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IMPROVING CONSTRUCTION CLAIM MANAGEMENT USING BUILDING INFORMATION MODEL (BIM)

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Abstract: Resolving construction delay claims is time-consuming and requires enormous effort that may lead to disputes between project parties. Analysis of project delay can be performed by various methods that range from simple and approximate to complex and accurate methods. Research indicates that the simpler methods are preferred since they require less information. Moreover, using different methodologies in analyzing schedule delays produce different analysis results due to the limitations of utilized approaches and the non-availability of unique method for delay analysis. The aim of this research is to develop a new technique and tool for schedule delay analysis that will utilize accurate information provided during the design and the estimation phases by extracting information from the BIM database. This will provide a systematic management tool to anticipate the impact of the delayed events on the construction schedule and minimize the resources and time required for delay analysis which will enable the project parties to settle their claims in the most acceptable and efficient manner. This paper presents a review of the current methods and their limitations. It then proposes a construct and methodology to address these issues. The research approach will be a design science, aiming at devising artifacts to solve real world problems.

1 Introduction

Construction industry is one of the largest industries and it contributed approximately $76 billion dollars in 2011 to the Canadian economy (Statistics_Canada 2011).In addition it has major impact on other industries such as manufacturing, transportation and resource management.

The construction industry is described as a complex and high-risk multi-disciplinary business, that may subject to a large number of disputes between construction parties(Semple, Hartman et al. 1994). One of major sources for dispute in the construction project is the late completion of project due to different reasons. In this industry, the construction contract determines the basis for the execution of project such as the time and the cost in addition to the relationships between different parties involved in the project; therefore, it is essential to complete the project within the allocated time and budget, but delays due to various reasons remain a problem which will result in an increase of the project cost without adding value to the project. Any claim dispute due to occurred delay may result in a complex conflict between different parties involved in the project, which may require a litigation, arbitration, or court for proper analysis and settlement. This will impose additional costs to all project parties, and produce a conflicting atmosphere in the construction industry. In spite of improvements in construction management techniques and utilization of the latest computer programs, the construction industry continuously suffers from delays; for this reason, construction delay analysis has become an essential requirement for any project in the construction industry (Alkass, Mazerolle et al. 1996) not only for preparing delay claims but also for proposing a proper and effective solution to overcome the occurred delays.

Preparing delay claims requires detailed review of all project documents prior to delay analysis in order to establish the causes of delays that will be used in the analysis to estimate the resulted effect on the project. This process is complicated and costly as it requires a significant amount of effort and time in addition to expenditures for legal counseling, experts, and support staff. Therefore, investigating and developing an artifact that facilitates efficient construction delay analysis using Building Information Model (BIM) capability as database for collecting all the necessary information will assist the analyst and reduce the time and cost associated with delay claim preparation and settlement. Moreover, it provides the information required to propose proper solutions to overcome the resulted delay (e.g. implementing new construction method, using alternative materials, increasing resources , etc); hence, reducing the total claims and conflicts in the project.

This paper presents a review of the literature to investigate various methods used in the construction delay analysis and highlights their limitations. It then proposes a methodological approach for integrating the delay analysis methods with Building Information Model (BIM) by designing an artifact to address these limitations, particularly the associated time and cost of delay analysis, and facilitates accurate delay analysis using state of the art technology in the construction industry.

2 Construction claims

In the construction industry, disagreements or disputes can arise regarding contractual obligations or expectations between different parties of a project. When one party feels that the contractual obligations or expectations have not been met according to the contract, and they deserve monetary and/or time compensation, they submit a claim (Semple, Hartman et al. 1994). Even with technological advances in construction management, the magnitude and number of disputes between the contractor and owners continues to be a serious problem particularly with regard to delay claims. When the settlement of dispute between different parties is not possible, claims are often presented to the court of law or a board of contract appeal(Bayraktar, Arif et al. 2011).

Mainly a claim in the construction industry is a request for compensations in term of time and/or money due to damages caused by others. The construction claim contains the causes and the effects of the claim along with its contractual and legal basis, supporting documents, and an estimation for incurred damages (Semple, Hartman et al. 1994).

2.1 Construction claim preparation and settlement

The construction industry presents legal in addition to engineering problems because litigation and claims in construction consumes significant amount of energy and resources from construction industry participants (Kraiem et al. (1987). In particular if it involves expenditures for legal counseling, experts and support staff. Many methods are available that can be selected by project parties for claim settlement based on the contract conditions, level of available information, cost and time frame in addition to acceptance of the project stakeholders to the resulted claim analysis. Common methods for construction claims analysis and settlement are Negotiation, Mediation, Conciliation, Arbitration and Litigation(Levin 1998).

Preparing delay claims is a complicated and costly process as it requires a significant amount of effort and time to gather high quality and detailed information to facilitate proper analysis of claims. Moreover, the insufficiency of documentations in the construction project may add to the complexity of claim preparation(Alkass, Mazerolle et al. 1995). Furthermore, the validity and correctness of construction schedule that will be used for delay analysis may add more complications to the analysis. Based on a study carried out in India by Iyer, Chaphalkar *et al.*(2008), it was found that the time taken for litigation ranged between 5 to 15 years after arbitration stage. Furthermore, Hohns (1979) found that the cost of litigation was approximately 15% of the amount of money that transfers from one party to another.

2.2 Causes of construction claims

Identifying the different causes of claims provides valuable information for the prevention of claims in the construction project. Semple et al. (1994) in their pilot study of 24 multidisciplinary projects of west Canada reported that, all 24 projects suffered from cost overrun ranging from 7% to 69% of the original budget, while 96% of projects had suffered from delays which resulted in an extension of project's time period ranging from 1% to 82 % of the original contract period. Moreover, most common causes of claims were related to (1) Increase in construction scope, (2) Weather conditions, (3) Restricted access, and (4) Acceleration. It can be noticed that, all the identified causes of claims have common impact on the project schedule which may result in an extension of the project's duration from its original schedule. However, delays may not extend the project schedule, because based on the principle of critical path scheduling; delays on network paths other than the critical path will not extend the schedule until all floats along those paths are consumed. Semple et al. (1994) stated that, all extensions to the project's original period that was agreed upon during the contract awarding will be considered as delays. According to Marzouk, El-Dokhmasey et al. (2008), delays are a common source of dispute in construction projects that cause severe losses to the parties involved in the construction contract. Moreover, Golnaraghi (2011) identified delays as the major cause of time and cost overruns in the construction industries. Hence, it can be concluded that construction claims primarily originate from the occurrence of delays due to many reasons and by different parties involved in the project. Normally delays affect all project stakeholders such as project owner, contractors, sub-contractors, suppliers and taxpayers.

3 Classifications of delays

Delays can be classified in to three major categories by taking into consideration the type of delay occurrence with respect to the project schedule, causes of delays, and the responsibility of encountered delays.

Stumpf (2000), categorized the delay based on their time of occurrence into (1) Independent Delays, (2) Serial Delays and (3) Concurrent Delays. Among the three types , the concurrent delay is one of the most problematic issues in delay analysis, particularly in determining the responsible party, because, the liability of concurrent delay may lie partially with both the employer and the contractor (Ndekugri, Braimah et al. 2008). For this, researchers have different views for analyzing the concurrent delays.

Moreover, delays may occur due to one or many reasons. Yang and Ou (2008) classified causes of delays into six categories of **Contract related causes** (change orders, quantity change, late drawings and specification delivery, late site liberation by client, etc.),**Management related causes** (delay in materials and equipments delivery, lack of resources, poor coordination, inadequate contractor skill, etc.), **Human related causes** (client interference, delay by client's representative, labor strike, war, infectious diseases, etc.), **Non-human related causes** (unforeseen site conditions, weather, natural disasters, etc.), **Design related causes** (complicated design, inconsistency between site conditions and design outcomes, etc.) and **Finance related causes** (budget deficit, contractor's financial problems, etc).

Furthermore, delayed events can be classified based on the responsibility of delays being either a contractor's risk event (CRE) or an employer's risk event (ERE). The employer's risk event (ERE) is an event, or cause, which is based on the contract, is at the risk and the responsibility of the employer. However, all other risks in the construction that are not at the responsibility of the employer will be a contractor's risk event (CRE) (Keane and Caletka 2008).

Delays can be either excusable or non-excusable. Excusable delays are delays in which the contractor has no control over the causing elements i.e. employer's risk events (ERE) and unforeseen events. This type of delay will enable the contractor to have time extension if the project's completion time is affected. Excusable delay may occur in critical path or non-critical path; however, Alkass et al. (1995) suggested that more investigation to be carried out in order to evaluate the possibility of covering the delay by either float consumption or by awarding time extension. Furthermore, the excusable delay will be a compensable delay if it is caused by employer risk events (ERE) such as late approval or non-compensable if it is caused by unanticipated event or "Act of God" that neither party has power over it.
Non-excusable delays is the second type of delays and it is described as, a delay event caused by contractor's risk event (CRE) which could be avoided by the contractor or it was a result of sub-contractor or contractor's negligence(Keane and Caletka 2008) .

4 Delay analysis process

To perform delay analysis, Yang, Yin et al. (2008) divided the process into five phases of (1) **Preparation phase** (to collect the required data.),(2) **Diagnosis phase** (to identify the impacted delay events for analysis.),(3) **Analysis phase** (to calculate the schedule impact according to the selected delay analysis technique.), (4) **Interpretation phase** (to clarify schedule impact.) and (5) **Summation phase** (to summarize analysis results and to generate a detailed report).

5 Schedule delay analysis methods

As per delay analysis process, schedule delay analysis will be performed after completing the data collection and diagnosis phases. There are various methods developed and used for the analysis and measurement of delays in the construction project. The selection of the most suitable analysis method depends on many factors such as the type and amount of available information, time of analysis, capabilities of the methodology, assigned time, funds and effort for the analysis process (Arditi and Pattanakitchamroon 2006).

Common delay analysis methods are based on critical path method (CPM) techniques and are performed by using the as-built, as-planned schedules (Kraiem and Diekmann 1987) in addition to the adjusted and entitlement schedules (Alkass, Mazerolle et al. 1996). Based on Keane and Caletka (2008) the different techniques used in the analysis of construction delays can be categorized into three general approaches of Additive, Subtractive and Analytical approach, from which different primary and secondary methods can be derived as noted in table 1:

Table 1: Categories of delay analysis adapted from Keane and Caletka (2008)

General Approach	Primary Method	Secondary Derivative Method
Additive	Impacted As-Planned	- Chronological Addition of Delays (One at a time). - Gross addition (all delays at once)
	Time Impact Analysis	-Chronological Event Analysis -Watershed Analysis -Windows Analysis -Contemporaneous Impact Analysis
Subtractive	Collapsed As-Built	-Chronological Insertion of Delays (one at a time) -Gross Insertion (all delays at once) -Windows Analysis (delays in each window)
Analytical	As-Planned vs As-Built	-Contemporaneous Float Mapping -As-Built Critical Path Deduction -Total Time Claim (gross difference) - As Planned vs Contemporaneous Updates -Gross time reconciliation (total time claim)

The common methods that have been used by experts in claim analysis to determine the impact of delaying events on the overall project completion date (Alkass et al. 1991,1993; Reams, 1990; Leary and Bramble, 1988) are, (1) Global impact technique, (2)Net impact technique, (3)Adjusted as built CPM technique, (4)'But for' or collapsing technique, (5)Snapshot technique,(6)Time impact technique, (7)Isolated delay type method (IDT).

According to Yang, Yin et al. (2008), the common accepted methods for delay analysis of construction project are time impact method, collapsed as built method, and windows method; however, no single method is accepted for all project participants and suitable for all situations. Furthermore, different methods of analyzing schedule, may lead to different results of delays for the owner and contractor as it was reported by various researchers such as (Stumpf 2000).

In addition to the above (Shi, Cheung et al. 2001) proposed a new method of computing activity delays and assessing their contribution to the project delay. This method is not based on critical path analysis and does not require the calculation or the updating of the critical path or as-planned schedule.

6 Problems associated with traditional methods

In delay analysis of construction claims it is important to select the best technique, as, it may be required to be presented in the court. Delay analysis techniques range from easy, simple date comparison to tedious, costly and time consuming detailed analysis, any of which may yield a wide variety of results(Alkass, Mazerolle et al. 1996). However, for insuring the accuracy of delay analysis method, the three main concerns that should be considered in the analysis are (1) proper classification of the delay types, (2) taking into consideration the concurrent delays, and (3) performing real time analysis (Alkass et al 1996).

There are many methods developed and used for the analysis of schedule delays; selection of suitable method depends mainly on the type and amount of available information. However, a major problem in the traditional methods of delay analysis which was reported by Stumpf (2000) is the inconsistency of analysis result. Using different methods in analyzing the schedule delays, will lead to different results of delays for the owner and the contractor. Moreover, It was noted by Keane and Caletka (2008) that, in construction delay analysis, the assumptions made by an analyst are fundamental to the reliability of the results(Keane and Caletka 2008).

In addition to the above, the insufficiency of information and documentation in the construction project may add to the complexity of the claim preparation(Alkass, Mazerolle et al. 1995). Furthermore, the accuracy of construction schedule that will be used for delay analysis may add more complications to the delay analysis. For this reason and in order to accept the schedule for delay analysis, the construction schedule should show that the construction logic and the relationships between activities are valid, activities' duration are realistic, and the required allocated resources are feasible; moreover, the schedule allows for foreseeable conditions such as work restrictions, weather, and time for inspections and approvals (Reams 1990).

Due to the above reasons, mainly weaknesses and the assumptions made for implementing each technique that lead to the variety of analysis results, researchers do not have a common opinion with respect to different analysis methods. The researchers' comments with respect to various techniques are summarized in Table 2.

Table 2 : Comments compiled from the literature, adapted from Arditi and Pattanakitchamroon(2006)

References	Delay analysis methods			
	Impacted as-planned method (IAP)	**Time impact analysis method (TIA)**	**Collapsed as-built method (CAB)**	**As-planned vs as-built method (ASAB)**
Sandlin, Sapple et al. (2004)	false results	Overcomes some disadvantages of others	Incorrect evaluation	N/A
Lovejoy(2004)	Good	Very good	Excellent	Fair
Sgarlata and Brasco(2004)	N/A	Useful for prospective analyses, but minimal utility supporting claims	Most acceptable by courts	Worthy method
Gothand (2003)	Major drawbacks	Reliable	Major drawbacks	Major drawbacks
SCL (2002)	Simple, limited	Most reliable when available	Suitable for some situations, subjective	Simple, limited

Hence, it can be concluded that, the main problem in delay analysis is related to the availability and accuracy of information (schedules and updates), time of analysis, capabilities of the analysis technique, and time and fund available for analysis. Therefore, using state of the art technology in solving the most important element in the delay analysis, i.e. providing detailed and accurate information, will minimize other problems such as time and cost of delay analysis.

7 Building information model (BIM):

In the information technology, Building information model (BIM), can be considered as the latest technological development related to the construction information and it is expected to provide new concept of designing, planning, executing, and managing the construction projects. Building information model (BIM), described by National Building Information Modeling Standard (NBIMS) as "an improved planning, design, construction, operation and maintenance process using a standardized machine-readable information model for each facility, new or old, which contains all appropriate information created or gathered about that facility in a format usable by all throughout its lifecycle"(NIBS 2008)."BIM advance the construction industry from current task automation of project and paper-centric processes toward an integrated and interoperable work flow where tasks are integrated into a collaborative and coordinative process that maximize the computing capabilities" (EASTMAN, TEICHOLZ et al. 2011).

BIM model for each facility contains all information related to the facilities, such as different type of activities, accurate quantities of work for each activity, required resources, cost and activity duration in addition to geometric information that can be used in 3D, 4D and 5D visualization of the facility. All these information are incorporated in the project's model during design and planning phase and can be used throughout the facility's life cycle. Therefore, BIM model can be considered as a source of complete and accurate data gathered during the project's life cycle. The recorded information in the project's database can be used to generate accurate and valid project schedule along with regular updates that can be used to facilitate proper analysis of project delay to minimize the time and cost of delay analysis. Moreover, it can facilitate the analysis of delay impact on the project schedule in a dynamic manner during project execution phase. The generated information of delay's cause and effect during design and construction phases can be utilized for the prevention of project delays and delay claims that result from them by either avoiding the cause of delay or investigating other available alternatives of design and construction to minimize the impact on project schedule. Moreover, recording the delay's cause and effect along with the selected solution can be used for future project in order to avoid delay claims. Furthermore, by utilizing the information stored in the project's database it will facilitate generating a visual 3D or 4D graphics to present a complex delay analysis. This will help to make complex technical issues understandable by different professionals without having necessary industrial knowledge.

8 Research methodology for designing the artifact

Design science research approach was selected because (1) the objective of method is to create an artifact intended to solve identified organizational problems (e.g. a method, models, constructs, instantiations) and (2) design science research has been found to be a critical success factor in combination with action research within the software process improvement (Øgland P 2009). Moreover, design science research was found to be attractive by practitioners involved in the research work, as, the creation of the artifact normally conducted in several iterations and improvements by joint efforts from both researchers and practitioners through contributing to all activities involved in the research work (Göbel and Cronholm 2012).

According to Holmström, Ketokivi et al. (2009), Design science research is conducted under many different research works such as, action science, action research, action innovation research, participatory action research, participatory case study, academia-industry partnerships for which, the common goal in all these endeavors is to develop an artifact to solve a problem.

Hevner et al.(2004) argued that, the research in information systems is characterized by two paradigms: behavioral science which “seeks to develop and verify theories that explain or predict human or organizational behavior ” and design science paradigm that “seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts ”.

For design science research seven guidelines, as recommended by Hevner et al. (2004) and noted in Table 3, should followed. Moreover, In order to provide a conceptual understanding of a phenomenon, the related conceptual model which consists of concepts and relationships between the concepts should be constructed.

Table 3 : Fundamental principle of design-science research (Hevner, March et al. 2004).

Guideline	Description
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

Therefore, In order to solve delay analysis problems using state of art technology, design-science research methodology in combination with a multi-case study will be used. The research methodology consists of following four stages, in which the three steps i.e. Action plan, Action taking, Evaluation stages to be executed in an iterative manner until satisfying the goal state (as defined in Initial stage).

a. Initial state, defining the problem and establishing the goal state

1. Quantitative and qualitative data collection will be used in establishing the current practice in delay analysis.
2. Efficiency of each method will be recorded to establish the Goal state and setting the performance metrics.

b. Action plan, investigating the alternatives

In action taking stage, different methods of claim analysis will be identified and the limitations of each method will be investigated.

c. Action taking stage

1. Delay analysis using different methods of claim analysis will be performed using data provided in BIM model.
2. The possibility of proposing new method (simulation) based on data provided by BIM model will be investigated.

d. Evaluating stage

Each investigation (delay analysis using BIM) will be done individually in order to evaluate the efficiency and the limitation of each method using performance metrics defined in goal stage.

During the research work, the proposed artifact will be tested with a hypothetical case to identify its advantages and limitations in comparison with the existing delay analysis methods. Moreover, the reliability of the integrated system will be validated through a real case study.

9 Conceptualization of the Artifact

The proposed artifact will integrate the Building Information Model (BIM) with the scheduling software that can access the project database and perform the analysis using project database. The delay analysis will utilize different methods taking into consideration related assumptions (Figure 1).

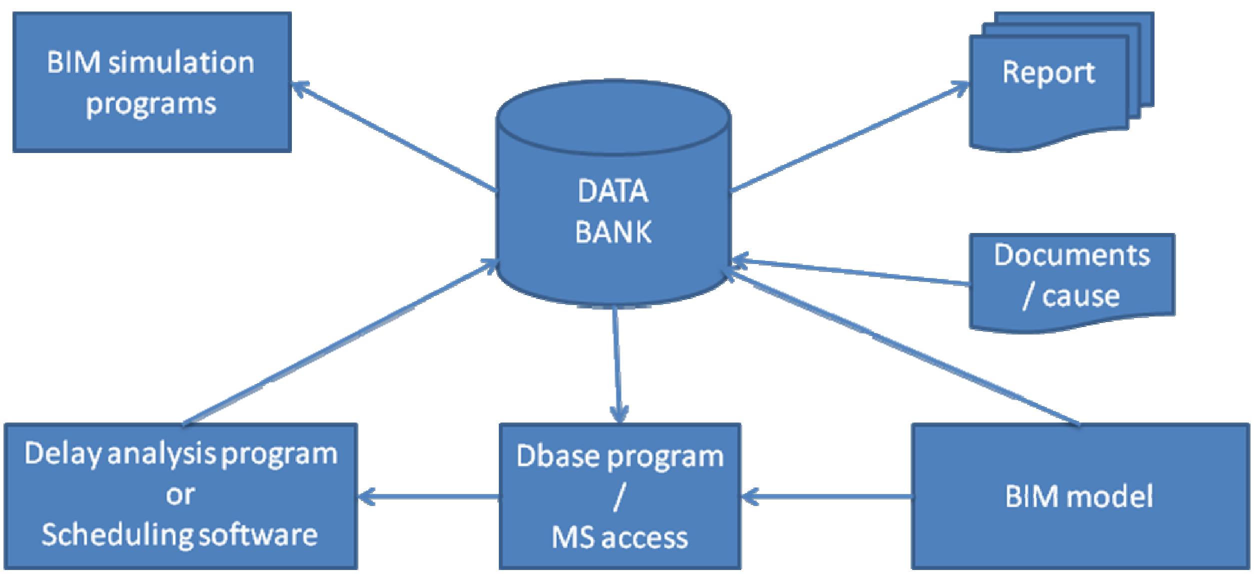

Figure 1: Conceptual frame work.

As shown in the Figure 1, at the initial stage, data bank will store the project BIM model along with detailed schedule of related activity as data base information. With each change in the BIM model due to design modification or project update, the new information will be synchronized with the data bank. The stored data will be utilized to generate a detailed report for model updates and updated project status along with delay report if any. Using this report, the project team can identify all impacted activity and resulted schedule delay due to design change or project status in a dynamic manner, this will enable the project team to properly identify and document the cause of delay, the responsible party (liability) of resulted delay, and to take any necessary action to avoid or minimize the incurred delay. Moreover, using BIM model in schedule analysis will enable to identify the problems associated with project schedule such as inappropriate logic and activity links. Furthermore, using dynamic schedule analysis that links the BIM model with the activities duration will help the project team to investigate different scenarios of construction methods for determining the best solution to overcome the lagging in the project schedule and complete the project on the required completion time and to have an accurate documented report associated with 3D model regarding project schedule delays (i.e. cause and effect), that will help to present the delay claims in the court and to make complex technical issues understandable by different professionals without having the necessary industrial knowledge.

10 Conclusion

The main issue with traditional claim and delay is the lack of accurate information to conduct the analysis. BIM is opening a new window of opportunity with the ability to extract the information directly from a centralized and shared database.

This paper presents a new approach that addresses most of the issues with traditional analyses methods that were described. It is expected that, by using the proposed artifact, the preparation and the analysis of delay claims will be done in more efficient and accurate manner in less time without imposing heavy cost on the project team. However, it will carry the limitations associated with CPM and related software. Moreover, it will require assigning a dedicated professional team along with all technological requirements such as BIM software for the project.

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