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A Petri Net-based framework for realistic project management and scheduling: An application in animation and videogames

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ABSTRACT

This paper presents a real life Petri Net-based framework for integrated and collaborative project management in the Animation and Videogame (A&V) industry. This framework provides an all-in-one modeling, scheduling, and simulation tool. The purpose of the framework is twofold: First to facilitate the configuration (and eventual reconfiguration) of projects and second, provide appropriate analysis tools. The modeling of the project activities and the associated resources is accomplished via a new class of Petri Net denoted here as extended attribute Timed Place Petri Net. This Petri Net class combines the strengths of colored and ordinary Timed Petri Nets in terms of modeling and analysis. The offline project schedule is generated with a Graph Search algorithm which explores the Petri Net state space. The algorithm is also adapted to handle reworks that often occur due to multiple changes during execution. Several scenarios can be simulated along with the calculations of duration, cost and resource usage. The potential of the framework is illustrated with two short case studies. The results and deliverables of the approach have been confronted with managers of several companies involved in the project who provided valuable insight and gave favorable remarks.

1. Introduction

In recent years there has been a significant growth in the animation industry at the global level. In 2013, the total worth of animation productions reached USD$ 90 billion [1]. A recent study shows that Colombia´s participation in the Animation and Videogames (A&V) sector has also been growing over the last few years [2]. In spite of all this, most Colombian A&V companies have neither enough specialized resources (in terms of workers and investment capital) nor high quality processes which satisfy international standard requirements. The same study shows that few of such companies have formal business processes or do any scheduling or coordination on their production projects. This results in poor planning of resources, high workloads during peak times and very low service levels [2].

This research is part of a government-sponsored project which aims to create world-class Colombian companies capable to compete with both quality and responsiveness to the ever increasing pressures of global markets in the industry of A&V. The project has an important industry component; thus far, four companies are part of this project and about two more are expected to join. The project consists of several sub-projects: paper and pencil, education with interactive tools, free software development and project management and optimization. This paper focuses on scheduling and simulation of the latter project.

The A&V industry has a standard production model which has four (4) main processes: (i) creative development, (ii) preproduction, (iii) production, and (iv) postproduction. The creative development focuses on the product concept, and also provides the main guidelines of the final work such as scope, target audience, and specific characteristics. The preproduction process establishes the “assets” (items of animation or videogames such as characters, movie backgrounds, and props) based on the characteristics described in the creative development phase. The production process involves the animation, tune-up and finalization of the assets and the integration of all media items as part of a first complete version which is polished in postproduction. This last process also includes edition and quality control of the final product before it is released.

Projects in the A&V are very particular in the sense that the customer participation throughout the process produces important modifications and adjustments that alter the original schedule. In these projects there are always “milestones” in which the progress of the project is assessed. Such milestones require approvals by either the customers or by the project leaders and

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usually lead to rework due to adjustments, changes in the customer requirements, and so forth. Therefore, a detailed schedule devised upfront will only lead to changes later on. As a consequence, the duration and resource usage in these projects is very difficult to estimate. Usually, A&V companies quote their prices including "time allowances" aiming to cover for this uncertainty. However, such allowances are calculated solely based on experience and without a formal methodology. Currently, companies estimate those allowances as a percentage of the total calculated time of the project. Even though the time is calculated by specialized project managers, based on their own experience, the estimation of such total time is rarely accurate (i.e. largely under or overestimates the actual duration) in most projects. To make matters worse, such A&V companies have few and incomplete records of their projects. This fact prevents the creation of historical records that can be used in other projects.

One of the characteristics of traditional project management is the very static nature of many projects. This may be true for construction of buildings but not for A&V projects. As said, A&V projects are very dynamic and require different technological tools; in essence, the A&V industry needs project management tools to quickly create, reconfigure, schedule and re-schedule projects that also provide estimates of project duration, cost and resource usage. Another issue is that companies, usually rarely re-schedule their projects, unless significant changes are required and/or priorities change. If there are delays, changes in requirements and scope of the project or other disruptions, companies resume the schedule when the disruption is fixed. Rework in the A&V industry is the most common "disruption" and normally occurs when a milestone is reached. Unlike other industries where the quality standards are set "up front", the quality (and eventual success) of a videogame depends largely on how the user experiences the product. As such, even in the most carefully planned projects having state-of-the art computer equipment and top professional staff, it is almost impossible to anticipate which changes (and when) the customer will request on the product. For this reason, many A&V companies are using today agile methodologies such as SCRUM, brought from software engineering. SCRUM is a technique based in managing small functional packages of work called "sprints" [3]. One of the aims of SCRUM is always to have a functional version of the product. If the client withdraws from the project of if the project runs out of resources, there will be a product. This method has greater flexibility than the traditional waterfall approach and also reduces risks for both clients and developers. However, if the project has no clear goals, it can go indefinitely as customers and stakeholders may keep demanding changes all the time.

In this paper, we describe a computer framework for the above requirements that is consistent with the realities of the A&V project management. The proposed framework uses Petri Nets with extended attributes as the engine for project configuration, scheduling and simulation. The project configuration is performed on the framework itself or on a BPMN (Business Process Model and Notation) editor that model the "flow" of work and the resources. Then, the model is exported in suitable formats (i.e. XML or XPDL) and transformed into a Petri Net with a straightforward mapping algorithm for validation and verification. An offline feasible schedule can be calculated manually or with powerful optimization algorithms that use the Petri Net structures. This schedule can be easily exported to commercial project management applications such as MS Project™ for further manipulation. To simulate the project execution, the user can specify the probability and level of rework and the activities in which the rework can occur. The user can also manually run the simulation.

This framework uses Petri Net for the following reasons:

- Petri Nets provide a powerful and yet easy-to-understand modeling formalism; this fact was very useful when the proposed models were verified with the managers of these companies. Despite the fact that such managers did not have engineering or computer science backgrounds, the verification sessions needed only brief explanations of the Petri Net models to such managers.
- Petri Nets and their extensions capture the essence of most project characteristics such as general precedence relationships, most resource constraints, time lags, calendars and event and exception handling.
- Petri Nets provide an all-in-one modeling, scheduling, simulation and execution tool. Besides the Petri Net modeling power, the scheduling part can be carried out with formal optimization techniques which search the Petri Net state space. Simulation of the project execution with stochastic duration times is also possible.
- The project execution of can also be run under the Petri Net-based framework in which the user can visualize the planned activities and current status of the project. This model also provides performance indicators to assess the progress of the activities.
- Petri nets are also capable of scheduling regeneration in the event of external disruptions. Rework and other disruptions can be easily modeled and handled.
- Maintaining and changing project constraints in the Petri Net model is relatively easy. Extensions such as multi-mode activities, non-renewable resources, multiple projects with resource sharing, multi-skilled workers can be easily handled. We point out that this is of primary importance for real-life applications. This makes this approach compatible with agile development methodologies that require quick reconfiguration and re-scheduling.

This paper describes the proposed framework and shows how the modeling, scheduling and simulation steps are performed. The remainder of the paper is organized as follows: Section 2 has the literature review of the main topics. Section 3 illustrates the Petri Net formalism. Section 4 presents two case studies of project estimation using simulation/re-scheduling. Finally Section 5 presents conclusions and further research.

2. Literature review

2.1. Petri Nets

A Petri Net is a directed, weighted, bipartite graph consisting of two kinds of nodes, called places and transitions, and arcs. Arcs are weighted and directed either from a place to a transition or from a transition to a place. In graphical representation places are drawn as circles, and transitions as bars or boxes. Places usually represent actions or conditions and transitions represent events. Tokens (black dots) reside in places and represent the truth of the condition or the action associated with the corresponding place. Tokens move through the net by the effect of transition firings. When a transition fires, a number of tokens equal to the weight of the connecting input arc is removed from all its input places. A transition can fire only if it is enabled; this is the number of tokens at all its input places must be greater or equal than the corresponding input arc weights. Likewise a number of tokens equal to the weight of the connecting output arc is put into all the transition output places. A place containing at least one token is denoted as a marked place. The marking of the net is an array which contains the current number of tokens at each place of the net. The initial marking is denoted as M_0.