COORDINATION OF INTERLEAVED CORPORATE SCHEDULES AS MULTIPLE PROJECTS COST CONTROLS

Abstract
Emerging technological advancements produced a large number of software tools that help project managers in planning, project cost optimization, collaboration and information sharing. However, when works begin, unexpected situations develop that force project changes, resulting in delays and cost overruns. Cost overruns are quite common in construction projects and are not caused by a single catastrophic event, but rather by numerous small delays and disruptions which are not detected until their cumulative effect becomes financially significant. Those disruptions are often caused outside the project, by subcontractors or misaligned actions in different corporate departments or different project stakeholders.
This situation is multiplied in case of a contractor with concurrent projects. A detailed Project Communication Plan is mandatory, but it still addresses a single project.
In three decades of both inside and outside participation in large number of project, the author could not observe a measurable integration of project schedules and corporate business processes.
A schedule activity may initiate multiple requests for actions, materials or services which are often cause of schedule challenges. Each request may trigger a request to another department, creating a thread of events that may influence project activity duration and cost. Each request, at any level, has a direction (from Sender to Recipient) and a deadline or consequently, duration, which implies that it can be regarded as a self-contained activity. A thread of linked requests can be considered a separate corporate schedule, with its own resources. On site project activity is dependent on successful completion of chained requests. They are interleaved in a joint corporate effort across different projects.
This paper proposes a possible solution to the above problem based on the model of Multidimensional Preemptive Coordination.

Keywords: coordination, project controls, multiple project integration.

INTRODUCTION

In current harsh economic conditions, contractors are faced with more pressures to significantly cut the costs and optimize their business processes. Cost and schedule overruns proved to be a major issue for successful project completion. Detailed project analysis showed that a large portion of projects are late, and that there is a significant statistical correlation between cost overruns and delays in schedules. Flyvbjerg et al. (2004) analyzed 258 projects across 20 nations (America, Europe, Japan and 3rd countries). A large 86% of late project caused on average 28% of cost overruns. The findings showed that the delays were not caused by some catastrophic event, but rather by a number of small delays which went unnoticed until their cumulative effect became significant.

Bordat et al (2001) conducted a research for the Indiana Department of Transportation (INDOT) trying to understand the causes of cost overruns. It was found that 55% of all INDOT contracts experience time delays and the average delay per contract is 115 days. Time delays, cost overruns and change orders are caused by design errors, unexpected conditions, expansion in project scope, weather conditions and project changes. The dominant category for change orders was found to be “errors and omissions”. One of the root causes of Highway Construction Delays was found to be the lack of team accountability for timely project completion

In 1996 the Florida Department of Transportation (FDOT) ordered a review of performance in controlling cost overruns in transportation construction projects. The purpose of the review was to understand to what extent are construction cost overruns avoidable and what actions can be taken to minimize the cost overruns and improve accountability for these problems. The responsibility for cost overruns was found to be shared among consultants, third parties (that include utility companies, permitting agencies and local governments) and FDOT staff.

This is consistent with author's observation. The delays are often caused by factors external to the project, and the project manager is in a constant state of extinguishing fires that went undetected. In contractor companies the situation is worse, because there is a multi-project situation with insufficient resources, which force the management to prioritize without the time to evaluate consequences.

There is not much a company can do regarding external factors like government decisions, weather and industry conditions. Inside the company, though, a lot could be done in coordination and transparency between departments and different stakeholders, which would raise accountability across the enterprise.

This paper proposes a model which integrates project schedules and business processes inside the enterprise, avoiding delays buried in the corporate vastness that can influence the outcome of the project activity and schedule as a whole.

A review of literature is given first, the observation process is described next, findings and discussion and the model is proposed last.

LITERATURE REVIEW

Numerous authors researched scheduling in both single project and multi-project environment.

Hinze (2004) gives detailed information about construction planning and scheduling. Alzahrani and Emsley (2013) study the impact of contractors' attributes on project success from a post construction evaluation perspective to identify what are the critical success factors that impact the success of project. Weglarz (2012) discusses different models of project scheduling: classical models – exact algorithms, heuristic models that deal with interval capacity consistency tests, non-classical models like probabilistic and fuzzy models and lastly the extensions to the above models. Ke and Liu (2005) present a project scheduling problem with stochastic activity duration times trying to minimize the total cost under set completion time limits. Kolisch and Padman (2001) survey the literature in area of project scheduling decision support with a perspective that integrates models, data, and optimal and heuristic algorithms, for the major classes of project scheduling problems. Steyn (2002) explains why Theory of Constraints (TOC) was initially applied only to project scheduling. A second application of TOC is to manage resources shared by a number of concurrent projects.

Much of the reseach was done in schedule optimization with resource constrained situations. Hartmann and Briskorn (2010) give an overview of extensions to the resource-constrained project scheduling problem (RCPSP). Gonçalves et al (2008) present a genetic algorithm for RCPSP. Valls et al (2008) propose a Hybrid Genetic Algorithm for the RCPSP with a new way to combine the parents. Mendes et al (2009) present a genetic algorithm for RCPSP where the schedule is constructed using a heuristic priority rule in which the priorities of the activities are defined by the genetic algorithm. Van Peteghem and Vanhoucke (2010) present a genetic algorithm for the multi-mode RCPSP, in which multiple execution modes are available for each of the activities of the project. Debels and Vanhoucke (2007) present a new genetic algorithm for RCPSP problem that is able to provide nearoptimal heuristic solutions introducing a decomposition-based genetic algorithm that iteratively solves subparts of the project. Agarwal et al (2011) propose a hybrid of genetic algorithms and neural-network approaches. Tseng and Chen (2006) present a hybrid metaheuristic algorithm for the RCPSP in which they combine ant colony optimization genetic algorithm and local search strategy. Fang and Wang (2012) propose an effective heuristic based on the framework of the shuffled frog-leaping algorithm for solving the RCPSP problem. Drezet and Billaut (2008) research a project scheduling problem where resources are employees of different levels of skills and activity requirements are time-dependent. Furthermore, employees have different skills and legal constraints dictated by the French workforce legislation have to be respected. Ziarati et al (2011) analyse the performance of three bee algorithms for RCPSP. Bellenguez-Morineau and Néron (2007) use Branch-and-Bound method to solve a special case of project scheduling problem, where each activity requires special skill resources.

Many authors researched multi project environment, but focused mostly on resource allocation between different projects. Browning and Yassine (1010) address the static resource-constrained multi-project scheduling problem (RCMPSP) with two lateness objectives, project lateness and portfolio lateness. Herroelen and Leus (2005) conducted a survey to review the fundamental approaches for scheduling under uncertainty: reactive scheduling, stochastic project scheduling, fuzzy project scheduling, robust proactive scheduling and sensitivity analysis. Cohen et al (2004) examine the control mechanisms of Critical Chains and some alternatives. They demonstrate that such alternatives may give rise sometimes better, possibly much better performance. Kim et al (2005) propose a hybrid genetic algorithm with fuzzy logic controller to solve the RCMPSP problem with objective to minimize total project time and total tardiness. Hartmann (2001) discusses the resource-constrained project scheduling problem with multiple execution modes for each activity and makespan minimization as objective. Jarboui et al (2008) propose a combinatorial algorithm use it in order to solve a multi-mode resource-constrained project scheduling problem. Herroelen and Leus (2004) review possible procedures for the generation of proactive schedules protected against schedule disruptions in the case of unexpected events.

METHODOLOGY

The observations used for this paper are the result of author's inside and outside participation in project management mostly in construction industry over the period of 33 years. The insights were gathered in interviews, meetings and discussion with project managers, field engineers, estimators, investors, owner project managers, department heads and their subordinates, accountants, fleet managers, repair shop team leaders, site managers and ordinary field workers in an attempt to understand the workings of everyday life for successful implementation of an integrated information system. The work started with estimating department and gradually expanded as the shortcomings of communication at the previous business unit was revealed by business realities of the next. Notes, drawings and schemas were transformed into ever changing software segments.

Three distinct periods should be highlighted because of different environments and authors role in them. From 1981 to 1987 the author was CIO of a large facility and assembly corporation. Started ad 1940, in the eighties it had 3800 employees and an average of 40 construction sites yearly, both domestic and abroad, each lasting from few months to few years. A very meticulous record keeping in manual form was getting replaced by computer technology. A special team consisting of IT people and estimating professionals was formed to start the transition. Team members interviewed upper management and site management to get first draft, and expanded to other departments and corporate altitudes as the project progressed.

The second period encompasses from 1987 to 1990 when the author held the position of Project Manager for Complex Software Projects, in our largest electrical manufacturing and assembly company, leading a joint venture project with, at the time, one of the biggest European software companies. The project was software integration of the national gas station grid into the national gas oil company. For the purpose of this paper it is more important the meetings, conversations, notes and work done within different departments, teams and team leaders of the software giant.

From 1992 to 2013, the author was the CEO of a software development company specializing in software for construction companies. A total of 114, mostly construction companies, were processed, including two from the top ten construction companies in Croatia. Their employee number varied from few dozen to few thousand, the largest being 2500 employees. The companies had form under 10 project per year to up to 30, most lasted from a month up to 3 years. During the implementation phases, numerous interviews, schooling and software modifications were made based on user input.

RESULTS AND DISCUSSION

During the observed period the author did not observe significant transparency in corporate business procedures or collaboration between projects. The use of project controls are consistent with the findings of CMAA/FMI (2004) survey which states that project controls are executed in Execl tables more than 80%, scheduling software and office tools (about 70%) and plain phone call and faxes a little less than 70%.

Team meeting and corporate meetings govern corporate coordination efforts (weekly, monthly). Their efforts to increase the performance in project delays resolution were not impressive. Romano and Nunamaker (2001) found that corporate meetings in America take on average, 9.6 hours per week. Between 8% and 15% of personnel budget of the company is spent on meetings. There are 15 participants in a meeting (depending on a company size). The total cost of meetings is in range of US$50 million to US$ 70 million annually. Disappointing fact is that 73% participants questioned meeting effectiveness due to poor planning, 11%-25% of time was spent on irrelevant issues, 33.4% consider meeting time is unproductive and majority of surveyed executives concluded that 20%-30% of the meetings were unneeded.

Teams, as well as business units, are closed to outsiders and rarely volunteer the information. The author witnessed a situation where such an attitude failed to secure gains for the company. A small contractor had two construction sites, two private housing projects, just a few miles apart. At one site gravel and small boulders were excavated and transported to a public depo. At the other site, gravel was needed for levelling and was purchased and transported from a corporate supplier. The schedules, by chance, overlapped, although initially diverged in time, but could result in significant savings had there been enough project transparency and awareness at the proper corporate altitude. The project manager that was aware of this situation, didn’t volunteer the information to upper management, he said he minded his own business. No apparent damage was done, as each of the projects proceeded according to their planned schedules, but the company failed to gain an unexpected opportunity,

In another example, in the largest local construction company, a tower crane was held on the construction site with various excuses for few extra months. Essentially, the project manager wanted to be sure that the crane would be available when he needed it in a later activity. Meanwhile, a needed crane at another site was subcontracted for the value of USD 65,000 per day.

Those observations are not particular to small and medium companies. In 1988 the author participated in numerous meetings in a large European software company (revenue of about EUR

200 million) in an attempt to coordinate gas station integration in the national gas oil company. The integration involved multiple divisions and multiple teams developing multiple products that had to converge in the final solution. The meetings were meticulously prepared, steps reviewed and decisions made. First milestones were met with ease. But, as a team leader of a junior partner, the author was allowed to contact different departments and team leaders directly, to familiarize himself with the workings of a big company. It soon became obvious that different departments and different teams had different priorities, which complied more with the organizational structure than with the project at hand. At the meetings everybody expressed wishful thinking. Fortunately, the author was able to reveal that the deadlines had no chance to be met, their internal detailed dispute confirmed it, and steps were taken to remedy the situation. Had it not been for sheer curiosity, the problem would remain undetected until it was too late. Extra resources would have been thrown into the project, the schedule would be met or not, but cost overruns would certainly appear.

Those events highlighted the significance of measurable corporate coordination and resulted in the model proposal in this paper.

First a description of the proposed model is given, then the base for the model is briefly explained, necessary model additions are discussed next and finally, the workings corporate interleaved schedules are explained.

MODEL PROPOSAL

The proposed model integrates everyday corporate activities into the schedule of every project, creating an infrastructure that coordinates the activity of multiple interdisciplinary teams in a multiple project environment. Each project activity may trigger multiple requests for some kind of action (requests for materials, for floating teams, for modifications, additional subcontractors, etc.) either as the result of regular activity or some unexpected event. Any of those mean that a sequence of actions has to be performed to remedy the situation.

Different teams and team members confront each of those requests. If a request is consequence of a regular activity, like supply chain, the request is confronted by a relatively constant team, although different team members might address a particular request. If an unexpected event occurs, a different team might be assembled, depending of the type of the event. It may have the same core, but different professionals might be recruited from other departments and corporate altitudes if required.

Each request triggers a sequence of steps (meetings, tasks, emails, quotes, contacts with suppliers, investors, outside parties) that have to be completed, traversing different corporate departments, different teams and different team members. Each step takes time (duration), has different participants and implies a direction of events. There are preceding steps that need be completed and steps following it, implying a thread of actions. Such a sequence can be considered constituent part of a distinct corporate schedule (business process) independent of the project schedule. Timely completion of such a schedule still influences the successful completion of the project activity and, hence, the whole project schedule.

Multiple requests from different projects intersect at different points of the Organizational Breakdown Structure (OBS), at different altitudes, different departments, different teams and team members. Ultimately, each team member is participant of multiple threads of activities that may influence multiple projects. From his/hers point of view, the participant is confronted with multiple activities that have to be attacked in particular order, each one, as we stated, with a duration and implied direction, some of them sequential, some parallel.

A particular project activity and consecutively project schedule can be delayed if those threads of action, schedules outside the project scope, get delayed. A project activity that is not on the critical path can change the critical path if it is sufficiently delayed, which happens often. Numerous small delays represent one of the biggest challenges for successful project completion.

How could we control better the corporate events which are not inside the project scope? There is no point in calculating critical paths for the schedules that are external to the project. But it would be highly useful if we could calculate the probability that those threads of activities would finish on time so that the flow of the project activity is not interrupted. If that probability is low, the project manager could be alerted that a particular activity is in jeopardy and that further action is needed, preventing possible delays. To be able to do that, we need to log the thread of external steps that might affect the outcome of the project activity. If we can log them, we can measure the time each step takes, its duration, and apply PERT techniques to calculate the probability that they will be completed on time for successful project activity completion.

All those steps, external to the project activity, are standard everyday corporate documents, so no extra work is needed. The Request for Material form is filled. If the material is not available, either quotes are requested or orders issued, delivery dates established, transport arranged, payment approved and executed and documents prepared. An unexpected event in this chain of events may introduce delays which are hidden from the project or site manager. Those activities are buried in the corporate structure and are not visible to the original requestor. They are not correlated in such a way that their cumulative effect can be measured, estimated and project stakeholders alerted.

The delays are not introduced only in regular business processes. Unexpected events occur on site that need project change, smaller or bigger, but involving a number of meetings, permits and modifications. Subcontractors might become unavailable or any number of reason. Every site manager is aware of such unexpected developments and all of them require a group of focused professionals from different corporate altitude to solve them.

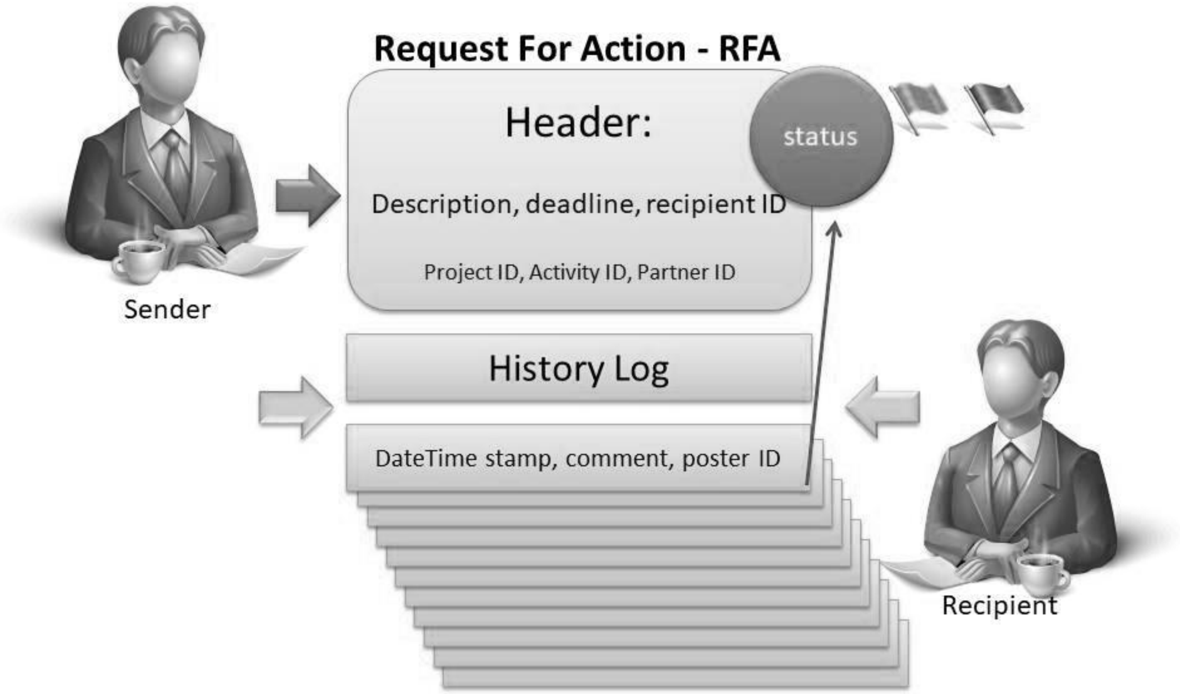
This paper describes a model of such an infrastructure based on the model of Multidimensional Preemptive Coordination (MPCoord). In the next section, the MPCoord model is briefly described. Additions to the model, necessary for its integration in project schedules are described next. The plausibility of concurrent interleaved corporate schedules is discussed last.

Multidimensional Preemptive Coordination (MPCoord)

Unexpected events are unavoidable certainty of everyday corporate life. They are faced by a designated professional or ad hoc assembled task force, a team of professionals at different corporate altitudes. They may request involvement of additional resources, across different departments to tackle the problem. Regular business processes follow the same pattern, they usually cross department boundaries where teams are constant inside a single department. If there are multiple team members in a team, a particular professional might not participate in every instance of a business process.

Multidimensional Preemptive Coordination is an infrastructure framework that coordinates such multidisciplinary interdepartmental task force, logs all actions taken and alerts all the participants of new comments, status changes and approaching or missed deadlines. It is conceived as a closed corporate social network visible only to the participants focused on resolving a particular problem. The alerts are propagated both horizontally, among the participants, diagonally across the depth of the request thread and vertically towards the upper management of each participant. It was first described by Bacun (2013) and later expanded (Bacun, 2014) to allow safe inclusion of stakeholders external to the enterprise.

Figure 1 Simple Request for Action

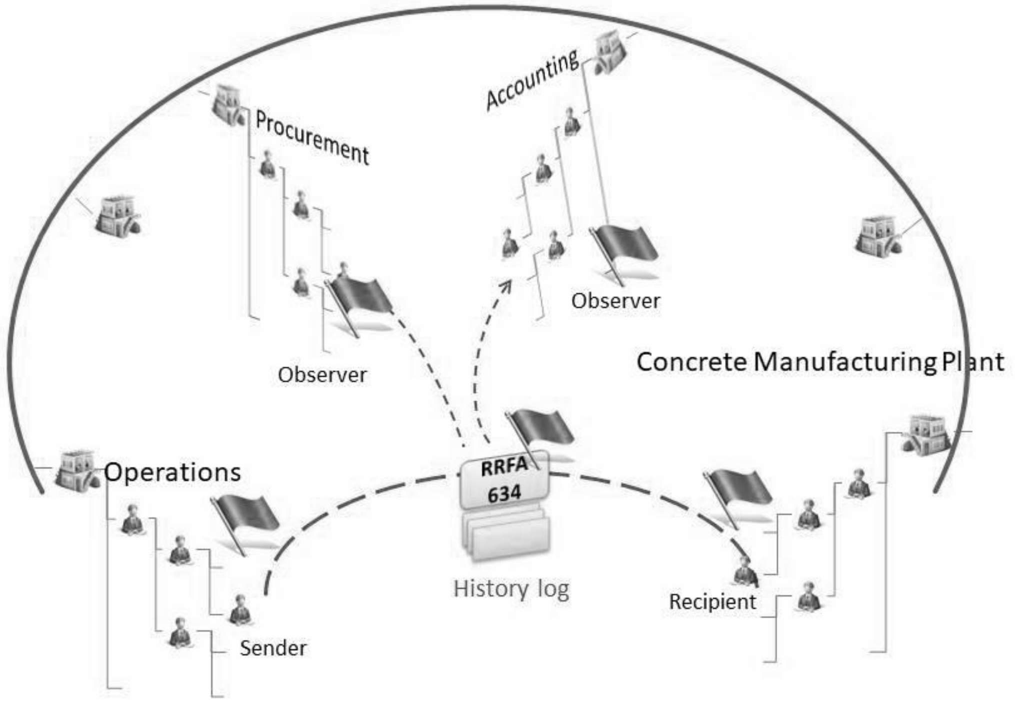


The simplest MPCoord element (Figure 1.) is a single Request for Action (RFA) with two participants: the Sender who issues the request to the Recipient, implying direction of the element. It has a Header, History log and Status. The Header is owned by the Sender. The Recipient cannot change its details. Both parties use the History log to exchange messages, comments, report progress and discuss ideas. Log records are time stamped and uniquely identified creating an audit trail of work done. It can optionally contain effective hours worked. Neither one can change log entries. The system may also post to the log in case of any change to the header or other events like approached or missed deadlines. Both participants use status to alert the other party of new developments. The status is configurable, and represents actual business situation (in progress, waiting for subcontractor response, etc.). The Header contains the request description, the deadline and an alert window period. The system monitors whether the request was read and flags it if it wasn't opened for a predetermined number of days.

The Sender may decide that further help is needed to resolve the issue. He may invite other stakeholders from any department or corporate altitude to join the discussion and observe the progress. Their arrival to the group as well as leaving is logged. They can post messages and be alerted of status changes and system alerts as any other participant.

Upper management of each participant is included in the discussion by default (Figure 2.). When any user logs onto the system, his/her position in the Organizational breakdown structure is established. Users external to the enterprise are identified by lack of corporate HR record. The Sender's upper management inherits Sender's rights, so they can change the header data, like deadline, description or Recipient, but these changes are logged. The Recipient's upper management cannot change the header data, but may change the employee that received the request, transferring the work to another individual they consider a better fit. Any upper level participant can post comments and will be alerted of status changes.

Figure 2 Upper management is included by default



The sender or his upper management are the only participants that can close the RFA, declare the problem solved. The difference between the issuing date and closing date gives the duration. The sum of effective hours recorded in the posts give actual effective duration. Posts with no effective work data are just comments, instructions or opinions.

The request might generate a sub-request which might be issued by any participant. Consider a project activity involving concrete pouring. The project/site manager would issue a RFA to the Concrete Production Plant that would route it to Planning. Once the Planning was done, another RFA would be issued to Transport Management that would be routed to their planning. If the concrete production needed resupply in the process, a RFA would be issued to Procurement Department where either quotes were collected or direct orders issued for known suppliers. In traditional corporate life, the original Sender was shielded from any events that occur after the initial request to manufacturing. If any unexpected event puts the concrete delivery (or part of it) in jeopardy, he will probably be notified at the last minute.

A sequence of chained sub-requests forms a topic, a thread of actions that must be completed to make concrete delivery on time to complete to project activity. The system combines History logs of all RFAs in the thread into a single billboard with horizon of visibility tailored for each level. Participant's visibility at any level is limited to the thread altitude he/she was introduced to and any sublevels, so that he/she is presented only with data relevant for his/hers involvement. The initial Sender sees the full thread and will be alerted if any unexpected event, deeper in the thread, occur. The thread trespasses multiple departments and multiple corporate altitudes, each request with its own duration. As all actions are logged, in case of recurring type of requests, like Request For Materials, expected, pessimistic and optimistic durations can be easily provided form corporate database. But more importantly, the effect of a delay that occurs somewhere in the thread depth is automatically communicated across the thread and its influence easily estimated.

Messages, comments, posts and other data are not visible to other employees outside the thread. Even inside the thread, participants have tailored visibility to their scope of work, so there is no data overload. It is a closed corporate social network where a multidisciplinary group of professionals is focused on resolving a particular business problem. They have an inherent alert infrastructure that propagates status changes, flags missed deadlines or small delays in other departments which may jeopardize project outcome. Upper management is automatically kept informed. Actions are logged so they can be audited and actual durations became part of the corporate knowledge base.

There are multiple concurrent closed corporate social networks coexistent in any particular moment in time, addressing different business problems, each one with arbitrary number of participants. Each professional is participant to multiple networks and he/she interacts with those networks via two personalized views, specifically tailored for his/hers horizon of visibility: My Requests and My News Wall.

In My Requests view the participant sees all the requests he/she issued, all requests that he/she was a Recipient and all the requests that he/she was an Observer. By default, only active request are shown. From a selected request, the thread can be followed to any depth, activity examined, comments posted or statuses altered. If the participant is also a manager, the first level of subordination from the Organizational Breakdown structure is showed by default, to avoid data overload. Further sublevels can be expanded as necessary. If any RFA of a subordinate is flagged, his structure position is also flagged. The manager can review all the requests for any subordinate, and intervene with a message, recipient change or status alteration. This view can further be filtered by date interval, status, project or partner.

My News Wall shows the posts from his/hers horizon of visibility, from any open RFA that he/she participates in. By default, posts from level the participant was introduced in the thread are shown, but status changes and flags are shown from the current level and thread downstream. Selecting a particular post, the participant will easily respond, and the system will route it to appropriate RFA, while maintaining conversations structure within the RFA. My News Wall can be filtered by date interval, status, participant or topic/request.

MPCoord integration into project schedule

Beside the basic information elements a RFA contains, it has a number of additional attributes used to enhance the functionality of the model. Partner Code enables tracking and measuring of suppliers, subcontractors or any other project stakeholder and evaluating their performance data at the corporate level. The Project Code in a RFA allows coordination of any action at the project level. Scheduled Activity Code entry in a RFA will allow tracking of corporate processes pertinent to a particular schedule activity. There may be multiple RFAs that are attached to a single project activity. A RFA can have attachments that determine its *type* which allows for integration with corporate Business Process Management.

Any number of documents can be attached to a single RFA, generally in PDF form or one of the image types. They can result from an internal corporate information system report, like a PDF report of a Request for Materials, or a scanned image of an external document. In case of internal attachments, there is a single attachment declared primary that defines RFA type. If the RFA thread is a standard corporate process, a recognizable type of a RFA may be considered an element of a

Business Process Model (Bacun, 2017). In that case, the following standard steps are known, as well as organizational position of the Recipients. This introduces a possibility of automatically generate standard business process steps, timings and durations, with additional benefits of the MPCoord model. Such a generated thread could be easily modified by the participants while maintaining an auditable trace of the changes. Rigidity of designed business process models proved to be one of the major obstacles in Business Process Management adoption,.

Assigning a RFA to a specific project schedule activity is the method to integrate standard corporate processes into the project schedule. They present the requirements for fluent activity completion. There may be an arbitrary number of RFAs assigned to a single activity. This, in fact, depicts the reality. In the concrete pouring activity example, there will be a RFA issued to Concrete Production Plant, probably a Request for Materials issued to Procurement for other materials required for the activity duration, a RFA to the leader of the floating team of carpenters and possible another Request for Modification that needs approval. Each one of those RFAs addresses different group of professionals, at different corporate altitudes. Some of them need to be fully completed if the project activity is to be completed on time and within the budget, others might be less constrained. That means that their cumulative effect should be aggregated differently. The Sender, in the example case the project/site manager, issues a RFA to Concrete Production setting the deadline. In case of multiple RFAs he would also set its aggregate switch. The Recipient will set the estimated time, as well as pessimistic and optimistic time and issue any sub-requests. The same principles will apply to the sub-requests.

The resulting RFA thread represents a corporate business process and can tentatively be called a schedule, as all of them have start, deadline, duration, direction and necessary resources. In the RFA thread, there may be a chain of dozen or few dozen of activities so they cannot be compared to a full-fledged project schedule of few hundred or few thousands activities. However, considering the fact that there might be multiple RFA threads per activity, their number might come close to the number of schedule activities. If any unexpected development occurs in any of the RFAs, proper stakeholders will be notified immediately allowing preventive actions. As a side effect of RFA practice, every action taken is logged and audited, so it becomes a part of corporate knowledge base usable long after participants are no longer present.

The model adoption does not introduce any extra work in the everyday business process. Material Requisition Forms are written daily, Change Requests are always in writing as well as any other document needed to justify a project action. Sometimes they are written by hand, sometimes keyed into the information system and sometimes sent via accompanying email, but generally without the confirmation of receipt. There is no reason why such a message couldn't be posted on RFA History log so that all the stakeholders would be noted immediately. If the Recipient didn't see the new message, the system would alert. The Sender could then elevate the status to critical, alerting not only RFA participants, but also upper management.

Corporate interleaved schedules

Integration of regular business processes into project schedule creates a net of concurrent activities across the enterprise. In a multi-project environment the number of activities is elevated exponentially. Activities from different project schedules require resources at the same time. Resolutions are made on corporate meetings, generally inside a single department. The requirements are prioritized without enough time to evaluate time or cost consequences. Project leaders are possessive of their projects, highlighting their accomplishments but not boosting the shortcomings.

It is easy to imagine two projects competing on concrete delivery about the same time. If both projects had their RFA schedules in place, they would intersect at arbitrary altitude points in the Organizational Breakdown Structure. A forgotten obligatory maintenance check in the delivery fleet, not visible at the project level, might cause delays that might be significant for one or both projects or it might not be significant at all. With RFA business process schedules in place in both projects, we can evaluate its influence. We would not be forced to recalculate the whole grid, it would be enough to recalculate variances across the thread and re-evaluate the changes at the schedule activity, flagging the RFA chain if needed. If the activity is on the critical path, financial consequences might be imminent. If the activity is not on the critical path, the delay can be significant enough to change the critical path.

Integration of RFA business schedules and project schedules introduces an enterprise wide net of interleaved schedules executing concurrently. The activities are transparent across departments, monitored and audited. The complexity of such grid is managed by custom tailoring the horizon of visibility for each participant. Although Organizational Breakdown Structure is observed and upper management is kept in the loop with ability to intervene, this approach is problem oriented rather than business unit oriented. New developments are easily addressed with quickly created teams with members engaged per need basis.

CONCLUSIONS

Cost overruns and schedule delays represent one of the most serious problems in construction today and are not getting radically better across years. There is statistically significant correlation between schedule delays and cost overruns. Numerous delays are caused by events external to the project itself, often inside the contractor enterprise, in different departments. Lack of communication, low transparency across the enterprise and confined business unit processes lengthen the time needed to resolve an emerging problem.

This paper proposes a model integration of standard business processes into project schedule based on Multidimensional Preemptive Coordination. A business process step, represented by RFA, has direction and duration. A sequence of such steps can be considered a schedule. Integrating one or more business processes with project schedule activity, we describe business reality, because any business activity is dependent on different corporate business processes.

In a multi-project environment those schedules intersect at different organizational points and corporate altitude creating a grid of concurrent schedules. The proposed model coordinates those schedules, provides an alert infrastructure and provides an auditable trace of events increasing corporate accountability.

Although the basic model was implemented in Carpio-ERP Information System it wasn't tested with a larger amount of data so the effect of data aggregation on system performance couldn't be assessed. The next steps will involve the design of a simulation environment of about 50 projects with 500 to 5000 activities per project, 10 to 20 participants per RFA, and a daily message load for a period of one year.

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