LOCATION-BASED MICRO-MILESTONES FAIR SUB-CONTRACTOR PAYMENT

Russell Kenley, PhD / Professor of Management, rkenley@swin.edu.au
Swinburne University of Technology (SUT), Melbourne, Australia
Unitec Institute of Technology (Unitec), Auckland, New Zealand
Toby Harfield, PhD / Research Fellow, tharfield@swin.edu.au
Swinburne University of Technology (SUT), Melbourne, Australia
Chun Ouyang, PhD / Senior Lecturer, c.ouyang@qut.edu.au
Queensland University of Technology (QUT), Brisbane, Australia

ABSTRACT

This paper introduces the new concept of location-based micro-milestones and argues for their use in achieving fair payment for subcontractors. It integrates location-based management (LBM) theory and Business Process Management (utilising YAWL: Yet Another Workflow Language) to illustrate how location-based BIMs can be utilised for the effective and fair payment systems. It outlines the rationale for linking LBM and YAWL methodologies to develop a BIM alternative solution to a traditional industry problem of late payment for sub-contractors.

Location-Based Management methodologies are now available in the powerful scheduling and control software (*Vico Office* by Vico Software). Originally developed in Finland, it has now become part of the BIM movement through integration into 5D environments (3D + time + cost), using location-based quantity data (from 3D BIM) and location-based scheduling (4D). While LBM is being rapidly adopted in industry, expansion of theory in workflow knowledge based on data from real projects remains limited.

YAWL has a well-established foundation based on concurrency theory and workflow patterns derived from research. It is informed by experiences with languages supported by contemporary BPM systems and it has a formal semantics.

Linking these two methodologies could provide a BIM solution to the problem of late payment to sub-contractors. The YAWL support environment could be extended to provide a workable interface for auto-generating construction payment processes from digital models based on LBM defined micro-milestones. The visualisation of the YAWL interface and related workflows could be used to both inform the analysis and to communicate the results.

This paper suggests a study to obtain proof of concept that LBM and YAWL can create an auto-generated certification and payment system for sub-contractors. Results could be configurable reference process models and workable prototype tools that trigger immediate payment of completed work according to the completion of location-based micro-milestones.

Keywords: Location-Based Management (LBM), Micro-milestones, BIM, YAWL, Fair payment.

1. INTRODUCTION

Fair payment is the next major issue to be solved in the financial management of construction projects and security of payment. Security of payment is of critical importance to all actors in the construction industry. The key principle underlying it is that any party carrying out construction work or supplying construction–related goods or services has the right to receive payment. All parties benefit from improvements in the payment system and ultimately it is in a client's interest that money goes to those for whom it is intended. Security of payment is generally considered as having been addressed through targeted legislation, and recent developments in practice are now turning to identifying mechanisms for not only providing security of payment, but ensuring ‘fair payment’ practices are followed. In the UK, a guide to fair payment practices (OGC, 2007) recognises the importance of reform in the payment sector. Accordingly, the payment system in construction needs new processes which are “practicable and efficient for all participants, reducing unnecessary transaction costs and without the need for additional regulatory and auditing activities” (OGC, 2007).

Unfair payments cost society dearly. The OGC (2007) conservatively estimates that public sector project costs are inflated by 2.5%. For perspective, a typical state hospital project of $2 billion could therefore include inflated costs of $50 million. New processes are required to retrieve this cost and ensure fair payment.

In commenting on the financial payment system, Kenley (2003) identified that manipulation of the payment system is a major factor in the construction industry, typified by unethical behaviour intended to fund one company’s operations at the expense of others (sub-contractors and suppliers). Such issues may have been of little urgency in good times, but the recent events of the global financial crisis (GFC) have once again raised concerns with poor payment practices. In a recent press article, Lawson (2010) indicates payment cycles have lengthened since the GFC. While such practices may be unethical, current management systems based on manual systems and monthly estimated progress claims do not provide mechanisms for systemically addressing the problem, which is furthermore not resolved with existing legislation. However, the major contractors clearly wish to address this problem, and such initiatives as committing to shorter payment periods and simplified invoicing, such as the use of RCTI (recipient created tax invoices) are becoming more common. There is good will on all sides, but as yet no method for a client or contractor to ensure fair payment.

In its guide, the OGC recommends that payments based on milestones will “simplify the interim measurement of progress” (OGC, 2007). This is a clear recognition that there is more certainty in a milestone payment than a simple ‘measurement of progress’ which always involves approximation. This certainty is reflected in moves to change the international standard for Earned Value Project Management to include milestones, where “progress and milestone events should represent measurable performance in terms of quality and technical performance as well as cost and schedule” (Solomon, 2010).

This paper proposes an innovative solution based on micro-milestones, managed by a business process model. The term ‘micro-milestone’ has been coined to reflect the concept of payment on completion of location which is a key concept in location-based management (LBM) of construction (Kenley & Seppänen, 2010). Location-based micro-milestones provide the granularity of data to ensure payments reflect work done.

The balance of this paper will outline the proposed research using LBM, BIM and YAWL. Section one provides a brief description of LBM theory including the concept of micro-milestones. Section two illustrates the multiple meanings of BPM and BIM. Section three introduces the application of YAWL techniques and possible outcomes of the modelling of micro-milestone data. The concluding section describes proposed research based on the traditional problem of timely payment for sub-contractors completed on-site work.

2. LOCATION-BASED MANAGEMENT

Location-based management (LBM) presumes that construction can be viewed from a production perspective. Production is defined as continuous flow ensuring optimal use of resources based on linear scheduling techniques. LBM (Kenley and Seppänen 2010) thus assumes that there is value in identifying work-flows based on *location* as the unit of analysis. The relevance of location when planning, scheduling and controlling construction has proven effective in a number of countries (Bjornfort and Jongeling 2007; Norberg and Olofsson 2008, Kala, Seppänen and Stein 2010).

LBM theory of construction production is explained using a sub-set of inter-related costs based on specific time in a specific location. Production is carried out in a defined location by a defined work-crew completing set tasks. Tasks are packages of work activities integrating time lags and quantities of materials necessary to carry out those activities. Thus, location-based planning has more analytical complexity than traditional activity-based planning using critical path management (CPM).

CPM uses a single layer of logic which operates only between any two activities. Production occurring inside an activity is described only by duration and there is no recognition of the repletion of work in multiple locations. However, LBM theory organises both activity sequence and sequence work through layered logic based on location thus ensuring differing rates of production are taken into account.

LBM expands the notion of activity to include new layers of logic that add more detail to both the *internal* task production of the location-based task and the *external* links between tasks. LBM is based on five layers of logic that are applied equally.

- Layer 1 logic: external logical relationships based on a generic logic network defining relationships between activities in any location that is automatically replicated.
- Layer 2 logic: external higher-level logical relationships between activities driven by different levels of accuracy ensuring correspondence with location hierarchy.
- Layer 3 logic: internal dependency logic between locations within activities is critical to achievement of flow-line logic linking task factors for uninterrupted work.
- Layer 4 logic: phased hybrid logic between tasks in related locations is the manipulation of lag driven sequence to optimise adaptability for workflow.
- Layer 5 logic: standard CPM links between any tasks and different locations as a quality assurance process focused on circular logic effects.

Planning is supported through data analysis ensuring optimisation scheduling. At the same time, LBM includes Monte Carlo risk analysis to highlight the risky parts of a project. Forecasts can be calculated based on the actual start dates and actual production rates. Thus, location-based logic is used to calculate the impact of control actions taken to recover deviations from the original plan.

2.1 Location-Based Management Micro-Milestones

In recent years, development of the location-based methodology has achieved powerful planning and control methodologies and supporting software has now emerged. While the location-based management system (LBMS) supports financial control in addition to production management, and in fact assumes that completion by location will drive productivity improvement, the issues of the financial payment system as an essential component of projects and companies in the sector has not been address. As we now address the issue of financial control, we can now introduce the concept of micro-milestones as a new LBMS concept.

A milestone is a trigger point which is satisfied by the completion of all contained work and which may therefore trigger a milestone payment. Many contracts contain milestones as trigger for payment and this concept is not new. However, the use of location-based management enables the tracking of milestones at the level of detail of completion of a task in a specific location – thus generating many (potentially thousands) of milestones. This would not be manageable within typical project administration systems, however modern location-based tools combined with supporting business process models now raises this as a very real potential.

Micro-milestones form at the completion of a location-based “task” in a location. The performance of the Task (method of control) as it moves through the Location (unit of analysis) affords LBM a rigorous methodology. The data centred on tasks is both general and specific providing work-team deployment linked to resources-flow and work-flow. In addition, all deviations from the original schedule including procurement requirements are calculated and collected. These detailed data inform consistent progress reporting because corrective actions are captured and factored into re-scheduling. Thus, a task within a defined location provides a container for construction data at a scale that is easy to collect, monitor and analyse (Kenley and Seppänen 2010). It is a simple step to include the financial data required for payment into a matrix of location by task.

3. BPM

For the last 20 years the construction industry has been attempting radical and incremental change in an effort to alleviate the inherent disconnected, fragmented, customised and temporary nature of creating a sustainable built environment (Ajam, Ashawi, and Mezher 2010). One method of achieving this goal has been the attempt to forge commonality using computing technology through identification of business processes.

At the same time BPM is a contested acronym that provides a story of the specific application of a proposed general methodology. A search of the literature provides four options in relation to the built environment:

1. Business Process Management
2. Business Process Modelling
3. Building Process Management
4. Building Process Modelling.

3.1 Business Process Management

In recent years the field of business process management (BPM) has risen to prominence in terms of its perceived importance by the information technology industry. Successful BPM implementations can lead to significant efficiency. Business process modelling and reference models gains, may help demonstrate compliance with standard practices and procedures, and can increase adaptiveness to changes in the environment in which a business operates (Fettke and Loos 2003). While there are several definitions of BPM (sometimes emphasising different aspects) the core concept is a definable business process.

Melao and Pidd (2000) provide a framework to locate the historical transitions for BPM. Business Process Management is concerned with managing processes within and between organisations as a continuation of Business Re-engineering (Neill and Sohal 1999). Obtaining effective and efficient organisations was predicated upon understanding how an organisation works through describing what people do (processes). Therefore the work processes done by individuals requires a method of documentation. This aim was the driver for the creation of a multiplicity of tools and methodologies based on an ‘industrial’ model providing the organising principle of ‘flow’.

At the same time ‘flow’ can be mapped on a number of levels. Four levels of processes are deemed, by most scholars, to provide a wholistic view of an organisation: functional, behavioural, organisational, and informational. The term Business Process Management is also used to describe a wide field of software applications. This systems perspective of ‘management’ includes a suite of functionality including enactment, management and analysis of business processes that have been operationalised within a system. The concept of an adaptable and process-aware system is indicative of the evolution from singular functionality to multi-level/multi-functionality systems (van der Aalst, ter Hofstede, and Weske 2003).

3.2 Business Process Modelling

Changing the status quo appears to be the purpose of being able to identify distinct work processes and flows through the introduction of IT management systems. Thus, development of process models requires fit to purpose between expected organisational outcomes and the ontology predicated in the model. Models are not neutral but provide interpretative capabilities concerning types and relationships according to Aguilar-Savén (2004) and outlined in Table 1.

Table 1: Fit to purpose between model perspective and expected organisational outcome

Modelling perspective	Expected outcome
• Mechanistic	• Better defined boundaries between functions.
• Systems	• Increased links between micro-processes.
• Communication/learning	• Increased communication between levels.
• Social construction	• Integration of organisational levels.

The organisational problems that must be solved and the types of reports generated are limited by the attributes and parameters of the methodologies and protocols built into the modelling capability. Inherently unique properties originate in functionality for managing organisational business processes. However, this fact has not lessened the desire to forge commonality using computing technology through identification of business processes. The four accepted modelling business process categories are: function (description of activities and flows), behaviour (how and when of activities), organisation (what, where and by whom of activities), and information (relationships of the whole).

The early shift within the construction BPM literature from ‘Business’ to ‘Building’ is an example of such a commonality.

3.3 Building Process Management

The early literature concerning Building Processes focused on the management of documentation through automation (Ajam, Ashawi, and Mezher 2010). The nature of construction with the distinctive divide between design, engineering and construction has always meant a significant amount of documentation. However, as issues of health and safety as well as sustainability have gained acceptance, security of accurate of documentation has needed a general and acceptable set of processes.

Furthermore, as computer technology and availability has increased, the day-to-day working of AEC practitioners now relies on electronic systems. Thus, much of the construction literature is concerned with integration of continually advancing information technology to provide better communication between the multiple stakeholders for unique construction projects. Thus collective management of documentation has lagged behind that of individual communication and management of the information generated by the expanding systems.

3.4 Building Process Modelling

Building Process Modelling of all linked phases in the construction process became an international goal with continued calls for increased sustainability. The effort focused on finding a tighter connection between the loosely coupled work-flows in the well defined processes through the lifecycle of a construction project. The effort to better understand how and why specific activities linked to the total project highlighted the difficulties of identification. The lack of clear boundaries for work-process, construction-process or management-process demonstrated construction is a more closely linked ‘flow’ than the widely perceived fragmented view (Ajam, Ashawi, and Mezher 2010).

However, the search for common building process identifiers or standards has been slowed by the parallel growth of computing capability. The good intentions of organising in a more cooperative and communicative manner to increase the productivity of the industry, has been hampered by incompatibility of both hardware and software used in building process modelling on individual projects. It is not at all surprising that ‘modelling’ is used by some authors as a synonym for management. Therefore the goal of the integrated construction processes based on inter-connectivity through the use of increasingly sophisticated computing from 2D remains a challenge (Tsai et al. 2009).

This challenge has become more focused as information modelling is gradually integrated in the built environment processes. The main discrepancies between the use of technologies by the different groups within the AEC industry is captured in the method of delivery of the final product of the design or engineering processes to the contractor.

There are two primary systems used in the development of infrastructure and building projects; the design system and the production system. How these are shaped and integrated for a given project depends on the method of procurement, however these systems remain essentially disconnected.

The design system has changed radically in the last 20 years. The advent and adoption of object oriented digital models for primary design and documentation has become the norm for major projects. Object-oriented models are fundamental for designing and documenting projects and rely on the availability of extensive data generated through information technology. The principle feature of these data-rich objects is the capability of embedding information about themselves and their context that can be used, but more importantly changed, throughout the project lifecycle (Ehrich and Haymaker 2009). Thus, digital modelling design systems have delivered demonstrable improvements to design productivity.

At the same time, this dynamic change in design processes has yet to make a significant impact on the real-world construction management process (Russell et al. 2009). While construction designs increasingly may be developed through 3D+ design systems, such as building information models (Eastman et al. 2008), the production system continues to rely on traditional methods and alternative data sources, mostly 2D. Currently, the two systems are out of sync in applying the rich data available for all phases of infrastructure and building construction.

4. BUSINESS INFORMATION MODELLING

As noted above Business Process Management is used to describe a wide field of software applications. This systems perspective of ‘management’ includes a suit of functionality including enactment, management and analysis of business processes that have been operationalised within a system. At the same time, many developers consider that BIM is more indicative of the concept of an adaptable and process-aware system. For them ‘information’ indicates the growth of operationalisation from simplicity to complexity. Thus the generic term Business Information Modelling (BIM) also has a multiplicity of meanings and purposes depending on the context, the products and the training of the developer.

While it is comparatively easy to conceive of an information system, it is more difficult to model accurately a system due to time/space limitations. However, the most difficult obstacle has been the inability to standardise either software languages or hardware connectivity. The state of the art is in flux because present a tools and methodologies that are in a constant state of innovation. At the same time, some communities of practice have formed and researchers have devised modelling topographies that assist innovation and efforts at standardisation (Goh and Chu 2002).

4.1 YAWL (Yet Another Workflow Language)

YAWL has three significant features that positions it uniquely in the crowded field of BPM (ter Hofstede et al. 2010).

First, YAWL has a well-established conceptual foundation derived from insights gained from the well-known workflow patterns research (see http://www.workflowpatterns.com). The term ‘workflow patterns’ refers to components within business processes that have generic applicability and are recurrent in form. A collection of workflow patterns was initially drawn from a close examination of 13 commercial workflow management systems and two research prototypes, and was later revised and significantly extended to cover many aspects of business processes. The patterns provided a foundation for system comparison, language development and also for workflow specification. Over time the patterns were used, as a *de facto* standard, in official tendering processes, and they influenced commercial and open source systems. YAWL was developed to show that comprehensive support for workflow patterns is achievable.

Secondly, YAWL has a formal foundation including both a precisely defined syntax and a precisely defined semantics. The abstract syntax of YAWL has been defined through the use of set theory and predicate logic, and the semantics has been defined based on a concurrency theory known as Petri nets. This formal foundation removes any ambiguity associated with the interpretation of complex constructs and their interplay and also allows for the development of sophisticated verification techniques that allow the detection of inherent flaws in an executable process model before it is deployed.

Thirdly, the YAWL support environment is considered one of the most advanced tools for modelling and executing processes. It offers comprehensive support for creation and enactment of process models with complex control flow, information handling and resource allocation, and services supporting various flexibility requirements but also allows these services to inter-operate. The YAWL system is *open source*. It is therefore not only freely available but can also be extended as desired, thus avoiding vendor lock-in. Its service-oriented architecture, with a rich set of interfaces, allows the system to interact with other systems and to be extended in a variety of ways.

To date YAWL has been successfully applied to modelling processes in film production (Ouyang et al. 2008) and healthcare (Mans et al. 2010). Thus, YAWL could provide positive results when applying BIM to construction processes.

5. PROPOSAL FOR LBM/YAWL FAIR PAYMENT SOLUTION

This section discusses a concept for a research stream that links the features of LBM and YAWL to advance theory and provide new solutions to traditional construction problems within BIM. Rationales are provided concerning the specific problem of certification and payment system for sub-contractor on-site completed work.

One way to expand LBM theory would be to explore a long-standing construction industry problem. For example, the concept of LBM micro-milestones could provide a solution to the perennial problem of delinquent payment for on-site sub-contractor completed work (Kenley 2003).

Sub-contractors are vital for construction. Subcontracting is both efficient and economical because sub-contractors are more skilled and cost less than the general contractor. However, timeliness of payment for completed work is a constant problem in most countries. One US study (Arditi and Chotibhongs 2005) found that owners, general contractors, and subcontractors all thought that 82 % of the time payment is delayed over 30 days. At the same time, neither the owners nor the general contractors believe payment delay is a problem. The US sub-contractors had a different opinion more inline with the UK government. From 2011, all government construction procurement documents must include the condition of sub-contractor payment be within 30 days (OGC 2010).

In Australia, payment systems rely on monthly assessments of work, often after it has been completed. However, lack of adequate site records makes the retrospective collection and validation of site-work problematic. In most cases incomplete information impedes compilation of a comprehensive payment schedule. Thus, depictions of work-flow and sequencing are often matters of dispute amongst subcontractors and site managers. However, this traditional situation has <u>not</u> been changed by Security of Payments legislation according to Ward et al. (2007).

Clearly the development of an entirely new approach to the management of the certification and payment system for sub-contractors in Australia could deliver fairer payments to individuals and provide greater security for the industry. The BIM solution proposed is work completion micro-milestones based on building process reference models for auto-generation of certification and payment.

As explained, LBM theory identifies a task within a defined location as a container for construction data at a scale that is easy to collect, monitor and analyse. It is therefore easy to envision that the completion of a series of tasks provides a well defined business process. Completed locations can assist BIMs in the setting of parameters for a discrete building process. In addition, because micro-milestones are based on workflows, identifying individual tasks (time and cost of resources) provides the data for certification purposes.

YAWL can provide a configurable process model that has the ability to incorporate variation which is part of a standard procedure. Thus the uniqueness of construction projects does not have to be considered problematic. Points of difference in a work-flow can be configured in relation to specific circumstances with commonality and variation considered as notion. These models could be AS-IS and TO-BE workflows based on LBM micro-milestones. YAWL provides visualisation of the interface and related workflows to both inform the analysis and to communicate the results.

The expected outcome of this proposed research project would be the development of configurable reference process models as the foundation for a workable prototype based on real rather than simulated data. Thus the solution to an endemic and unfair payment system for sub-contractors could be the auto-generation of certification and payment using LBM and YAWL methodologies.

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