

An Introduction to Business Transformation of Technology Services

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Abstract

The exploration of an emerging academic discipline to develop new skills for a service-led economy has recently made tremendous progress in the areas related to technology services. This paper examines the technical and economical factors that affect the knowledge-based services provided in support of server electrical design and packaging. The service group basically provides system level electrical design and integration support in the form of electrical and physical design rules, engineering consultation and system level electrical verification of server designs. This paper also describes a business transformation methodology and model based on scientific and stochastic processes to transform the support group into a high value-added service provider.

Introduction

The exploration of an emerging academic discipline to develop new skills for a service-led economy has recently made tremendous progress in the areas related to technology services such as system integration, packaging, testing and compliance. Specifically, the application of scientific, engineering and management disciplines to tasks that one organization (or team) performs for others is referred as a Services Sciences, Management and Engineering (SSME) discipline [1]. In more practical terms, this discipline tries to bring together ongoing work in computer science, operations research, industrial engineering, scientific engineering, business strategy, management sciences and legal sciences. The goal is to integrate this knowledge needed to create more systematic approaches to service innovation with increased levels of productivity, efficiency, quality, performance, compliance and reusability. This will lead to work evolution and business growth including work-sharing and risk-sharing relationships between service providers and clients [2].

The world economy is experiencing the largest labor force migration in history, driven by global communication and technology innovation. Today, more than 50% of the labor force is in service related jobs. As the result of this shift in the world economy, the industrial and academic research facilities need to apply scientific methods to the practices of services. This requires the development of a multi-disciplinary skill base, especially in the area of highly complex and high value services, which requires people knowledgeable in business, science and information technology.

This paper examines the technical and economical factors that affect the knowledge-based services provided in support of server electrical design and packaging. The service group

basically provides system level electrical design and integration support in the form of electrical and physical design rules, engineering consultation and system level electrical verification of server designs. This paper also describes a business transformation methodology and model based on scientific and stochastic processes to transform the support group into a high value-added service provider whose revenues are linked to the value provided by the services rather than by functional head count. The approach, based on the theory of enterprise transformation [3], draws on value deficiencies, work processes, decision-making, and social networks.

Enterprise Transformation Theory

Service sciences management and engineering aims to bring together work in computer science, business operation research, industrial engineering, business strategy and management sciences to effectively transform existing service-oriented businesses. The goal is to integrate the knowledge needed to create more systematic approaches to service innovations. This will lead to more predictable improvements in service productivity, quality, performance, compliance growth, knowledge reuse, and work evolution. This is especially important in work-sharing and risk-sharing relationships between the service providers and the clients.

This paper presents a service-oriented business transformation model for highly technical services (technical knowledge services.) The goal is to develop an effective and efficient business and financial model for highly technical services that can be simulated using stochastic processes and techniques. This model can then be used to understand critical parameters affecting the business outcomes and to optimize the business process.

Today, a technical support group providing system level electrical integration, design and packaging for server designs typically operates as a budgeted function to provide and support applications of design rules, electrical verification and engineering consultation for server designs. The goal is to transform this support group into a high value-added service provider whose revenue is linked to the value provided by the services rather than to functional head count. The overall objectives of the transformed organization include increasing the value of current offerings to current customers, expanding the value provided via adjacent services to current customers, and expanding the market served to new customers.

The approach presented herewith is based on the theory of enterprise transformation [4]. This theory draws on four key elements to achieve the aforementioned objectives as

follows: Value deficiencies drive transformation; work processes enable transformation; management decision-making determines the scope of the business; and social networks determine the nature of the implementation.

In order to define the value of the technical service, one needs to understand the customers' perceptions of value as defined by the provider's outcomes. This includes attributes such as time, quality, productivity and cost to the customers. Other important aspects of the perceived customer value are the economic worth of this value, the value streams associated with the flow of this value through the organization's work processes, and the value opportunities to remediate potential deficiencies in providing additional value as perceived by the customers. These value definitions and deficiencies can be obtained from both current and potential customers through the use of interview templates, case studies and market sources. Value deficiencies can be either actual (i.e., not providing value expected by customers) or potential (i.e., not providing value that the organization could potentially provide, taking advantage of unexploited capabilities and market opportunities).

In order to determine work processes within the organization, one needs to review existing key work process documentation and map these processes to the actual work flows and processes that create the organization's outcomes, to the assessments of the value added by these processes to the end users, and to the identification of process changes and new processes to remediate value deficiencies. These work process changes have to support achieving the objectives outlined above for the enterprise transformation.

In order to determine the scope of the business and to determine what market segment should be pursued, one needs to gain insight to the decision makers' reactions to the nature and results of the market analysis and the existing work processes. This includes an understanding of the extent to which the business transformation is necessary, and of the nature of the decisions they are likely to make.

Finally, in order to determine the social networks associated with the value currently and potentially provided by the organization, one needs to identify how information and knowledge flow in these networks and the extent to which these networks are tightly or loosely connected in the organization. In addition, one needs to determine how the distribution of the organization's personnel relates to the functioning of the associated social networks, and to understand the extent to which the organization is best virtually organized and supported.

These four tasks result in an overall business transformation implementation plan and model. It includes consideration and formulation of tasks, schedule, budget, resource allocation, and key metrics of evolving success.

Business Process Modeling

As a precursor to business transformation of a service-oriented business, methods and techniques to model business and design processes are needed for the characterization of existing processes and for the generation of alternative or changed processes. The business process model can then be

utilized to specify, evaluate and improve alternative processes and techniques.

Business process modeling has received increasing attention in industry and in the research literature [5, 6]. One key driver has been the need to understand processes so that enterprise resource planning systems can be implemented. Another has been the need to make processes "lean" and more predictable. Here, the focus is on understanding processes with a view toward improving value creation. To facilitate transformation analysis, a business modeling approach must support (or be extensible to support) the following: Model resources needed, model time delays of tasks to be performed, model task pre-requisites or dependencies, capture uncertainty through probabilistic modeling, provide evaluation functions such as pricing for services, support decision logic, and provide methods for performance assessment and optimization.

A variety of methods exist for business process modeling. The concept of event-driven process chains [7] is used here to develop an applicable business process model. Event driven process chains (EPCs) are widely used in business process modeling. An EPC consists of a number of elements that are used to model a process.

- A **function** is an active element that models a task or activity. A function has an initial state and a resulting state(s). For each execution of the function, the resulting state depends on decision logic embedded within the function. Functions can be hierarchical in that an EPC can comprise a function within another EPC.
- An **event** is a passive element that triggers a function. An event can also be created by the result of a function.
- A **control flow** is the temporal/logical relationship between events and functions.
- An **operator** is a point where process flow may split or be joined. Operators may be "or," "exclusive or," or "and."
- A **process** is an ordered collection of functions and events, connected by control flows and operators. A process flow follows a path outlined by the process.
- A **process marker** is a link between different processes.
- An **organization unit** represents which person or organization within the enterprise is responsible for a particular function.
- A **material, information or resource object** is used by a function as input data, or can be created/alterd by a function and returned as output data.

Figure 1 illustrates a very simple EPC diagram for a process that responds to a request for a proposal (RFP) from a potential client for a new server design. Events are hexagons; functions are rounded rectangles; organizations are ovals; material/information/resource objects are rectangles; and operators are circles. The process flow is the sequence of events and functions. Once an RFP is received, technical analysis is performed to determine feasibility and project requirements. Technical analysis is a function provided by the design group. It needs licenses and person-hours to perform its function. Its output is the feasibility of fulfilling the deliverables of the RFP and the project requirements for doing so. A more complete EPC might show as output a

document outlining project requirements (an information object), and might also indicate an alternate infeasible output event that would terminate the process.

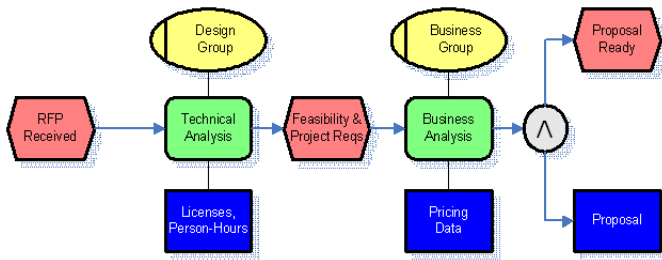


Figure 1. Event-Driven Process Chain Example

Once the business group receives project requirements, it conducts business analysis to develop a proposal. This function depends on pricing data, which is needed to determine a cost based on project requirements and a value to the client based on value metrics. After business analysis, the flow results in a proposal and a proposal ready event. The particular operator used here denotes that the process takes both paths. The proposal ready event may trigger a function in another process, such as a formal proposal submission and logging process. A more complete EPC might indicate the possibility that the value to the client may not be worth the cost, in which case a do-not-proceed event would result.

The business model based on event-driven process chains supports our basic requirements for modeling. It can be used to model processes based on provider and client interactions, and it can be used to evaluate process alternatives. Moreover, EPCs can be transformed to Petri nets for formal analysis (e.g., reachability and deadlocking) [8]. EPCs can serve as the basis for simulations that incorporate time delays and can give computational form to uncertainty, management decision-making and pricing methods.

Social Network Modeling and Analysis

Social networks are ubiquitous in business and organizations, and they have important ramifications for work processes, enterprise effectiveness and enterprise transformation. The formal study of social networks is a relatively recent development in social science research. Traditional social science research focuses on characteristics of individual elements, often representing people and associated attributes. Social network analysis (SNA), on the other hand, focuses on the relationships between elements (i.e., actors), as well as on their individual attributes. Typical data representations include (i) network graphs, with nodes representing actors and arcs representing relationships, and (ii) matrices, with row and column indices representing actors and matrix elements representing relationships.

Social network analysis, then, is the characterization of actors and networks using statistical methods. In-depth discussion of SNA methods is provided in [9, 10]. It should be noted that specialized statistical methods are needed. Standard methods assume independence of observations.

This assumption typically is not met in social networks, due to the relationships between actors. In addition, most research focuses on static analysis of social networks, not considering changes to the network or changes to its interaction with the outside world over time. From a computational perspective, Huisman and van Duijn [11] review available software and enumerate research question categories of interest in enterprise transformation:

- Determining properties of actors, relationships and networks (e.g., centrality of actors, identification of cohesive subgroups and cliques, density of network, connectedness of actors in network, identification of structural holes);
- Comparing relationships within a network or between networks (e.g., for predicting behavior of a network, given behavior of a similar network);
- Modeling associations between relationships and actor attributes (e.g., for predicting actor roles in a network);
- Comparing and categorizing actors (e.g., grouping based on attributes); and
- Development of networks over time (e.g., influence of networks on the organization over time).

The notion of social networks is extended with a meta-matrix, which incorporates knowledge, tasks and resources, so that the interconnections of these elements with one another and with people are represented [12]. This type of representation is especially relevant for a knowledge-based services provider.

In the context of enterprise transformation, some effects have been researched. In particular, loosely connected networks tend to be more open to innovation, while tightly connected networks tend to be better at implementing transformation [4]. The effect of social networks on transformation, still, is very much an open research area.

Modeling Design Services

Design services are enabled by the business processes integral to supporting client needs, as well as the design work processes that produce results. Server design is a complex activity. An EPC model of design services, comprising many different element types, can be complex, as well. In the Architecture of Integrated Information Systems (ARIS) approach, which underpins the SAP enterprise resource planning system, this complexity is mitigated by dividing the various elements into different views [5]:

- the **data view**, which includes events and conditions,
- the **function view**, which includes functions and their relationships,
- the **organization view**, which includes users and their organizations, and
- the **resource view**, which includes information technology resources.

Typically, in this type of modeling effort, the resource view is not considered explicitly, since the first three views are more relevant to process modeling, rather than to IT implementation. The relationships between elements in these different views are encapsulated in a separate **control view**, which is useful for modeling the decision logic in a service-

based system. However, for our purposes, two additional elements are needed: representations of value and of social networks. Figure 2 illustrates a modeling architecture that enhances the basic EPC constructs with a representation of value created and social networks, including representations used in the meta-matrix. The design services organization creates value, which is measured by various metrics, and which enables downstream value. The personnel interact in social networks with one another and with outside colleagues (e.g., internal customers). This interaction affects their work processes (e.g., input of new projects). From a meta-matrix perspective, personnel have skills (i.e., knowledge), and these skills are prerequisite to being able to perform functions (i.e., tasks). The model provides for people-people networks, people-skills networks and skills-tasks networks. Thus, Figure 2 represents an integrated view of EPCs and the meta-matrix social network representation.

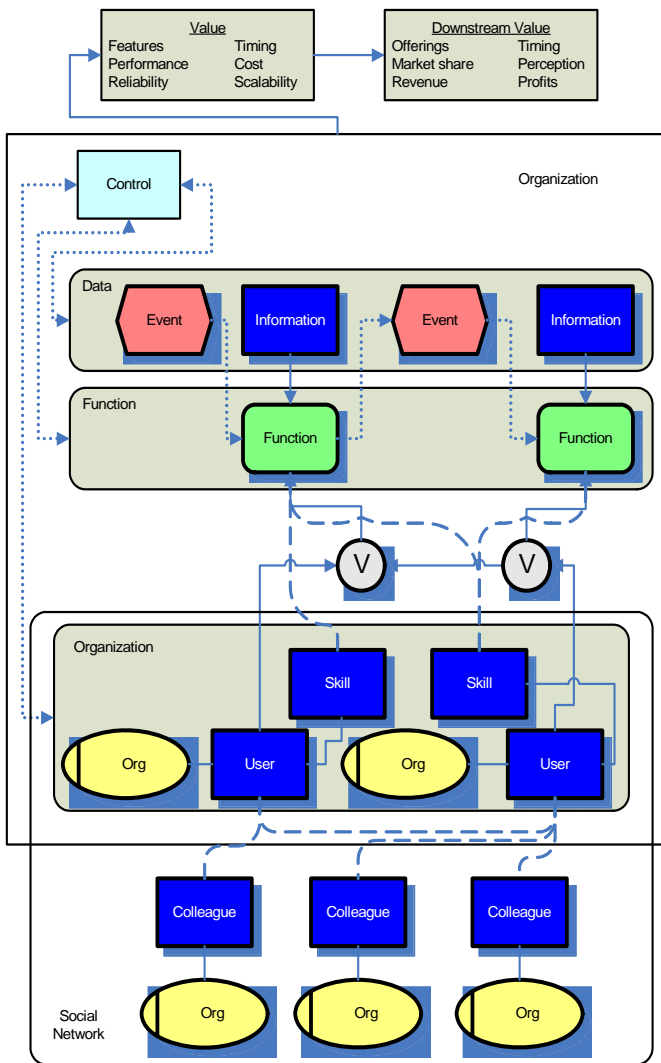


Figure 2. Modeling Architecture

The electrical design service group provides system level electrical design and integration support in the form of electrical and physical design rules, engineering consultation and system level electrical verification of server designs.

Figure 3 shows an EPC model of a typical system electrical design flow used for a server design project. This EPC considers design processes, which primarily reside only in the data and function views, which are relatively static. The organization and control views, on the other hand, are dynamic. These non-design processes govern resource allocation (e.g., assigning personnel to tasks) and prioritizing project activities (e.g., to meet deadlines).

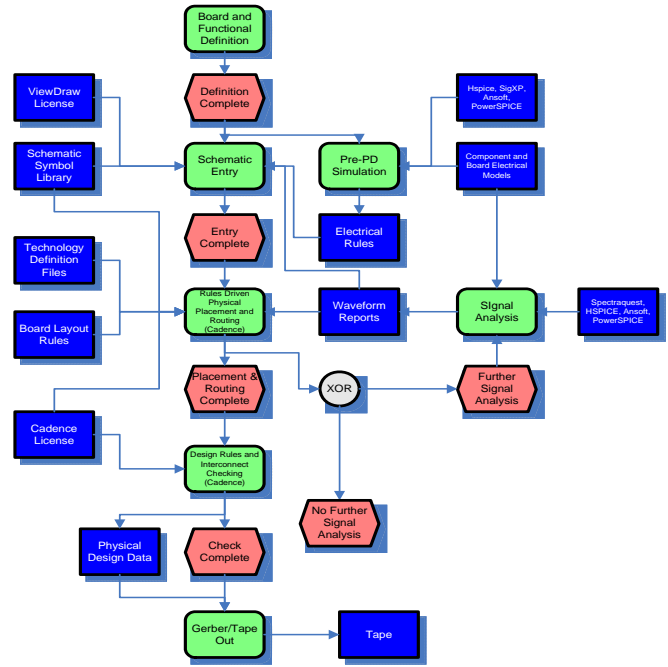


Figure 3. System Electrical Design Flow

Projects are generated external to the overall design group, by a marketing function that monitors market trends, as well as technology developments (e.g., new processor technologies). Once initiated, a project is then given to one of the electrical design service team's internal customers for design coordination. This coordination involves several design service providers, including the electrical design services group. Projects are differentiated according to product type and may be low-end servers (1-2 socket servers, essentially commodity products), high-end servers (4+ socket servers, differentiated in the marketplace) or blades.

For each project, the electrical design team appoints a focal point (FP), who works closely with the internal customer and who manages the electrical design and integration aspects of the project. It is critical that the FP keep on top of new developments with the project, since they may affect the feasibility of current work. This is accomplished through design review meetings. Sometimes, there are conflicts between the results of the electrical team and those of another group (e.g., the mechanical group). The internal customer typically reconciles these conflicts based on input from both teams on what is feasible or not vs. what is desirable.

The focal point handles the tasks that he or she is capable of handling and refers others to interface experts. This

referral is based on a task-skill relationship. For those tasks that the FP cannot effectively perform, he engages another member of the electrical design services team, i.e., an interface expert (IE), who performs a specific design task and reports results back to the focal point. The IE provides deep technical knowledge in a particular area. After performing a task, an interface expert may be called on to provide assistance later, if problems develop with a previous result from the IE. For example, an IE may perform feasibility analysis and provide a result that a particular design architecture is feasible. If problems arise later, the IE performs additional analysis and design work to correct them. Team personnel serve in either role, depending on project needs and their skills, although some team members may tend to favor one role over the other. IEs prioritize multiple project requests by the urgency of the project need. Since a team member typically has multiple project assignments at any point in time, the notion of time-slicing comes into play.

Each task has a duration that may vary probabilistically. Design tasks can be complicated from the uncertain technical nature of design work, especially when new technology is being used in the design. That is, a task may be added to a project due to a failure in the design process that requires remediation or extra work, or due to a change in the overall design dictated by design work done by another group. With a number of projects active at any time, there is contention for capabilities. Figure 4 illustrates, from the perspective of one project, how an FP interacts with the design lead and with IEs to generate tasks when needed and assign tasks to IEs. This involves significant operational decision-making, considering the resource constraints, project deadlines and dynamic/uncertain nature of the design process. This decision logic is encapsulated in the control view of the business process EPC.

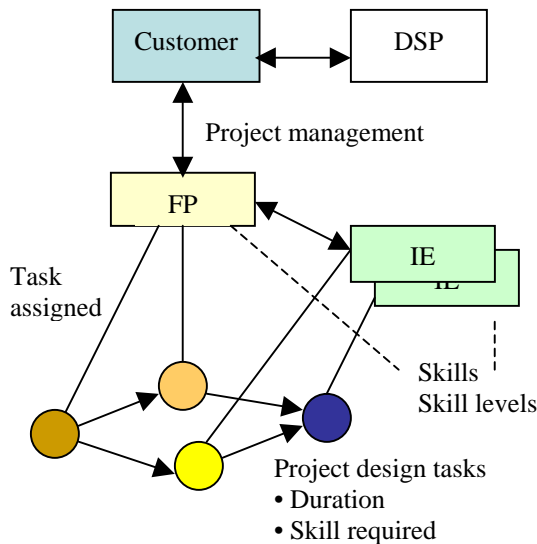


Figure 4. Project workflow

The people-people social network model currently represents attributes of role and location for each actor (since the electrical design group is located in two separate cities)

and represents the communication intensity as the relationship between actors. This model has been developed for the electrical design services team and its internal customers. A separate people-skills and skills-tasks networks model the relationships among people, skills and tasks.

Work processes create value. Drawing on the concept of value streams [13], Figure 5 illustrates the notion of a value network for design services, with the various organizations represented as nodes, and services provided as arcs. Design service providers consist of technical support groups, such as the electrical design and integration services group. Multiple design service providers provide design services to internal customers, who develop designs for products. The internal customers coordinate the work of the various design service providers. Vendors give services to the design providers, in the form of component models and technical assistance. The internal customers then provide finished product designs to marketing, which in turn markets designs and sells products to end users. In reverse of the arcs shown, organizations set requirements on other organizations. For example, marketing sets requirements on the internal customers for product designs based on analysis of market needs. At each stage of the network, value is created. Value is realized on deployment to the end user, through profits, market share or other measures. A value stream results from the services provided to create one product. A complementary material network, not shown here, consists of vendors providing components to manufacturing, which in turn provides finished products to the supply chain for delivery to the end user. The design service flow tends to emphasize value, while the material flow tends to focus on cost [14].

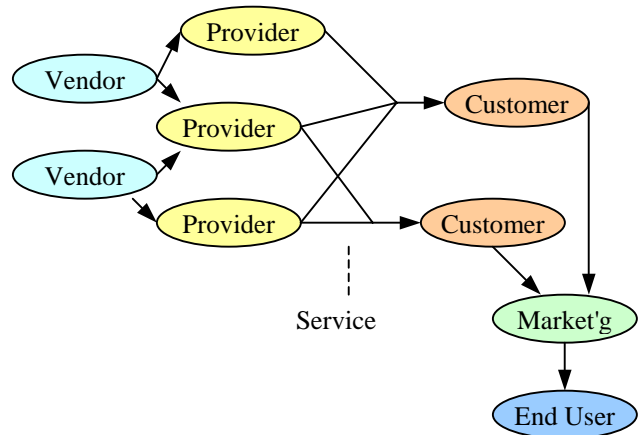


Figure 5. Value network for design services

Value can be viewed from two perspectives – value provided by the overall design process, and value provided specifically by the electrical design team's work. Value provided by an overall design derives from the aggregate measures of market share and operating profit. These are impacted by time to market and by product features. Time to market is critical. For low-end servers (1-2 sockets), time to market operates as a constraint, where the constraint comes from the announcement of a new processor chip by the vendor that supplies chips. When the announcement is made,

the design must be ready for production due to competitive pressures. For higher-end systems (4+ socket systems and blades), this constraint is somewhat relaxed, due to cooperation with the vendor. Product features that create value are the following:

- Cost of materials (primarily for low-end servers),
- Speed,
- Reliability,
- Scalability,
- Expandability, and
- Density (blade systems).

We are currently conducting market research to determine the effect of these features on market price and perceptions. Internal perceptions, based on interviews, are that the most value comes from differentiation in the design of high-end servers and blade systems.

The electrical design team contributes to the value created by the overall design. Perceptions, based on interviews of team members, are that its greatest value source comes from providing specialized design rules needed for high-end servers and blade systems. For low-end servers, value comes from applying existing design rules correctly. From interviews with internal customers, the value provided by the electrical design team is critical to the design process. Current research is aimed at quantifying this value, so that the pricing of the team's services can be linked to the value created. One quantifiable aspect of the electrical design team's output occurs with up-front feasibility analysis if a design specification. If the electrical design team provides a result that a specification is not feasible, there are savings realized from not moving forward with design work and lab prototypes prior to revisiting the design. Electrical design team outputs that can be linked to value include the following:

- Speed-up or delay of design process,
- Reduction in expected cost of materials,
- Number of design passes per project,
- Number of design rule set releases,
- Error rate,
- Resource utilization and
- Number and mix of projects completed per year.

Current research is aimed at linking these outcomes to overall value so that alternative pricing models can be developed.

The primary potential value deficiency identified in this research is commoditization of the server business, which affects the overall business, and affects the electrical design team through commoditization of design services (e.g., offshoring of design services). The corresponding potential value deficiency is not staying abreast of the innovation curve. As today's innovative servers become tomorrow's commodity products, it is important that the electrical design team (i) capture and reuse methods, so that designing products requires less effort as they become more commoditized, and (ii) continue to innovate its design methods for next generation servers. Other potential value deficiencies that drive transformation include the following:

- Risk of too many design passes for a particular project (impacts time-to-market),
- Risk of a failed design (impacts cost and time-to-market),
- Not having enough personnel resources (impacts time-to-market),
- Mismatch between simulation and lab results (impacts time-to-market),
- Inaccurate component models from suppliers (impacts time-to-market),

Simulation Modeling

To test the effect of different work processes, decision-making and market conditions, we are employing discrete-event simulation of the business and design processes used by the electrical design team. Simulation historically has been used to analyze workflow systems such as manufacturing for design and performance improvement [15]. Increasingly, it is being used for similar purposes in business process modeling [6] and even organizational modeling [16]. It allows analysis of business process behavior over time, incorporating the effect of uncertainty. Multiple replications of a model run provide capability for statistical analysis.

Input data to the electrical design services model includes the following:

- Number and mix of project types given to the design team,
- EPC models representing flow of design tasks and non-design business processes,
- Social networks of people-people, people-skills and skills-tasks (i.e., meta-matrix structure),
- Duration of various process steps,
- Probability of errors,
- Inputs from internal customers during execution of a project (e.g., changes that create new tasks for the electrical design group), and
- Electrical design team services pricing model.

It should be understood that many of these input data are stochastic in nature, and thus are represented by distributional forms with parameter input (e.g., mean and variance). For instance, in any given time period (e.g., a year), there is a varying number and mix of projects given to the electrical design team. Likewise, the duration of process steps varies, as do inputs from internal customers. Output measures from the model include the following, among others:

- Personnel utilization,
- Number of design passes,
- Number of design rule set releases,
- Number/percent of on-time project deliveries,
- Number of projects finished per time period,
- Associated productivity measurements (e.g., number of projects finished per person-hour or per budgeted dollar),
- Electrical design team revenue from projects, and
- Overall value from projects deployed.

Since the model is run over a number of different replications, the above measures are averaged over the replications so that statistical significance can be obtained in designed experiments. These simulation experiments can be

designed to test the effect of different factors on performance of the electrical design team. The standard form used is to a set of input factors (independent variables) and a set of output factors (dependent variables), and to design the experiment using different levels of the input factors in an analysis of variance (ANOVA) format. The input factors are sub-divided in the sense that some can be controlled and others cannot reasonably be controlled. The former are cast as decision factors, while the latter are cast as environmental factors. Decision factors are those things (work processes, social network structures) that can be changed in the organization. Environmental factors, on the other hand, cannot be changed (at least not without considerable effort). Even though the environmental factors may not be under control, it is important to know what the interaction is between them and decision factors, so that appropriate decisions can be made, given likely environmental conditions.

Current work is addressing implementation of the model. We are investigating use of agent-based simulation approaches, such as RePast [17]. Agent-based simulation offers a distributed work and decision-making paradigm that is suitable for organizational modeling and simulation.

Conclusions

The methods and techniques described in this paper can be used effectively for modeling and optimization of highly technical service organizations. These results can then be used to establish a business transformation implementation plan. The use of EPCs to model the work processes allows for stochastic simulations and optimization techniques to be applied to the model based on the statistical distribution of the independent parameters affecting the business outcomes. Social network modeling allows the effect of human interaction on performance to be studied. Future work involves implementation of these concepts in computational form and analysis of models using designed experiments for purposes of organizational improvement and transformation.

Acknowledgments

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