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Title:

Organizational Modeling and Simulation in a Planning Organization

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Abstract

A team of researchers is pursuing an innovative approach to model development in a dynamic command and control (C2) organization. This team is developing an organizational modeling and simulation capability that differs from typical process modeling. Normal process modeling and simulation tools capture work processes but neglect the people and the information hierarchy. Modeling and simulation tools that focus on the organization holistically, account for other aspects of the organization, including implicit activities required to complete a certain task while portraying the hidden activities that are inherent to work (i.e., coordination costs). This type of research was started by the Virtual Design Team (VDT) research group; initiated at Stanford University in the late 1980s to help managers design organizations and work processes for executing fast-track development of complex products [1]. VDT is an agent-based computational model of a project team and a set of work processes they are attempting to execute in a concurrent manner. VDT has been successfully used to model work activities, communications, and exception handling within traditional organizations working on projects in areas such as construction, aerospace, consumer product development, and healthcare [2]. This will be one of the first applications of VDT-like capabilities in a dynamic C2 organization, building on prior work done by Stanford with the Naval Postgraduate School [3].

Introduction

Researchers from the Air Force Research Laboratory, Northrop Grumman Corporation, and Stanford University are engaged in a project to investigate modeling and simulation of dynamic command and control organizations. This effort will help define how organizational modeling and simulation can benefit organizations that must evolve to meet the demands of a changing world. These organizational changes can be minor, like a group of planners reviewing a novel way to evaluate courses of action or they can be larger-scale involving the development of new organizational structures and new leadership strategies. The research problem is that software tools do not currently exist that account for this type of environment. The objective of this research is to modify existing software tools that allow researchers to better analyze and assess organizational change in dynamic environments. At the same time, it will develop viable models for these dynamic command and control environments to accurately predict baselines which then can be used to test alternate operations with regard to new processes or new structures. These tools can assist in planned re-organizations, or to conduct what-if planning of organizational changes. Contemporary organizational theorists suggest that complexity in demands requires commensurate complexity in organizational design to meet the needs of these demands [4]. Ultimately, different organizational design options (i.e., structures) have inherent strengths and weaknesses [3, 5] and the selection of one option over another should be driven by the goals and objectives of the organization. This may require organizations to experiment with various organizational design options. A computational simulation model of workflow in organizations can be a flexible tool to try numerous changes in a model and see results prior to implementation as opposed to moving personnel into different groups and then assessing the outcome after several weeks of work within the new structure. Such 'A priori' return on investment analyses are often lacking in the practice of organizational development. The drawbacks of trying re-organizations without some type of planning or modeling is that it can shake up the organization without knowing whether the changes will work and then more changes may be required to find the optimal structure. This effort seeks to eliminate (or at least minimize) the trial and error of organizational changes and replace it with modeling and simulation to provide valid indicators of which organizational structures will provide the best results.

Background

The Virtual Design Team (VDT) research group [6] was initiated at Stanford University in the late 1980s to help managers design organizations and work processes for executing fast-track development of complex products. VDT is an agent-based computational model of a project team and a set of work processes they are attempting to execute in a concurrent manner. VDT has been successfully used to model work activities, communications, and exception handling within traditional organizations working on projects in areas such as construction, aerospace, consumer product development, and healthcare [1].

VDT-related research evolved the VDT technology into a standalone, easily extensible simulation engine developed during the late 1990s to simulate more dynamic and heterogeneous organizations executing non-routine work. It was used to prototype and test extensions to the VDT model, and as a part of a genetic programming system for automated design of near-optimal organizational structures [7].

During the early 2000s, a new implementation of the VDT model called POW-ER [8] was developed with funding supplied by the Center for Edge Research at the U.S. Naval Postgraduate School. POW-ER was developed with the intent of allowing the VDT model to be extended easily by individuals with modest programming skills, to model radically decentralized "Power-to-the-Edge" [9] organizations that communicate many-to-many to develop shared global awareness and self synchronize their actions as needed to respond to dynamic task environments. POW-ER has been used to study cross-cultural effects on organizational performance [10], peer-to-peer knowledge networks [11], and the effects of learning and forgetting on project performance [12].

In this project, the VDT model is being applied to support organizational change efforts in command and control (C2) organizations. The C2 environment is dynamic, fast-paced and requires personnel to be focused and agile. It is imperative for the organizational structure of this C2 organization to reflect an agile approach towards work in order to maximize the task throughput [9].

The advantage of this tool is that it allows change management personnel to test possible change interventions, including different organizational structures, within the model. The simulation provides instant results, indicating the benefits or barriers in relation to personnel that are backlogged, meaning that too much work has been assigned to that group, schedule slips, too much work overall and quality risks, meaning the risk of completing certain tasks or attending meetings events. Numerous interventions can be tested versus implementing change and waiting to determine the benefits or expense of implementing the change.

Development of the extended C2 Simulation Model

This investigation has shown that the traditional discrete project-based modeling methods used with VDT/POW-ER has some limitations with respect to representing ongoing activities within C2 organizations. Many tasks are ongoing and continuous, and personnel may be processing multiple requests simultaneously. Emphasis has therefore been placed on the development of *information flow* modeling techniques. This approach models ongoing tasks over a fixed period of time, with the additional capability to examine the impact of high-priority transient activities. Routine tasks extend for the duration of the simulation, through use of the existing maximum duration work model. Transient sub-projects can be scheduled to occur starting on specific dates, or may occur at random dates through use of the POW-ER event nodes. However, the existing simulation model was found to have a number of limitations that made it difficult to implement this style of modeling:

- The existing exception handling mechanisms assume dedicated work on specific projects. When a problem is encountered while performing a task, work is suspended until the problem is resolved. With information flow modeling, a task may be used to represent an ongoing series of sub-activities, it would be inappropriate to stop the entire task due to a problem encountered in one sub-activity.
- The need to model global activities spanning multiple time zones, results in activity 24 hours/day and 7 days/week, which is difficult to represent using the existing VDT/POW-ER simplified work-time only simulation model.

- While extending tasks to match the desired simulated time period can represent simple routine work, more complex repetitive activities can not be properly represented this way.
- Further enhancements to the simulation model make it difficult to use existing software as the primary modeling tool, necessitating improvements to the POW-ER editing user interface.

To address these deficiencies, a series of extensions to the existing POW-ER simulation model has been developed, producing the *POW-ID* simulator. These extensions were intended to better support representation of ongoing activities in an information processing organization over a fixed time period.

The VDT simulation model (and POW-ER which replicates many of its features) suspends all work on a task while waiting for a decision on an associated exception. This represents typical work-flow in traditional project organizations, where problems encountered while working on a task may require information input from project managers (supervision) or peers (coordination) before work can proceed. POW-ID adds the option of continuing work on the task in parallel with decision-making about an exception that occurred in executing the task. This is intended to better represent the work flow in an information processing organization, where tasks represent routine processes being performed on overlapping sets of related projects for fixed periods of time.

The VDT/POW-ER models assume project work occurs within a single time zone on a standard daily work schedule. To better support representation of global activities, POW-ID extends the simulation model by implementing a 24 hour clock with actor specific work schedules.

POW-ID also adds the ability to simulate stochastic or scheduled retriggerable events. When an event is re-triggered, downstream tasks are scheduled for work again, thus allowing simulation of repetitive activities. An event may also be set to occur on a fixed schedule by setting the schedule attribute to a time and date relative to the start of the project or another milestone.

Research progress to date

The strategy consisted of multiple steps including 1) review previously developed process models 2) collect data to facilitate model building, 3) build the models as required, conduct verification and validation, and 4) present the results to the stakeholders. For the first step, process models that were developed under a separate effort were reviewed and provided a good baseline to start model building, at the same time, the research team was directed to a key process and a certain unit within the organization to start the analysis. The second step was to conduct a series of data collection trips. These consisted of personal interviews, typically in the workplace setting, to gain an understanding of the tasks, coordination, number of meetings, and other activities of their particular function. Third, notes were converted into models using the software model building tools. Difficulties arose when trying to pin down the amount of interviewees' time spent on each task. The nature of the business is to work a certain task and then work other tasks while moving back to the first task at a later time. This has been difficult for the modeling, meaning that it is not the way some work is thought of. Typically a task arrives at your inbox, you complete that task and then you move it to the outbox. The nature of this work is that it arrives at your inbox but you spend time shaping and working it but leave some parts incomplete since you do not have all the information. This requires you to return to the work at a later time. Despite these difficulties, the modeling has pressed forward and then subsequent to model building, model verification and validation has been conducted and baseline simulation runs were investigated. The results are preliminary but a few examples are shown in the results section. The next steps to be investigated are to try several interventions that reflect the changes that are desired by the C2 organization.

Results

A set of simulations were conducted with models built about C2 organizations. The output is used to compare the POW-ER and POW-ID software to see how it was handling such certain computations. The following figures shows three parameters of output obtained by running POW-ER and POW-ID across a set of examples.

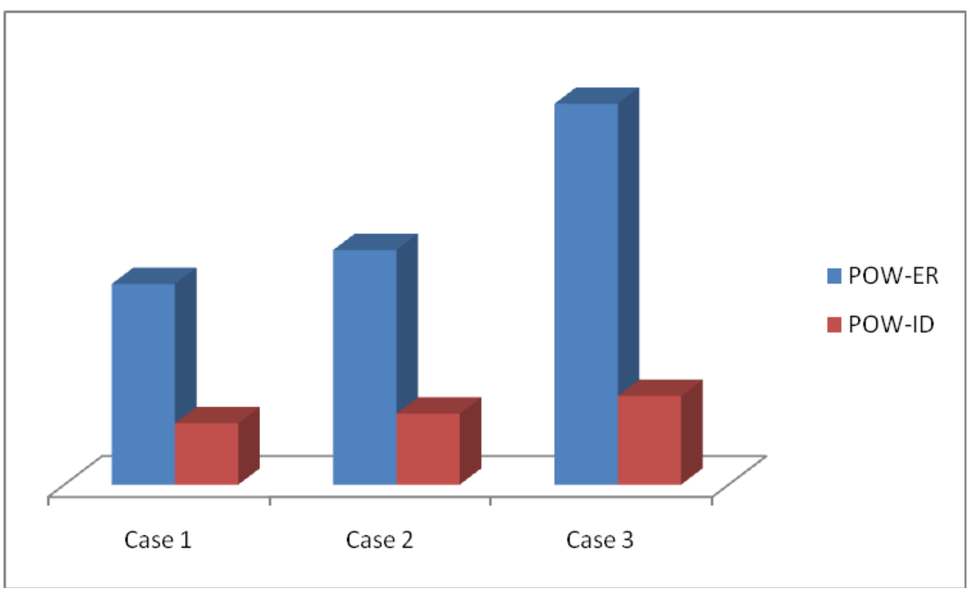

Figure 1 Identical simulation case runs with POW-ER and POW-ID

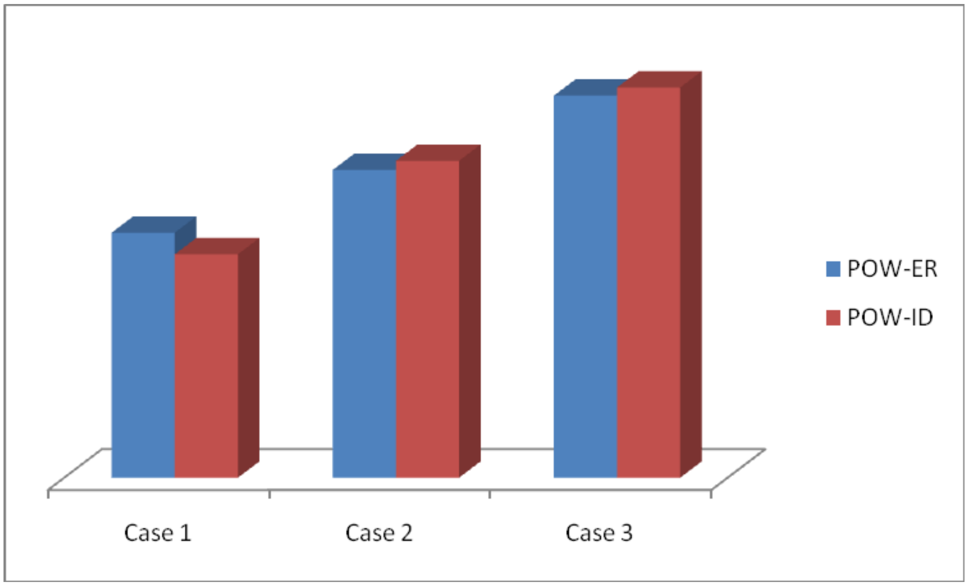

Figure 2 Identical simulation case runs with POW-ER and POW-ID

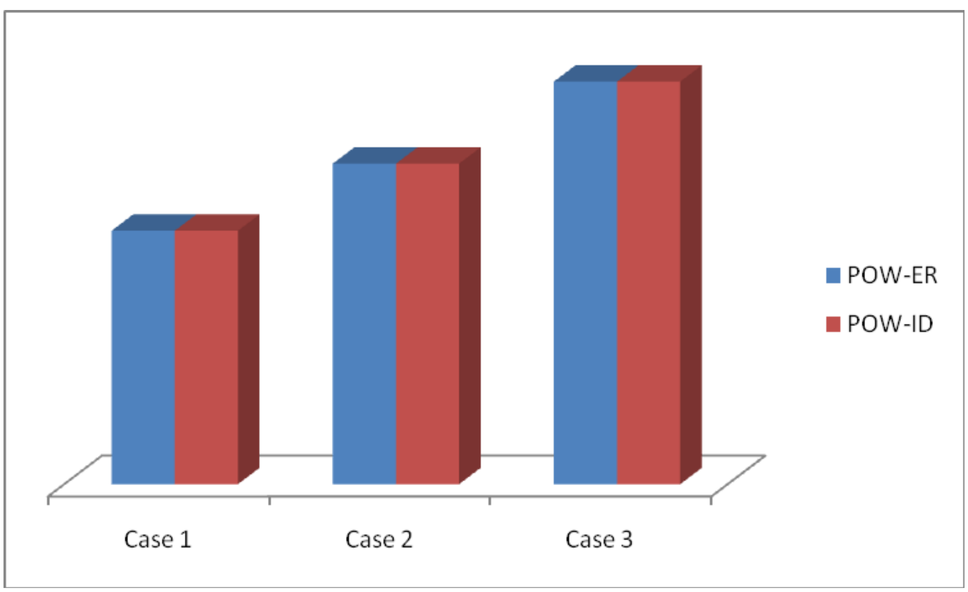

Figure 3 Identical simulation case runs with POW-ER and POW-ID

Conclusion

Figure 1shows that the POW-ID software provided better consistent output across the three cases while the POW-ER software showed a dramatic difference for this particular factor. The other figures of other factors showed a relatively small difference in the output. This provides us with two positive outcomes, POW-ID can help provide better output for studying organizational change in these C2 organizations and we maintained a consistency that is required in modeling and simulation.

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