are involved in the management of facilities. This number is supplemented by approximately 3,000 sub-contracting staff, whose roles cover tasks such as security, cleaning, and repairs and maintenance. It was emphasised that all the sub-contracted staff are managed by the organisation's own FM staff.

Current Practices

The sole method for logging issues is through a telephone helpdesk. Helpdesk operatives then enter this information directly onto a server-based helpdesk system. This system then has the facility to send job tickets or reports to the relevant parties depending on the nature of the incident. For example, when someone reports a leaking toilet this job ticket would be printed out and faxed to the mechanical and electrical (M&E) contractor. The M&E contractor would then go and attend to the job and, on completion of the work, fills out by hand information back onto the original fax and then faxes this back to the helpdesk for that information to be entered onto the system. Figure 1 illustrates a typical reporting and job allocation scenario for the banking organisation.

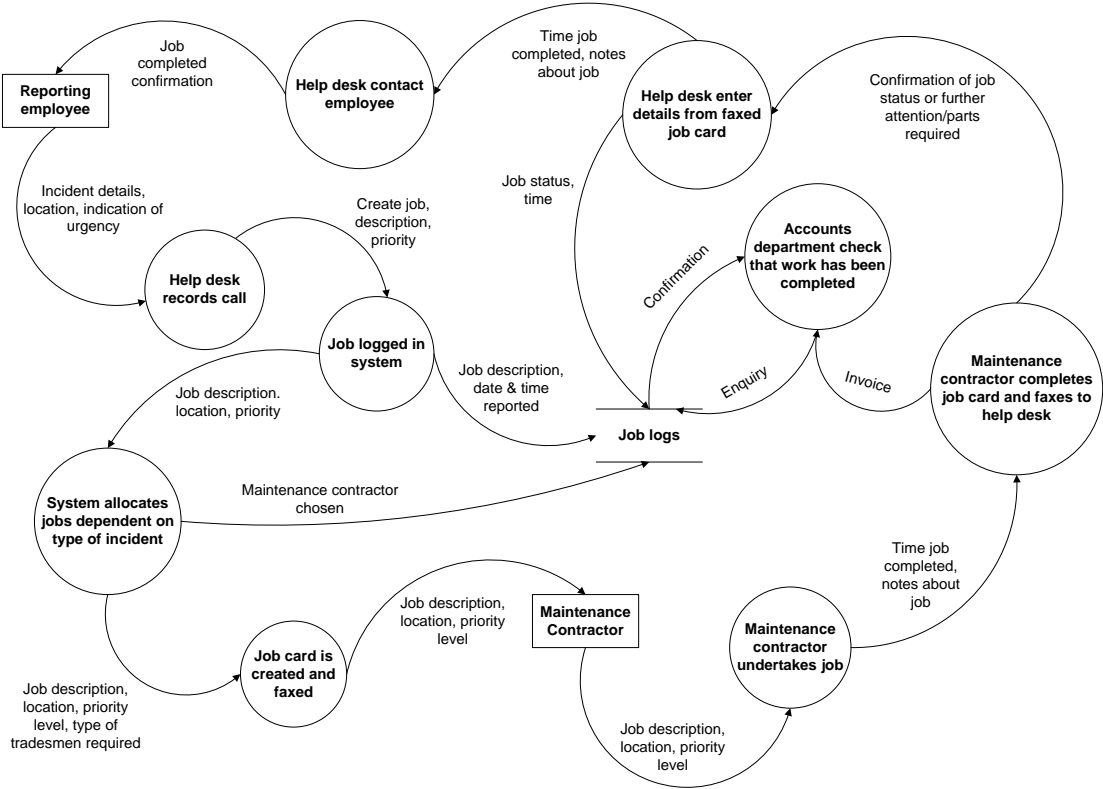


Figure 1 - Data flow diagram (based on the Yourdon and Coad method) representing typical reporting scenario for the banking organisation

Scope for IT usage

There is a FM system in place which relies on an intranet, as opposed to an Internet backbone. However, transfer of information ‘over the last mile’, i.e. from helpdesk operator to FM operative and back again, involves extensive use of paper and fax. The banking institution studied is sizeable compared to the other case studies and has many sites varying in size considerably. This site arrangement does not lend itself ideally to WLAN (wireless local area network) technology, but rather that of GPRS (General Packet Radio Service) over 3rd party subscriber lines. GPRS is better equipped in providing connectivity to many sites, i.e. bank branches, dispersed around a country. For the head office sites, of which there are 150 for this institution, WLANs could be considered for providing regional connectivity to mobile FM operatives.

Key problems

As well as being inefficient in terms of the amount of double-handling of data, the current job workflow process offers no accurate facility for tracking work in progress or for recording the duration of time it takes to complete a given task. This latter point was cited by the facilities manager as being a key area where accurate data has not been attained. This was primarily due to the current method of filling in job data post-shift. It was suggested that the time documented for jobs completed in a day were quite often calculated crudely by dividing the length of shift by the total number of jobs attended. By this method, it is not possible to predict, to any level of accuracy, the expected duration of specific jobs or tasks when they occur in future.

3.2 Healthcare organisation

Organisation overview

The healthcare organisation is a hospital NHS Trust and based on approximately 2 acres in total with an additional 3 small specialist units located off the main campus. The hospital, which provides care exclusively for children, has over 80,000 out-patients each year. In addition to the patients themselves, the hospital receives approximately 3-4 times the amount of visitors that a general hospital would expect purely because it is a hospital catering for children. On any day, the hospital can expect over 1,500 car visits.

The NHS Trust employs 2,500 staff, 14 of which are in facilities management. The FM is predominantly run in-house with the exception of linen and catering, which are let to external contractors.

Current Practices

The method of reporting, allocating and tracking jobs within the hospital was the most rudimentary of the three organisations studied. Figure 2 illustrates the information flow through a typical reporting and maintenance scenario.

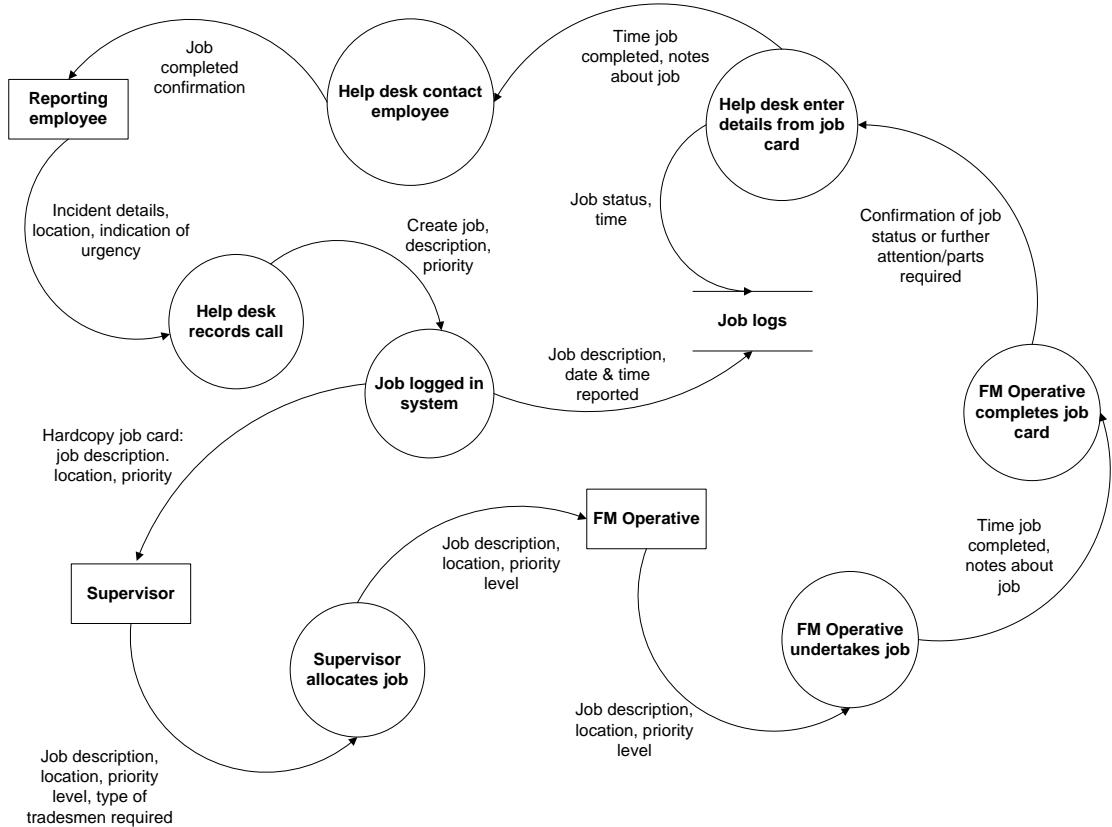


Figure 2 - Data flow diagram representing typical reporting scenario for the healthcare organisation

Scope for IT usage

There is considerable scope for the greater utilisation of IT within this organisation. FM workflows are heavily paper reliant and prevent accurate tracking information for jobs at nearly every stage of the repair/maintenance process.

Key problems

The data flow diagram illustrated in Figure highlights the lack of automation associated with their FM reporting and tracking system. Duplication of effort in terms of data handling is rife and the inefficiencies this brings are compounded by the lack of timely job completion reporting.

The standalone FM system is markedly outdated with no facility for accessing from other machines. This current arrangement leaves the organisation vulnerable to any hardware component failure that could occur.

3.3 Academic / Higher-education institution

Organisation overview

The university is based on 400 acres of land with 320,000 m² of that area constituting buildings. The university is essentially campus-based, non-dispersed with only a few residences located off-campus. These are not served, at present, by a dedicated computer network from the university.

The university employs approximately 3,000 people with 220 of these categorised as 'FM' staff.

Current practices

The university has four helpdesk staff who receive, and process, job requests from the following sources:

- telephone calls
- emails
- web-based forms
- word-of-mouth from mobile FM staff

- written

The procedure for a typical job request at the university is almost identical to that found at the hospital but for the greater range of reporting methods available and the electronic issue of an acknowledgement, in the form of an email, for the originator of a job request. On completion of a job the originator is contacted again by email to check whether they are satisfied with the work that has been done. External contractors are required to complete job cards in the same manner as the in-house staff. Figure 3 illustrates the information flow through a typical reporting and maintenance scenario for the university.

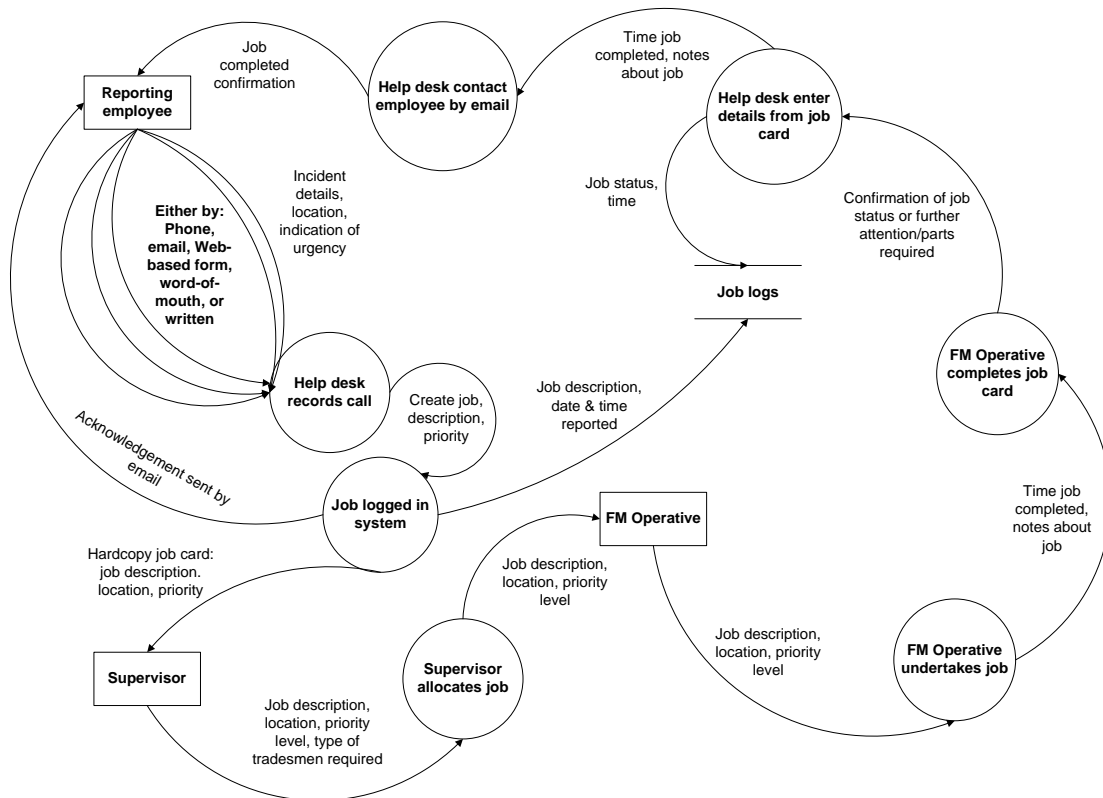


Figure 3 - Data flow diagram representing typical reporting scenario for the higher-education organisation

Scope for IT usage

The university is well along the way to embracing a Web-based approach for its FM system, but it has not augmented it with the benefits that wireless connectivity to mobile operatives could potentially offer.

Key problems

As with all the organisations studied, the system used at the university is let down by its inability to reliably check a job's progress once a fault is logged. The feeding of information back into the system is also subject to the inefficiencies previously highlighted, namely double-handling data entry and duplication of effort.

Comparative Analysis of findings

Organisation overview

In many ways the health and higher-education organisations chosen shared similarities in their geographical structure both being basically closed campuses. The campus structure is similar to that found when considering the majority of construction sites. In contrast, the banking organisation is geographically diverse with thousands of individual branches as well as numerous offices of considerable size.

At the university, the budget set aside for FM is approximately £6M and this represents 4.6% of the university's total budget. Only 0.3% of this £6M is set aside for IT provision within FM. Decisions on IT for FM are made in-house as a result, and it is fair to assume that, given the relatively meagre allocation for IT, there is very little scope for waste or inefficiency with the provision of software systems and hardware. Therefore, it was unsurprising to find that some of the systems used with FM date back to over 15 years old – a few lifetimes in terms of IT innovation and enhancements.

The hospital FM department receives £7M, which represents approximately 7% of its organisation's total budget with IT hardware allocated by the hospital's IT department. Unsurprisingly, the banking organisation's FM budget is by far the largest amounting to some £90M, although the proportion of this amount allocated to IT provision was not provided.

Current practice

Current practice for all three organisations reflected many of the same traits and anomalies. In contrast to the virtually technically absent system used at the hospital, the university has recently incorporated some Web-based aspects to their reporting system. It is encouraging that the university does currently use a Web-based system for the reporting of jobs and that those that submit requests, by whatever method of submission, receive an acknowledgement that their request has been "received and logged". Regrettably, double handling of data does occur as the helpdesk staff have to manually input all non Web-based requests into the system. Submission of requests, regardless of whether they are keyed in by FM dedicated staff or not, are all into the same Web-based system.

Scope for IT usage

Tracking jobs in real-time is one aspect which is not covered by any of the participating organisations. Concerns were aired by the banking institutions that reporting data on workers time utilisation was effectively unusable as it relied on the worker filling in a time sheet following their shift and relying on them to allocate the time they spent of each task accurately. This was obviously not happening and a move towards an instantly updatable job form, completed at the point of performance, and instantly synchronised with the FM system via WLAN would provide more trustworthy data.

There is an acceptance to move towards using Web services for FM systems but there was reluctance, consistent across all three organisations, to move away from their existing FM

system providers. In all cases, the existing software provider's tool was deemed out of date and incapable of accomplishing all the things they would like, however, there was a real fear of choosing something unfamiliar for their staff to learn as well as populate with legacy information.

Wireless technologies were not utilised to any extent for the purpose of FM in any of the organisations studied. However, the benefits of wireless connectivity were unanimously recognised as potentially offering real business benefits for streamlining processes.

In terms of reusing data collated from design and construction phases of new-build projects there was a very positive response from the facility managers interviewed. However, current practice shows that this data is not getting passed in the required quality or in the correct format to be usable directly in FM systems.

Key problems

Each of the three facility managers from the organisations expressed a real frustration in not having enough input at the design stage of new-build projects. In terms of passing key information and data from new-build projects it was found to be commonplace for often only hardcopy records of drawings and H&S files being provided from contractors. It is recognised that as well as being fairly unusable, hardcopies take up valuable floor space and require specialist archiving.

All three of the organisations studied, to differing extents, operate less than efficient procedures for reporting and tracking aspects related to the management of facilities. This is mainly down to unnecessary double-entry data inputting using both paper-based and electronic methods culminating in wasteful duplication of effort.

Leading on from this point, in none of the organisations studied is there a trustworthy real-time tracking facility that encapsulates jobs logged, jobs under way and jobs completed. There is a notable lack of reporting tools available. This is partly due to reliance on legacy FM systems and the hesitation, witnessed at all three organisations, to upgrade.

The most rudimentary system for reporting and tracking observed was at the NHS Trust hospital. Their staff numbers of 14 compares with 200 plus at the higher-education institution but both operate on effectively the same budget. Outdated MS-DOS systems running on standalone workstations were still in place at the hospital, which incidentally felt no immediate compulsion to upgrade.

When considering operating departments within organisations, FM is typically viewed as a cost centre as opposed to a revenue generating part of an organisation such as sales. In many cases the capital is not provided for upgrading hardware and software where it may be in other departments.

4.0 Discussion and recommendations

Commenting on the future of Web Services, Gilpin (2004) expects most vendors to deploy Web Services technology primarily as an extension of existing platforms, applications and tools, not as a foundation technology for completely new applications and environments. By taking this rationale and applying it to sectors such as building and property, which are generally accepted as late adopters of new technology, it has the opportunity to challenge his prediction and build FM systems around new Web Services technologies rather than try to redesign their current outdated and inadequate standalone systems.

4.1 Web-based ASP

The use of Web-based collaborative tools in the AEC industry is becoming commonplace and is seen as offering recognised business benefits such as the reduction in administrative time

and resources and continuity of data from project inception through to the operations and maintenance phase (McAndrew et al, 2004). These benefits however, have only been realised when the necessary network infrastructure has been put in place, from the beginning, and available at every phase and location. There is little to suggest that similar Web-based technologies could not work equally as well, if not better, in the FM arena. Considering organisations such as higher-education institutions and hospitals, which mainly operate in single campus like locations, the integration of wireless communicative devices and Web delivered services could be rolled out with both success and at an affordable cost. Existing infrastructure such as hard-wired Ethernet networks and the increased popularity of WLANs which currently serve core business processes (i.e. non FM ones) could be ‘piggy-backed’ for utilisation by FM personnel. The type of information passing to FM systems from mobile FM personnel would be relatively small in terms of bandwidth used. This would be especially true if such a wireless Web-based service utilised XML and Flash for mobile devices where careful consideration is taken in attempting to minimise bandwidth consumption. A view should be taken within FM departments not to limit in-house engineers access to the systems functions, or limit the amount of information they have access to view and amend. The intention should be to allow full client access to the FM system.

With regard to external contract personnel, provisions should be put in place to facilitate the access of systems through Web-based ASP with access privileges determined and administered by the facilities manager. By utilising the same Web-based system for both in-house and external personnel issues of double entry data inputting and disparities in quality and detail of information can be mitigated against.

Recording and tracking workflows through a single system will undoubtedly provide added scope for integration with financial systems being utilised by the client. This could bring

benefits by streamlining and automating payment methods as well as providing a more accurate record for the management of assets in terms of current value and condition. Additional benefits will include improved and maintenance and servicing data to work from for the preparation of planned maintenance schedules and asset regeneration/new-build programmes.

There should be a drive to update asset registers to a point where any FM operative within an organisation can provide meaningful asset condition and valuation for the purpose of creating planned maintenance schedules.

4.2 Wireless LANs (WLANs)

The utilisation of wireless technology in the delivery of the system should be seen as an enabling force rather than a 'nice-to-have' add-on. The current paradigm of assuming that technologies such as Wi-Fi® should be restricted to white-collar businessmen accessing their email accounts in airport departure lounges should be disregarded. Effective utilisation of wireless provides regular, blue-collar workers with the ability to contribute to a FM system at their point of performance. This idea should be grasped for numerous reasons. Firstly, wireless hardware is now relatively affordable, with 802.11g access points and card adaptor sets on the market for less than £100. Secondly, and more importantly, the utilisation of a technology such as wireless enabled devices allows the FM worker to carry out his or her tasks as normal but negates the need to sit at a desk back in the office to feedback into the system on their completed work. Often this feedback is not fed into systems by the workers themselves but by administrative staff in the office. From the research undertaken, it has been identified that this is an inefficient way of reporting in terms of double, and sometime triple, data entry/handling and the associated time lags and scope for administrative error that is inherent with it. A wireless Web-based solution has certain advantages over that of batch

downloading and synchronising at the end of the working day. Facilities managers and originators of incidents would benefit from being able to interrogate the status of jobs in real-time and act accordingly with this information.

Depending on the type of organisation and the premises, facility managers could consider deploying wireless 'Hotspots' within their buildings to provide an additional source of revenue. Hennessey (2004) suggests this approach which involves facility managers providing high-speed wireless Internet connectivity for mobile workers. Airport departure lounges, high street coffee shops and hotel lobbies have been early adopters of hotspots for generating additional revenue but this list could be taken further with the addition of other types of organisations. In particular, higher-education institutions and leisure facilities could investigate the possibility of offering hotspot services with a view to utilising space which may often be under utilised at certain periods of the day. This may be attractive to mobile workers who could utilise hotspot connectivity to their work whilst being close to leisure facilities such as swimming pools or gyms and thus improving their overall work-life balance.

One of the precursors to WLANs was WAP (wireless application protocol) which was heralded as a data transfer solution for mobile workers. WAP adopts a thin client approach but is let down badly with respect to the relative crudeness of the handset hardware produced, typically restricted to use in mobile phones, with a poor display and user interface. Kikta *et al* (2002) note that proponents of WAP are keen to point out that a mobile phone is an entirely different user interface compared to the typical Internet application. That said, WAP has never delivered the business empowering benefits that were once touted.

Table 1 highlights some of the perceived benefits and shortcomings of wireless technologies when considering the implementation of mobile services:

Table 1 - Perceived benefits and shortcomings of wireless enabled services

Benefits	Shortcomings
Undisruptive in terms of installation. i.e. little 'hard-wiring' required	Security of data issues (i.e. relatively poor encryption)
Offers a cheaper long-term alternative to 3 rd party service providers such as O2, Vodafone, Orange, etc... for services such as GPRS	Different variations of 802.11 standard leading to possible expensive (labour intensive) resolution of interoperability issues
Relatively low cost of wireless LAN hardware	Expense of latest handheld mobile devices / PDAs which could be easily lost or stolen
Choice of 802.11 variations to suit location and budget	Quality and continuity of signal strength in general and effect to interference with Bluetooth
Low on-going cost of maintaining network	Employees with 'sausage fingers' may encounter difficulty in operating mobile handheld devices

5.0 Other areas relating to FM to benefit from improved technology

Space management is another area which may be closely controlled with the implementation of CAFM and CIFM systems. By working with asset data in real-time it will be possible to accurately assess how efficiently floor and room space is being used. For organisations such as Universities where a degree of flexibility is required to adapt to different users and functions at different times of the year, i.e. in term time with students and out of term time with conferences. If it can be assumed that a University's FM workforce is salaried full-time employees then the peaks and troughs of demand and allocation to tasks has to be managed closely. An accurate Web-based facilities management service could provide the necessary information for this to be handled effectively and efficiently.

Radio frequency identification (RFID) is one of the most exciting technologies currently being exploited for differing uses across many sectors. The huge interest in the technology is highlighted by Walker *et al* (2003) commenting that 'RFID' was the fourth most searched term on the Forrester research site in 2003 and that a search on Google for the term returned 620,000 documents, of which 75% had been published within the previous 12 month period.

A Gartner Dataquest Guide (2004) describes the technology as an analogue-to-digital conversion technology that uses radio frequency (RF) waves to transfer data between a movable item and a reader to identify, track or locate an item. It does not require physical contact or a line of sight between the reader and the tagged item such as a traditionally bar-coded item does. RFID tags can also be read over a longer range – 100 feet or more.

Workers will know roughly where a defective item is located from an initial description. Proximity tags will aid accurate pinpointing of the item and will sound an alert as the worker walks past. The worker could be alerted to an outstanding defect when walking past and could feed back into his handheld more detailed notes about the problem.

Readers located at doors and exits, similar to those used in retail, will log any movement of assets from one space to another. This feature would be of particular benefit in hospitals where it is vital that the location of potentially life-saving equipment is – and that information is readily to hand in the case of an emergency.

6.0 Conclusions and Further Work

This paper has set out the case for incorporating wireless Web-based services for FM systems in use in the industry today. This has been based on the following observations and reasoning:

1. The building and property sectors are notoriously late adopters of new technology.

However, the research found that there was a general acceptance that a Web-based

service was the way forward for FM systems. The organisations studied exhibited a certain reluctance upgrade and change FM systems. There was a fear that by taking the plunge with a new system, the benefits could be offset by a number of factors. These include having to re-train staff to use a new system, attempting to successfully filter and transfer existing and legacy data to a new system, and of course the question of money – funding new IT out of already tight budgets.

2. Wireless technologies were not utilised to any extent for the purpose of FM in any of the organisations studied. However, the benefits of wireless connectivity were unanimously recognised as potentially offering real business benefits for streamlining processes. The blue-collar FM operatives within the organisations studied do not currently have the facility to contribute to reporting and tracking aspects of FM systems in real-time. By utilising wireless-enabled handheld devices, at the point of performance of the operative, timely and accurate information purporting to the work in progress can be relayed into a Web-based FM system for interrogation by others. This would then negate the need for the FM operative to spend time within their working day desk-bound and thus theoretically increase the amount of time they are available to tackle work directly related to their trade or profession. Facilities managers and those who initiate job requests would be able with a real-time wireless Web-based service to interrogate on the progress of jobs and act accordingly with this information. This could mean that facilities managers could act upon jobs they see as taking longer to complete than necessary, possibly critical tasks, and thus allocate extra resources for those particular jobs in future. For those who report problems, a real-time service would provide some way to check on the progress of work without having to contact help desk personnel and risk experiencing a help desk brush off due to lack of timely information available.

3. There needs to be an increased effort made by software developers targeting the building and property sectors to integrate the information created in the design and construction phases of projects so that it can be used throughout the operation and maintenance period of the facility. In particular, H&S information should be readily available to all FM operatives, and all drawings should be stored in an appropriate electronic format and accessible for interrogation and amendment as necessary. By implementing a Web-based service as a repository for these files valuable space can be freed within organisation's buildings through a reduction in the amount of hard-copy archives required. This was accepted as a major benefit by the interviewees.

A Web-based approach to FM is considered useful. Further work is focussing on the development of a suitable demonstrator to illustrate the key concepts. Figure 4 shows a technology overview for reporting and tracking requests within the proposed wireless Web-based service.

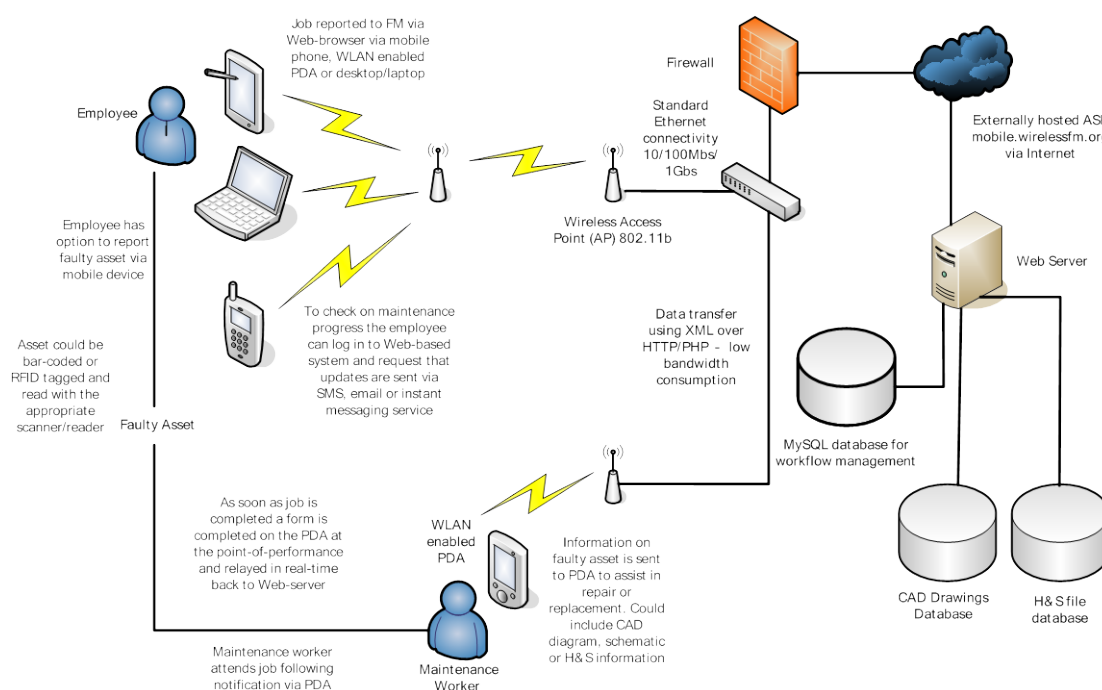


Figure 4 - Technology overview for proposed wireless Web-based service

Further to this, the possibilities of emerging technologies such as RFID asset tagging could be investigated to ascertain whether real value could be added to the management of facilities.

It is apparent from the case studies undertaken that there is scope for a Web-based system driven by wireless network technology within FM. However, any recommendation to this sector of industry must be proved to be fit for purpose and that the workers within FM feel empowered by using them to the extent that they want to use them. The technology is available at present for facility managers to implement schemes affordably. There will need to be, on their behalf, a step-change in their opinion about the adoption of new technologies and the courage to effectively skip a technology generation or two and embrace wireless and what it offers.

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