Core business architecture for a service-oriented enterprise

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The business architecture of a service-oriented enterprise can be adequately represented through five main architectural domains: business value, structure, behavior, policy, and performance. In this paper we focus on the *core business architecture*, the set of essential elements in each of the five domains, and the interrelationships among these elements. The business architecture described in this paper identifies the key elements required for business reasoning and for its application to business transformation through service-oriented solutions. A business scenario involving a fictional company in the apparel business illustrates the concepts presented here.

INTRODUCTION

The pace of global sourcing of business functions is rapidly increasing as more and more enterprises look not only to outsource the non-core aspects of their business but also to subcontract expertise in areas in which they are lacking.[1] In such an environment, driven primarily by global sourcing of business activity and standardization of various business functions, the business architecture of a service-oriented enterprise is of interest not only for business design but also for the design of the information technology (IT) solutions that affect all aspects of the operations of a business.

The ideas of service offerings and consumption of business services are not new, even though they are done now in a mostly ad hoc manner. Because most businesses today have a service orientation, either as consumers or providers of business services, our focus is on the applicability of the business architecture presented here to the service-oriented enterprise, but the architecture is not limited to such enterprises. Business architecture is widely regarded as the art and science of delivering coherent, dynamic, and complete business designs. When discussing the business architecture of a service-oriented enterprise, we consider five main *domains:* business value, structure, behavior, policy, and performance. We focus in this paper on the *core business architecture*, the set of essential elements in each of the five domains, and the interrelationships among these elements. This view of business

architecture identifies the key elements required for business reasoning and for its application to business transformation through service-oriented solutions. In this paper, business architecture is expressed through modeling. The elements of the core business architecture are described through various metamodels, which provide abstractions of the five business architectural domains and the relationships among their elements. The Unified Modeling Language (UML**)[2] is particularly suited to describe such models, and we make use of it whenever appropriate.

A *business value model* describes how an enterprise participates within a network of enterprises, how it produces value, and what constitutes the basis for strategic decisions regarding its offering portfolio and partner relationships. A *business structure model* describes how the enterprise organizes its work in the form of nonoverlapping business functions. The analysis of the business structure model helps decision making related to sourcing business activity, business investments, and so on. A *business behavior model* describes how an enterprise defines its internal business operations and the behavior of business partners exposed within its business ecosystem. In this context, business services represent the externalized view of the operations of a service-oriented enterprise. The notion of *business policy* is critical to specifying directions and guidelines for all aspects of the business architecture. Finally, a *business performance model* specifies the elements needed for evaluating the performance of the enterprise, according to key performance indicators (KPIs), as well as specific business operations.

Business strategy is not included as part of the core business architecture. Instead, it is treated as an external input that impacts several business architecture domains. For example, to achieve its business goals, an economic entity (part of the business value model) has to develop and implement its business strategy.

Business information spans the five models in the core business architecture. For example, information models define the parameters passed into and returned by service functions. Information models also provide the business vocabulary used in service agreements, business rules, performance metrics, and so on. Because modeling of business information is fairly mature, we have chosen to leverage its existing concepts, techniques, and tools rather than introduce it as another model within the core business architecture. For those familiar with information modeling in the context of IT solutions, it is important to note that business information defines business data from the business perspective rather than the IT perspective. Unlike IT-oriented data modeling, business specifications typically do not address details such as data types (e.g., distinguishing integers from floating-point numbers), lengths, or multiplicities.

It is worth noting that concepts of business architecture in a service-oriented enterprise are distinct from similar concepts of IT solution architecture although, at first glance, they appear to have common terminology. The idea of business services is more than just placing a "business" qualifier in front of a "service" as understood in the context of service-oriented architectures (SOA). For example, a credit-check service from the SOA perspective includes the syntax and semantics of invoking such a service, the format of the messages exchanged, the software component involved in implementing this service, and so on. In contrast, a credit-check business service describes the business aspects (i.e., service pricing, billing methods, etc.) and operational aspects (e.g., process based on financial history or process based on personal references) and does not include the solution aspects. The business service concept has attributes that are relevant to communication among business people, such as the various terms and conditions associated with business service consumption, governance, management, and so on. In SOA parlance, many of these are considered to be nonfunctional requirements for solution design, useful to solution architects but not very meaningful for business-level communication. In many cases, business services would indeed be implemented as Web services using SOAs. However, this detail is not relevant to the business architecture, which models concepts important to business architects and analysts. It is important to understand this distinction in order to fully appreciate the concepts associated with modeling the business architecture of a service-oriented enterprise.

This brings us to the need for and relevance of core business architecture. Tool developers and business transformation practitioners can extend these basic models with appropriate attributes as required. Note

that several business architectural elements are shared across multiple business domains and so should not be considered independent when the business design spans multiple domains. For example, how does the decision to introduce a new service offering based on analysis of business value impact the operations within an enterprise? What partnerships are necessary with other enterprises in the ecosystem and how does that affect the business operations underlying the service delivery? There are numerous such issues that span multiple business architecture domains; reasoning on these issues is facilitated through a set of five interrelated models as presented in the core business architecture.

From the perspective of business-modeling tool integration, the core business architecture also supports better design by promoting the use of interrelated business domain models. Today, many business modeling tools have been developed for single business domains, using tool-specific underlying metamodels. Even within a single vendor, tool portfolios that have grown through acquisitions have incompatible metamodels; therefore, models created in one domain cannot easily be bridged to models in other domains. One solution to tool integration is to create point-to-point transformations across domains. A more efficient solution, however, is to treat various business modeling tools as providing different views of the integrated business architecture models. This benefit can be seen in a narrower context; whereas IBM Rational* Software offers a number of bundles and suites for software development,[3] it has only one architectural model.

Another important use of business architecture is in the semiautomated transformation of business designs into IT solutions, as demonstrated by the IBM model-driven business transformation (MDBT) technique.[4] For example, a business artifact such as a "customer order" contains basic information about the names of the properties of a customer order. Such business information within the business architecture can be the start of an IT solution design that adds details, such as the maximum number of line items in an order. This suggests that business architecture modeling can have profound implications for information-system modeling and implementation.

Motivation and approach

Software modeling has been a very active area of research and practice. The Object Management Group (www.omg.org) has pioneered the Model-Driven Architecture** and a variety of models that are used to develop software solutions. These approaches use model-to-model transformations to transform a computation-independent model (the OMG** term for the business-independent model) into a platform-specific model. At the IBM Research Division, MDBT has been used to develop models and tools for business transformation engagements. In *Figure 1* we show the four-layer modeling framework that lies at the heart of MDBT and use it to position the core business architecture elements proposed in this paper. The arrows in the upper right corner show those five elements making an impact on planning and design activities in the business domain. Although MDBT introduces business-domain-related models, the bulk of the tooling emphasis has been on the IT domain, which is much more mature in terms of both concepts and model-to-model transformation techniques. Our work complements MDBT by exploring models for the business domain in greater detail.

For the business domain, there have been a number of approaches that model and formalize business intent toward the goal of building IT solutions that support business needs. A number of methodologies were developed (e.g., Jackson Development Methodology)[5] for capturing business requirements in a systematic and unambiguous manner, primarily to support IT development. The need for specifying business architecture was recognized and some progress was made, especially in the last five years. Traditionally, the business was represented as a loose conglomeration of more formal constructs such as process models, organization models, and IT architecture models. Zachman's seminal framework became the starting point for formalizing enterprise architecture.[6] Over the years, a number of tools have been developed to capture enterprise architecture, such as the Telelogic System Architect** product from Telelogic AB.[7] Enterprise architectures provide a systematic documentation of the linkages within a business architecture but do not support the formal reasoning that affects business and IT transformations. A typical reaction from customers has been, "This is a comprehensive enterprise architecture, but what can I do with it?" A number of enterprise architecture frameworks have

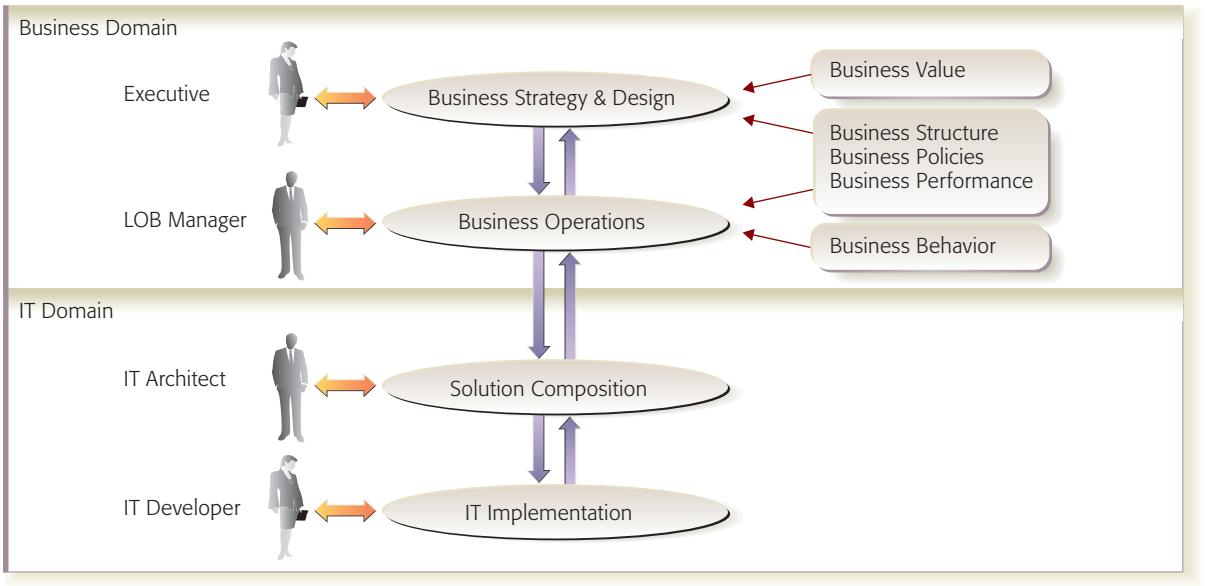

Figure 1
Positioning of business architectural domains with respect to the MDBT layers

been proposed, such as The Open Group Architecture Framework (TOGAF**) from The Open Group (see, for example, Reference 8) and the Department of Defense Architecture Framework (DoDAF) from the United States Department of Defense.[9] Strosnider et al. have proposed BizADS (Business Architecture Development Standards),[10] which was the first comprehensive attempt at defining and providing a model for business architecture within IBM. This specification, rooted in linguistic grammar concepts, is fairly complex and, without integrated tooling support, has seen limited adoption within the practitioner community. On the business side, the balanced scorecard[11] is an intuitive and practitioner-centered approach for measuring business performance, but it is easily integrated with other formal aspects of a business.

The current trend toward a service-oriented enterprise necessitates a formal characterization of business architecture that reflects service-oriented business thinking. For example, consider the situation in which a business has plans to introduce a new service offering. From the IT perspective, SOA techniques allow one to model the functional aspects of the service in order to develop an appropriate IT solution, but, from the business perspective, there are several aspects of this new service that are not adequately modeled within the business architecture. Models related to understanding the business value of the service, commercializing the service, making services operational, modeling service performance expectations, service governance terms, assessing the partnership requirements for service delivery, and so forth are at best handled in an ad hoc and inconsistent manner within the business architecture. Furthermore, because the business domain models are interdependent, understanding and accounting for the interrelationships among the various models is critical to successfully designing and introducing the new service.

One of our motivations in developing a core business architecture spanning multiple business domains is to use it as a framework to facilitate service-oriented business reasoning. Hence, the core business architecture presented in this paper has several salient characteristics that differentiate it from work to date. Primarily, we develop formal relationships between the different entities that constitute the business architecture. Using a small number of key architectural elements, we show how these can be used in a business scenario related to introducing a new service offering. We describe a number of simple link concepts such as offerings, business components, and business artifacts, that allow us to reason all the way from business goals to their eventual IT realization. Another area of

differentiation is our treatment of business service as a first-class modeling entity within the business architecture. Most service-oriented structures start at the IT end and encapsulate IT capabilities as services. In the architecture that we describe, business service relates to all the key business architecture domains, and much attention is paid to modeling both the business aspects and the operational aspects of business services.

We have selected a business scenario from the retail industry to help demonstrate the feasibility of our approach. Apparel Company is a fictional company inspired by Li and Fung[12] that works with clothing retailers to provide them a complete production-planning service (refer to ***Figure 2***). Instead of manufacturing and supplying apparel to various clothing retailers, Apparel Company primarily coordinates the flow of material and information across various enterprises in its global supply chain of textile manufacturers and other material vendors, clothing assemblers, logistics providers, clothing retailers, etc. The annotations on most of the figures reflect examples relevant to a service-oriented enterprise such as Apparel Company in offering a production-planning service.

In the following sections, we present details of the core business architecture models, including diagrams annotated with an example from the retail clothing industry. Finally, a scenario illustrating the business issues related to introduction of a new service offering is presented to further demonstrate the usefulness of our approach for business reasoning through a case study. We conclude the paper with a discussion of some of the challenges involved in realizing the concepts presented herein.

BUSINESS DOMAIN MODELS IN THE CORE BUSINESS ARCHITECTURE

As mentioned earlier, the business domains represented in the core business architecture are business value, business structure, business behavior, business policies, and business performance. In this section we describe our approach by discussing the five aspects of business architecture and the corresponding models.

Business value model

Most economists believe that the objective of a business (operating within its value network) is to maximize the economic value it creates. Value is

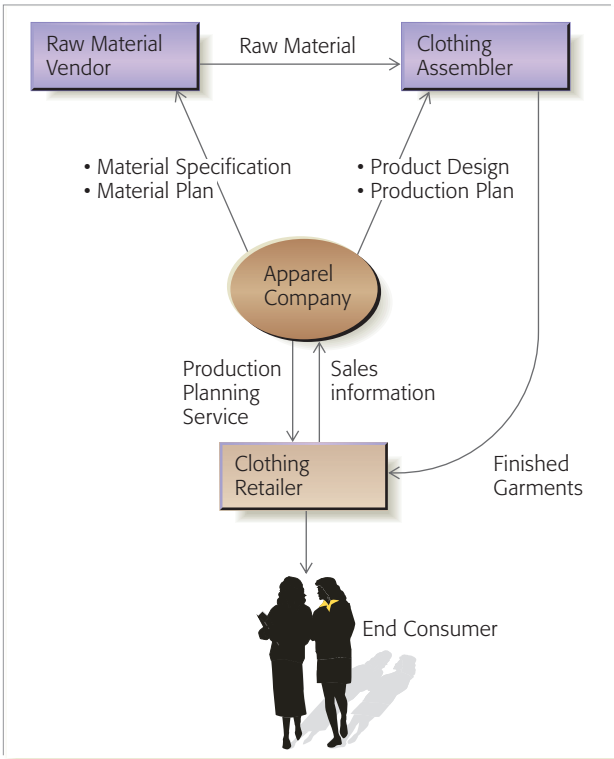

Figure 2
Business operations of Apparel Company

increased when value inflow exceeds value outflow within an enterprise, where value is captured by financial measures. Because such analysis requires financial data, it makes sense to apply accrued value calculations only at the granularity of the enterprise or its lines of business, where such information is readily available. ***Figure 3*** shows the elements of business value relevant to the core business architecture. These elements include the economic entity, its offerings, and the value provided by these offerings, as described below.

Economic entity

An economic entity is an accounting term that applies to any organization or unit in society, such as a hospital, company, municipality, or federal agency. In commercial business, it refers to a group of entities comprising the parent entity and each of its subsidiaries. In our business value model, the economic entity provides value through its offerings.

Offering

For any economic entity, the offerings that it provides and consumes include products, services,

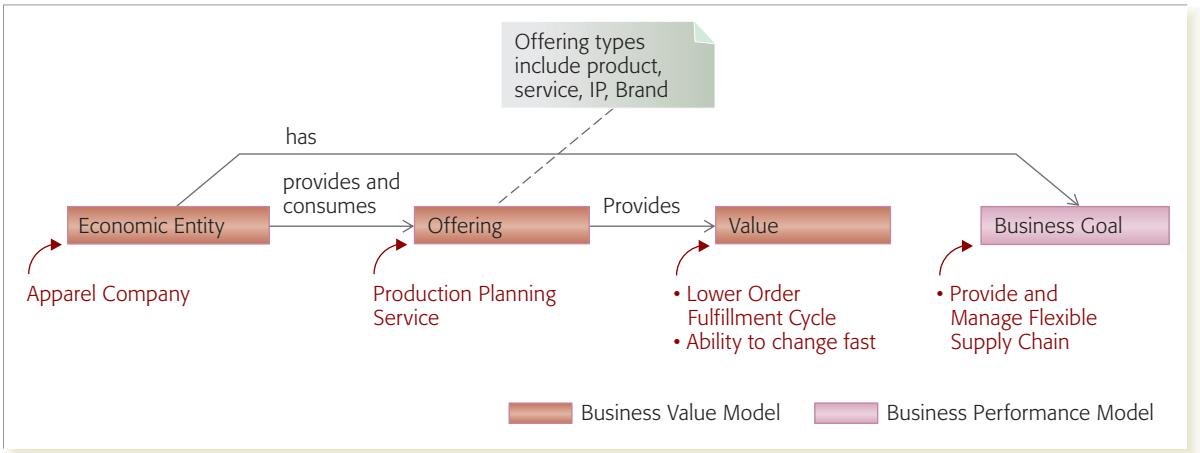

Figure 3
Business value model

intellectual property, and brand-related value.[13] Various combinations of these offering types flow through the value network in which the economic entity participates. For a service-oriented enterprise, its business services are indeed a major part of its offering portfolio. In providing these business services, the design of the business structure as well as business behavior models are strongly influenced by the design of the business value model.

Value

The value provided by an enterprise is primarily through its offerings and measured in terms of financial metrics. One of the advantages of modeling value within a network is that it allows one to decouple the flow of value from the financial flows involved in any business transaction. This separation allows one to analyze the value flow within the network and thereby identify business relationships that are established for value transfer and not necessarily financial flows.

Also shown in Figure 3 is an element representing the business goals of the economic entity (part of the business performance model).

The core business value model presented above can be extended to support various analyses including the value-network analysis (VNA). VNA is an emerging research area to model the flow of value within a value network, which describes the value contributed by various economic entities and can help in creating business strategies for designing offering portfolios and for identifying partner relationships to pursue in order to increase residual value.

Business structure model

The business structure model discussed in this paper reflects the architecture of specialized enterprises,[14] which offer business services and are best described in the form of business components. Examples of such specialized enterprises are fairly common today, especially within the finance industry, where many financial transactions involve participation by many different parties. Today, business components represent a logical grouping of the work done within the enterprise. However, as more businesses view themselves as specialized enterprises offering specific functions and skills, it will become easier to design enterprises as groupings of service centers based on business components. Within an enterprise, the business components can then be tightly or loosely coupled to implement business processes through "choreography" of their business services.

Figure 4 shows that the business structure model consists of business components and associated business artifacts, business services offered, and the strategic capability that can be derived through collaboration among various business components. This core business structure model can be extended to support a variety of analyses, including understanding work distribution within the enterprise, IT application coverage of various business components, generating a business component heat map (a

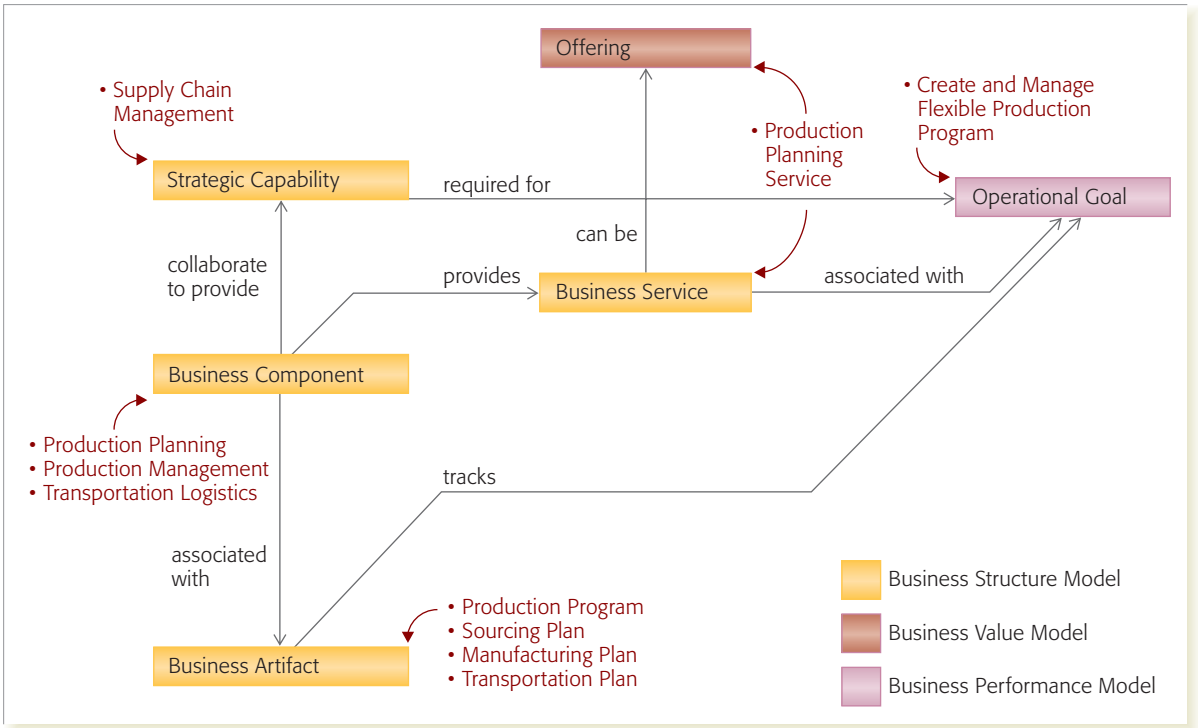

Figure 4
Business structure model

diagram that profiles these components), and so on. For example, the IBM Component Business Model* (CBM) comprises tools and method guidance to help clients make investment decisions or create a road map for business transformation.[15] Other promising areas for extending the core business architecture relate to newer techniques for establishing business component boundaries and realizing operations of business components in various ways, including composite business services and service centers with associated ownership and responsibilities, resource management capabilities, service management capabilities, and so on.

Traditionally, organizational structure has also been an important element in describing aspects of business structure. Although this is an important topic for discussion, it is outside the scope of this paper. This is primarily because our focus has been on those elements of business architecture that are critical to transforming business designs into IT solutions. In the future, we may include organizational structural elements and their interrelationships with other business architecture domain elements, especially because concepts of social networking and related technologies are providing useful insight into how work actually gets done within an enterprise and have led to new design ideas about how organizations should be restructured.

Business components

It is useful to group work done within an enterprise by means of a logical framework of business components in order to understand the enterprise structure and how various business resources such as people, processes, and technology are allocated throughout the enterprise. A framework based on business components also helps in making decisions regarding the sourcing of business services, such as the decision as to which services to develop in-house and which to source from business partners. Such insights can lead to better decision making regarding investments for various business transformation initiatives within the enterprise.

The IBM approach to representing componentized businesses within an industry involves the use of

CBM maps. The business components are grouped along two dimensions. Columns represent business components related to a single business competency. An enterprise requires a specific set of business competencies in order to compete within its industry, and these competencies are shown as column headings in the CBM map. The business components within each competency are further organized by accountability level—direct, control, or execute. The *direct* accountability level refers to a grouping of components that are responsible for setting the policies and direction within a business competency. The *control* accountability level refers to a grouping of components that are responsible for controlling and managing the work associated with a business competency. The *execute* accountability level refers to a grouping of components that are responsible for executing the work within a business competency. Additional details on CBM maps can be found in Reference 16.

Business artifacts

A business artifact is a concrete entity whose purpose is to track the progress toward a specific operational goal within the business. Each business component is responsible for managing the life cycle of the specific business artifacts that are related to work done within the business component. The life cycle of a business artifact is described in terms of the states through which it transforms. We identify at least three business artifacts associated with any business component—one is specific to the purpose of the component, and the other two are applicable to all business components. In the case of Apparel Company, the Production-Planning business component is responsible for the life cycle of the Production-Program business artifact, which tracks the operational goal of Creating and Managing a flexible Production Program. The other two generic business artifacts are Service Request and Resource Administration Request. Each business component has its own instances of these business artifacts, and their life cycles help to organize and manage work within these business components. The life cycle of the Service-Request business artifact ensures that each request is handled to completion within the business component and that any problem states are properly dealt with. Similarly, the life cycle of the Resource-Administration-Request business artifact ensures that appropriate resources are made available to each business task so that it can achieve the operational goals.

Business services

Business "componentization" promotes the concept that work performed within a business component can be offered as a business service, thus making a tight relationship between business components and business services. An example can be found in the case study by Kumaran et al.[17] Each business component provides certain business services and also consumes business services offered by other components. To provide specific business behavior, business components collaborate through "choreography" of services offered by other components. Business services offered by an economic entity are, in fact, a subset of business services offered by business components within the economic entity.

In the context of the business structure model, business service is described in terms of "what" the business service does. The description of "how" the business service operates is included within the business behavior model, which is discussed in a later section.

Strategic capability

Any enterprise differentiates itself in the marketplace by leveraging specific capabilities that allow it to achieve its operational goals. For example, if Apparel Company has an operational goal to provide clothing per new design on demand, then it requires a strategic capability to effectively manage a globally dispersed supply chain, for which an enabling capability is establishment of trusted relationships with a large number of globally dispersed vendors and manufacturers. Development of this supply-chain management capability leverages multiple business components, including production planning, production management, transportation logistics, and so on, and manifests itself through the choreography of appropriate services offered by these business components.

Business behavior model

In the context of a service-oriented enterprise, business services provide the foundation for the business behavior model, which describes business operations as viewed from within the enterprise and as viewed from outside (the latter in the form of business services). For purposes of our discussion, we highlight these aspects through two scenarios. The first scenario is related to realizing business service functions, and the second scenario is related

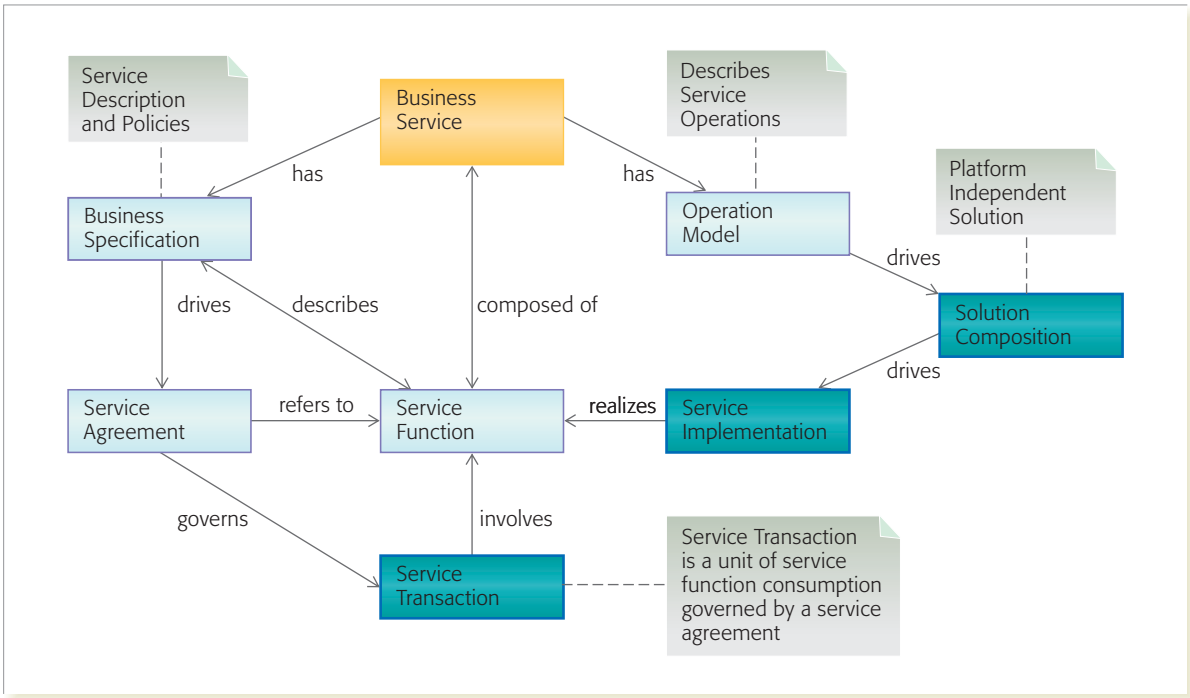

Figure 5
Business service model

to consuming these service functions within end-to-end processes. Both of these scenarios of business behavior leverage business services, which brings us to an important discussion about how business services should be modeled. The service models that are widely published in the literature are primarily Web services, which have been designed from the perspective of application integration and interoperability across heterogeneous systems. These service models are not suitable for modeling business behavior, which is our purpose here. We require a model of business services that is designed from the perspective of business people and supports flexible and value-added partnering among businesses.

In our view, a business service has two aspects—its business specification and its service operation model[18] (refer to ***Figure 5***). A service can have multiple business specifications and multiple service operation models. The service provider can use its own business logic to associate a business specification with an appropriate operation model during service provisioning. Figure 5 includes three elements from related models, not elaborated upon in this paper, to show where solution composition builds upon the specifications and models. Both the business specification and service operation model are inputs into service-oriented solution composition when techniques such as MDBT are used.

Business specification of a service

The business specification of a business service describes a business person's perspective regarding what the service does, how the service is consumed, how its performance is measured, and how the service is managed. Some or all aspects of the business specification can be described by both the service provider and the service consumer. The respective business specifications then become the basis for matching the service consumer's needs with a service provider's services. They also form the basis of a service agreement between the service provider and the service consumer. The elements making up a business specification include the following:

1. Service preamble containing service name, general description (such as capabilities of the service and where it used), and provider information
2. Service functions associated with the particular business service (See ***Table 1*** for more about the

Table 1 Business services and the corresponding service functions

Characteristic	Service	Service Function
Exposure	Service exposed (advertised) by means of a catalog	Function not independently exposed in a catalog except as a function provided by a service
Bundling or nesting or both	Service bundles one or more functions	Functions can invoke other functions but do not bundle multiple functions
Invocation	Service cannot be invoked, but a service agreement has to be in place (implicit or explicit) before invocation of its functions	Functions within a service are invoked by service requestors
Agreement terms	Terms are established for the service but can refer or apply to specific functions	Terms refer to functions only in the context of a service agreement
Discovery	Service can be discovered by searching a service catalog	Functions are indirectly discovered through services. Functions are not listed in a catalog without belonging to a service.
Ownership	Service can be owned by provider	No function-level ownership
Atomicity (runs to completion without cancellation)	Does not apply to service except in a degenerate case	Interaction with a function within a service can be either atomic or conversational (i.e., sequence of interactions)

distinction between services and their service functions.)

3. Service interaction model, showing the sequence of commitments from various parties involved in a service transaction
4. Terms and conditions governing various aspects of the business service, which are expressed using business policies, business rules, and business vocabulary and are related to service consumption (e.g., service delivery, financial details), service management (e.g., exception management, governance policies), and service performance (e.g., performance metrics, nonperformance penalties).

The service agreement represents the realization of a business specification that is acceptable to both service provider and consumer and can be unique for each relationship. From an operations perspective, the service agreement can be used to validate whether the service operations will indeed meet the terms agreed to between the two parties. It also provides the requirements for developing the service performance monitoring solution.

Service operation model

The service operation model describes how a service function within an offered service should be realized. The model allows the service provider to communicate the description of service operations to the service implementor as well as the service consumer. *Figure 6* shows the main elements within the service operation model, which includes service function, business task, and resources. In the Apparel Company business scenario, a service function such as Create Production Program involves business tasks, such as Assign Manufacturers, which leverage resources such as a catalog of trusted vendors. The assignment of manufacturers results in the Production-Program business artifact changing its state to Manufacturers Assigned. Additional relevant elements include offered business services and business artifacts from the business structure model, business policy from the business policy model, and operational goals from the business performance model.

Business tasks. In our approach to modeling the business component's operations, business artifacts play an important role in identifying the business tasks performed within a business component. Starting with a business artifact, the business operation can be created as a graph of business tasks and as repositories through which the artifact flows during its life cycle. Details of business artifacts and operational modeling can be found elsewhere.[19,20]

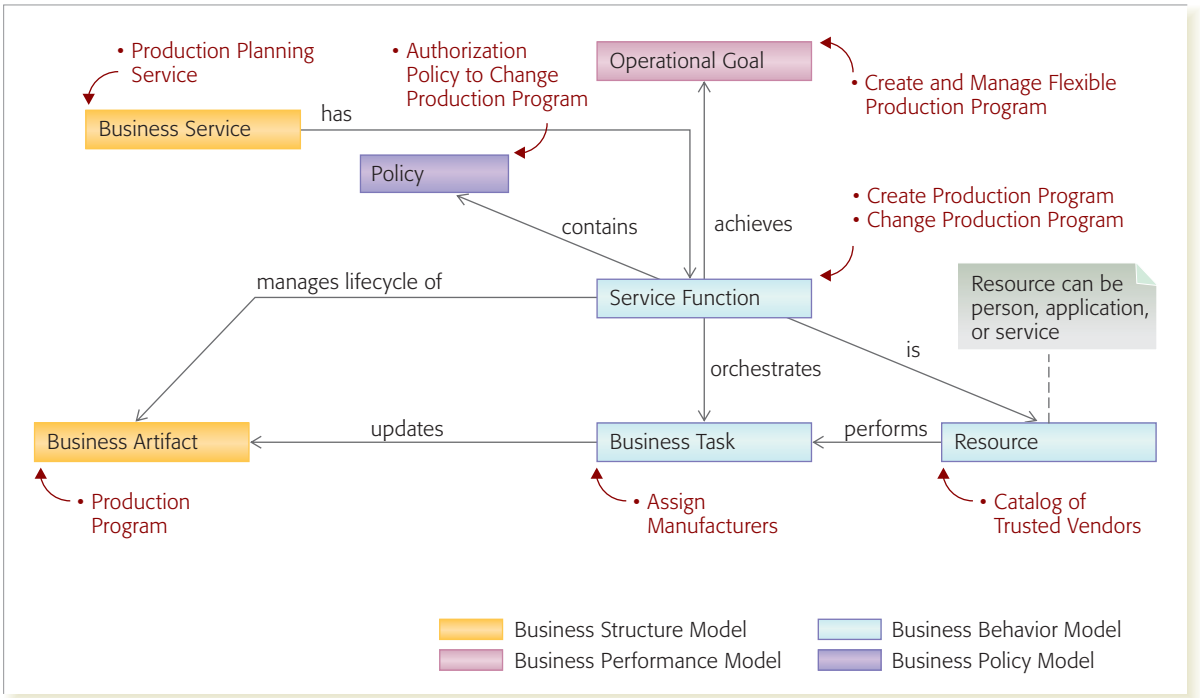

Figure 6
Service operation model

For Apparel Company, the business tasks within the Production-Planning business component are derived by analyzing the life cycle of the Production-Program business artifact. Each business task is meaningful for achieving the Create-and-Manage-Flexible-Production-Program operational goal. From the business modeling perspective, each business task represents a unit of work that makes some significant change to the state of the business artifact. In our example, the Schedule-Raw-Material business task is completed before the Production-Program state can change from Open to Supply Committed. Other states in the life cycle of the Production-Program business artifact include Manufacturers Assigned, Manufacturing Capacity Committed, Program Approved, Program Suspended, Program Archived, and Program Expired.

Resources. Business tasks apply resources toward achieving their operational goals. Completing a business task requires resources, which can be people, processes, applications, and third-party services. Resources called business performance managers are associated with ensuring that commitments to clients are adequately satisfied.

Service function. The service functions of a business service that is offered by a business component are instrumental in achieving the operational goals. They are also the externally visible part of the operations of the business component. For a service such as Production Planning, offered by the Production-Planning Component, the service functions include Create Production Program, Change Production Program, and so forth. The service function can be developed either in-house or completely outsourced to a third party for implementation. When completely outsourced, the service provider creates the business requirements for the service function and locates service implementors that can deliver this service function. These business requirements are in fact modeled as a business specification for the consumed service, as mentioned in the previous section. When the service function is more complex and developed in-house, then the service operation model can be modeled by using two mechanisms: business "service choreography" and "process orchestration." Business service choreography describes business behavior as a sequence of commitments between one or more service providers and the service consumer during the life cycle of a business service transaction. In

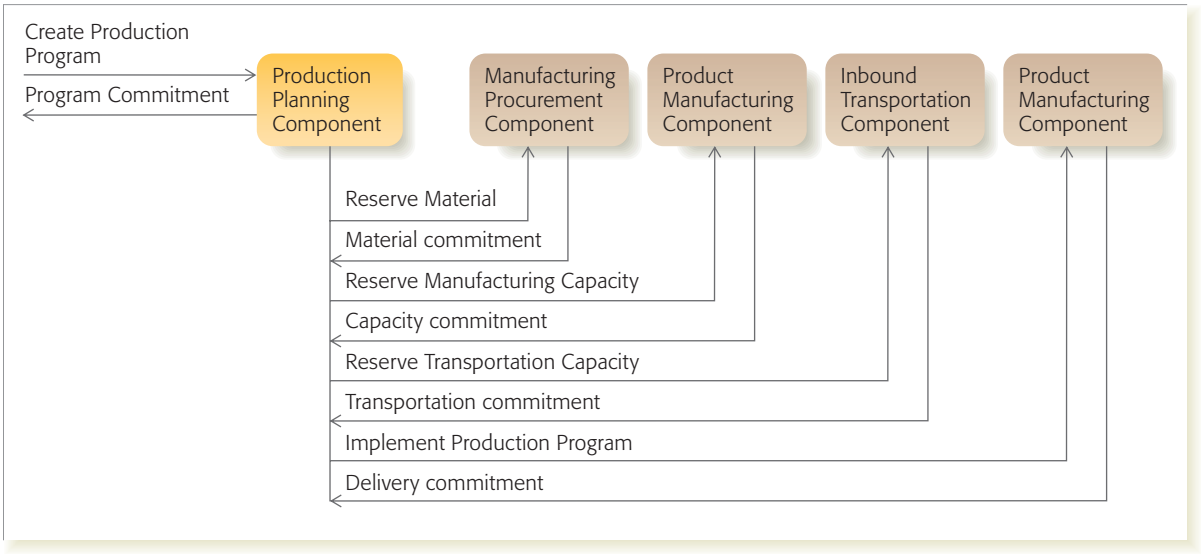

Figure 7
Service Choreography (Apparel Company)

contrast, process orchestration describes business behavior through a sequence of business tasks performed by a variety of resources, including people, applications, and services from business partners. The following sections cover details of these two mechanisms for modeling business behavior.

Note that service choreography in modeling business behavior describes a sequence of business commitments, whereas in modeling the SOA-based IT solution design, service choreography is a sequence of service function invocations. This distinction allows the two models to be separated, providing flexibility in implementing business services, through both SOA-based and other IT solutions.

Business service choreography. The choreography of business services, which could be provided by various business partners, is modeled as a sequence of commitments between the service consumer and the service providers. For example, the Program Commitment given by the Production-Planning component reflects the commitments it receives from the Procurement, Inbound Transportation, and Product-Manufacturing components (refer to ***Figure 7***).

The steps involved in creating such a model begin with identifying the business flow logic at the highest level, as a sequence of business tasks. These business tasks are accomplished by business service functions provided by various business components. These business tasks need not be decomposed any further. Instead the business specification for the consumed service is created, including various policies associated with service performance, service consumption, service management, and so forth. These policies are used to locate services from various providers or serve as the requirements for service implementors. Eventually, the finalized service agreement between the service consumer and a service provider will also be used to monitor each service transaction for financial settlement and other purposes.

Process orchestration. To model a service function as a process orchestration, one needs to first identify all the business tasks within the business component that are relevant to the service function design. The service function can then be modeled as a sequence of business tasks performed by various resources on the business artifacts to achieve the operational goal. In ***Figure 8***, the Change-Production-Program service function, offered by the Production-Planning component, is modeled as a process orchestration. Several business tasks, such as Adjust Sourcing and Adjust Transportation, are performed in-house by using various resources, including people, decision support applications, and

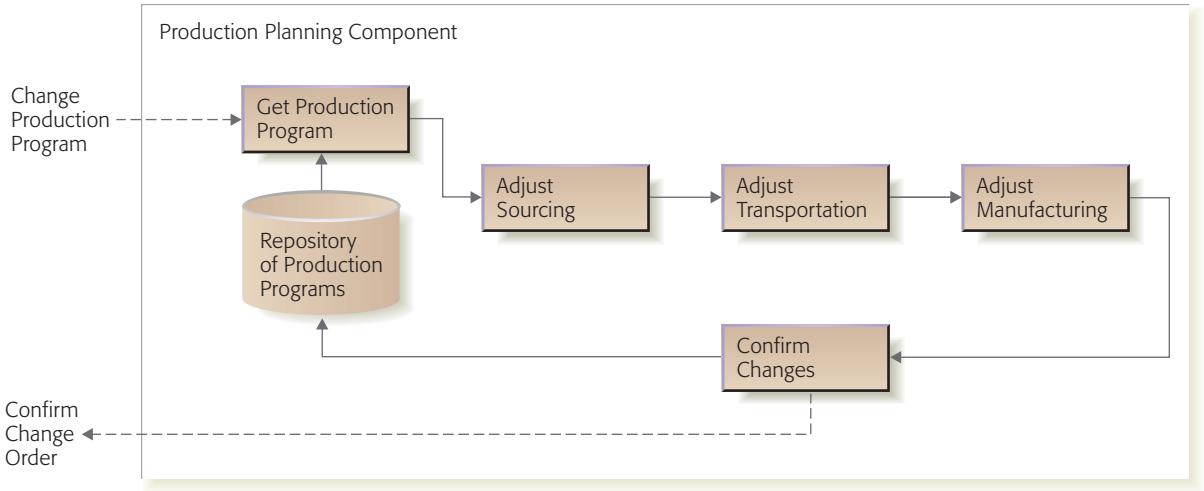

Figure 8
Process Orchestration - "Change Order" (Apparel Company)

so forth. Some of these resources could also be external services such as the Adjust-Transportation Web service offered by the logistics provider.

Note that several service functions can share the same business task. Any deadlock or contention between service functions is avoided through the use of business rules based on the state of the business artifact being processed. In some cases, additional business tasks may be introduced within the process orchestration to change the business artifact into an appropriate state. This is one reason for using business artifacts in modeling the behavior of a business component.

End-to-end process modeling

Although service-oriented enterprises are characterized by service-oriented business thinking in both providing and consuming of services, one can expect that there will be large-grained business processes within any enterprise that are more associated with consuming services and are not necessarily part of any service-function realization. Even in these situations, the two business behaviors discussed in the previous section, business service choreography and process orchestration, are useful in modeling the behavior of end-to-end processes. We do not treat the modeling of the business behavior of end-to-end processes any differently than we treat the modeling of service operations, but, when multiple service providers are involved in supporting an end-to-end process or a service function, their commitments to the service consumer are better modeled through the business service choreography approach.

Business performance model

Enterprises define performance goals to meet their mission and to set strategic direction. Once an enterprise has analyzed its direction and defined its goals, it needs a way to measure progress toward those goals. Many factors contribute to the success of an organization. KPIs (key performance indicators) are used by businesses to define and measure progress toward their goals and represent quantifiable measurable objectives, agreed to beforehand, that reflect the critical success factors of an organization. For example, The Supply-Chain Operations Reference model (SCOR)[21] is a process reference model that has been developed and endorsed by the Supply-Chain Council as the cross-industry standard diagnostic tool for supply-chain management. SCOR enables users to address, improve, and communicate supply-chain management practices within and between all interested parties. In SCOR, the supply chain KPIs are defined and expected to be used by business analysts in the supply-chain management domain. The selection of metrics treated as KPIs is based on domain and industry knowledge. The metrics themselves are computed from other metrics and measurements. Further details can be found in another paper in this issue.[22]

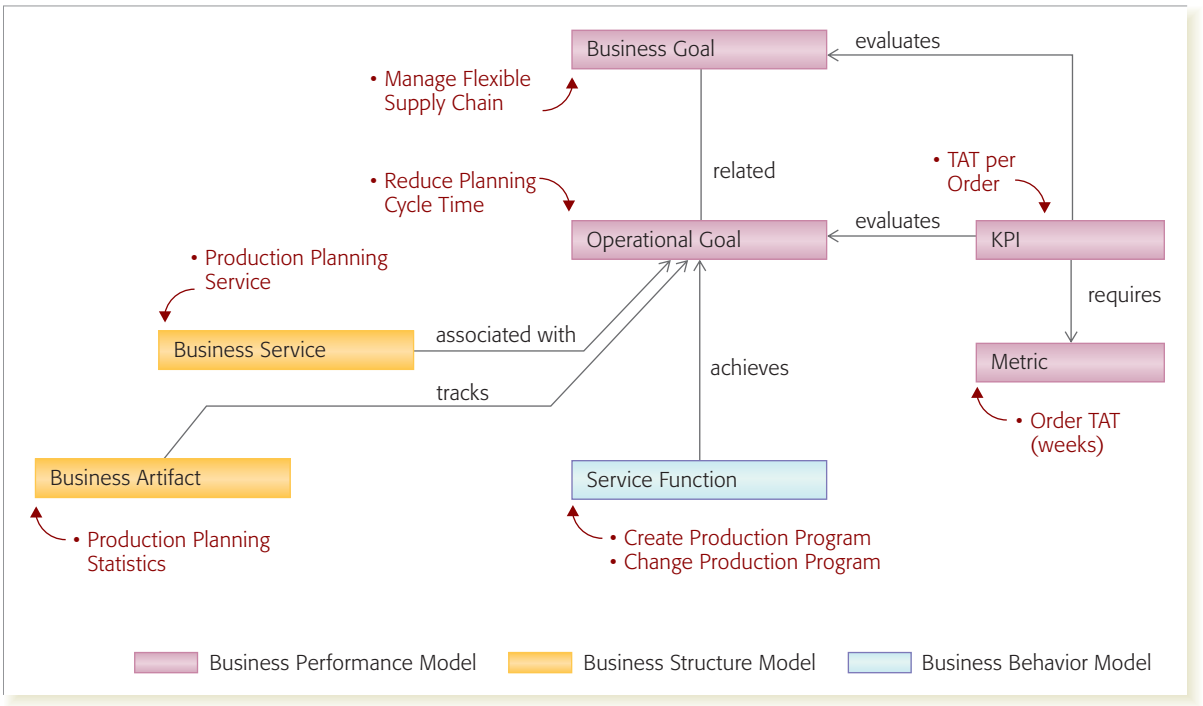

Figure 9
Business Performance Modeling

Evaluation of business performance happens at various levels within the enterprise. To achieve the business goals, which are established at the enterprise level, a set of operational goals are established to evaluate the performance of various business activities. Both the business goals and the operational goals are evaluated in terms of KPIs, and the translation of the business goals into operational goals in many cases is based on industry and domain knowledge. In a service-oriented enterprise, these operational goals are achieved through service functions. As shown in ***Figure 9***, the model elements useful in modeling business performance include business goals, operational goals, KPIs and other metrics, business service, service function, and the business artifact.

The operationalization of the business performance model introduces the concept of commitments from management of the service provider organization to its clients. Such a commitment model is composed of four element models from the core business architecture: goal, artifact, business performance manager (resource), and service function to manage business performance. Methodologically, the steps in developing a commitment model include the following:

1. *Identifying business goals through analysis of business performance in an enterprise*—In addition to asking what goals the business is expected to achieve, an analyst also asks, "What needs to be done when the desired goal cannot be achieved?" For higher goals, interviews with business owners and executives are sometimes necessary for discovering and defining enterprise goals. IT-level goals can often be derived from the nonfunctional perspectives at the business level such as security and availability.
2. *Identifying business artifacts representing metrics, situations, decisions, and actions*—Artifacts, relationships, and attributes are identified from goal specifications. Among the business artifacts, a metric artifact measures a goal; for example, the goal "reduce planning cycle time" could be measured by the metric called turnaround time (TAT). Situation artifacts define business conditions of concern—for example, excessive TAT for the Production-Planning service. Decision artifacts define the logic of responding to specific situations. Action artifacts contain the real

Table 2 Types of business rules

	Modality Type	Example in SBVR Structured English
Structural	necessity	**An** order **always** *has* **exactly one** customer.
	possibility	**It is possible that an** order *has* **more than one** line item.
	impossibility	**An** order **never** *includes* **another** order.
Behavioral	obligation	**Each** order **must** *be processed* **within** one business day.
	permission	**A** customer representative **may** *approve* **a** credit.
	prohibition	**A** clerk **must not** *change* **the** terms and conditions.

management directives that apply to the target business service.

3. *Defining business performance managers (BPMs) within the organization responsible for achieving the goals*—BPMs can take many forms: human agents, automated software agents, business process agents, and so on. BPMs interact with one another for the sake of achieving business goals associated with them. BPMs sense changes in their environment and respond to business situations with elaborate decisions and actions.
4. *Defining the services of BPMs that enable them to achieve the goals*—Note that the assignment of service functions to BPMs needs to take into consideration the granularity of the business services being managed. For example, a production-planning service for a clothing retail chain has a very different scope compared to another service for responding to shipment delays from a single supplier. This assignment is facilitated by the fact that each business service is tied to the fulfillment of specific business goals, which can be used to match the BPMs that provide service functions for fulfilling the same goals.

Business policies and rules

Policies of all kinds pervade businesses. They occur in outward-facing service definitions such as service agreements, information models, and performance metrics. They also inform computations and decisions in the implementation of internal components. Policies arise from internal sources such as business needs, from corporate-level guidance, from external laws and regulations, and from ethical motivations. Based on the OMG *Business Motivation Model* (BMM),[23] such policies "govern or guide an enterprise," specifying business design aspects that complement information and operation models. Policies thus are an important element within the business architecture of service-oriented enterprises.

Business policies are written in natural languages for evaluation by human beings. That evaluation requires two types of interpretation. First, the ambiguities of natural languages always demand clarification. Second, application of policies to specific business contexts generally requires analysis of impacts, consequences, and trade-offs. Thus, policies provide guidance but insufficient detail for implementation.

The application of policies in specific contexts leads to *business rules*, meaning highly structured, discrete, atomic statements "carefully expressed in terms of a vocabulary." Thus, business rules are based on and derived from business policies. These concepts are standardized in the BMM and the OMG *Semantics of Business Vocabulary and Rules (SBVR)*.[24] SBVR uses the terms "practicable" and "enforceable" to distinguish rules from policies.

Business rules, in the sense used here, are about business requirements, rather than about execution. Several key characteristics distinguish business rules from IT-level rules:

1. Business rules specify "modalities" about what is necessary, possible, impossible, obligated, permitted, or prohibited. These capture important senses of real-world regulations, contracts, service agreements, and business practices. ***Table 2*** lists the key modalities defined in SBVR and gives an example of each. In these examples, SBVR keywords are given in boldface, terms (names for objects) are underlined, and verbs (names for relationships) are in italic.
2. Business rules are expressed in a form meaningful to business users. For example, the SBVR specification proposes two variations of "Structured English," and three diagram-based representations of business vocabularies. Similar work

in academia[25–27] has demonstrated "Controlled English" tools for capturing business rules.

The common objectives of these forms of expression are precision and clarity among business users and between business users and IT implementation staff.

Business rules may address individual entities (artifacts, people, or organizations) or groups of entities. Rules are built from logical connectives ("and," "or," "if-then," and so forth) that connect clauses built from relationships in the information model. Many business rules compute or test formulae. For example, service-level agreements may use rules such as "95 percent of all incoming customer orders must be fulfilled within two days of receipt." Thus, business-rule concepts are founded upon well-established concepts in mathematics and philosophy.

Business rules, in the sense described here, model "what" is required, rather than "how" it should be implemented. The power of this approach becomes clear when one considers implementation issues. In many cases, a single business rule must be implemented in multiple aspects of an implementation. Consider an order-processing system that supports both paper-based and Web-based application interfaces. The rule "**It is possible that an** order *has* **more than one** line item" might need to be supported in both user interfaces. The one-to-many mapping of business rules to implementation functions is a key characteristic of business rules.

Business rules complement business-level information and operation models by capturing information generally not described in either. For example, the obligation cited above, "each order must be processed within two business days," cannot be modeled directly in standard modeling techniques, such as Business Process Modeling Notation (BPMN).[28] Business rules may extend various aspects of other kinds of models, such as:

- *Operation models*—Rules may specify the details of decisions, guards, and computations.
- *Specification models*—Rules may detail service agreement terms, such as business performance criteria.
- *Business performance models*—rules may define how to calculate metrics, when to generate alarms, and so forth.
- *Information models*—rules may qualify aspects of information relationships.

An interdependency exists between business rules and business information models. Business rules reference the terms and relationships defined in business information models. The examples cited above mention terms such as "order," "line item," "clerk," and relationships such as "order has line item" and "customer representative approves credit." Typically, a business-level information model evolves to support the rules, and vice versa. It provides the "vocabulary" referenced by various elements within the business architecture. Business-level information modeling covers three key elements:

1. Named service objects, such as order, customer, and so forth
2. Properties of the service objects, such as the name of a customer
3. Relationships among service objects, such as an association between order and customer.

One of the major challenges in implementing business rules is the sheer number of such rules within any business. In a client engagement involving one of the authors, the first approach to codify some business rules involved the use of a spreadsheet that grew to 25,000 cells for a single product-brand process. Extrapolating to other product brands could have resulted in the spreadsheet size growing to 100,000 cells, which obviously is difficult to manage, understand, or apply consistently. Fortunately, in this case, the rules had a very symmetrical structure, with systematic variations across the multiple brands and process variations. The manageable solution exploited the symmetry by employing roughly 500 business rules that were dynamically applied depending on the particular brand or business scenario.

BUSINESS SCENARIO: INTRODUCING A NEW SERVICE OFFERING

The core business architecture presented in this paper can be used for various business reasoning situations. We illustrate its relevance and usefulness in the context of launching a new Production-Planning business service at the fictional firm Apparel Company. Launching a new service is a major event for most large enterprises and involves making several business decisions as well as

designing the service operations. Multiple business analysts and consultants may simultaneously work on various steps in the new service introduction method. In such a dynamic environment, it is easy to lose sight of the original business goals driving the new service design and its implementation. However, the interrelated models within the core business architecture preserve the integrity of the business intent by ensuring that information captured once within each model is kept current across all tools viewing that model. The interrelated models also allow information to be entered out of sequence, which is helpful when information is available in bits and pieces during client engagements. The following steps describe a method for introducing a new business service and highlight the contribution of various model elements within the core business architecture toward supporting it:

Step 1. Establishing business goals—Most business transformation projects require a thorough understanding of the business goals of the enterprise, such as increasing revenue, reducing costs, and entering new markets. The business goals are usually modeled using elements within the *business performance model* of the core business architecture. For Apparel Company, the business goal is revenue growth.

Step 2. Identifying new service opportunities—For a service-oriented enterprise whose business goal is to grow revenue, introducing new service offerings is a logical next step. Deciding which new offering to introduce can be analyzed through the value network analysis (VNA) technique that leverages the *business value model*. In the case of Apparel Company, it recognizes opportunities related to providing production planning, logistics management, and product design services to other firms within its value network. It also finds that the production-planning service has the highest potential for revenue growth. The *business structure model* provides the modeling elements to describe the various business services offered by Apparel Company, including their business specification through the *business behavior model*, which expresses *business policies* related to service consumption, service management, and service governance using industry- and domain-specific vocabulary.

Step 3. Evaluating business capabilities and partnerships—The ability to introduce a new Production-Planning service in a competitive manner requires analysis of Apparel Company's capabilities. The IBM CBM analysis technique, based on a componentized view of business, leverages the *business structure model*, allowing one to make sourcing decisions regarding the business capabilities, that is, whether to invest in improving in-house capabilities or to leverage capabilities of business partners. Additionally, should Apparel Company decide to leverage the capabilities of its business partners, VNA techniques based on the *business value model* can help decide the most suitable partners within its value network.

Step 4. Setting operational goals for the new service offering—Regardless of whether the new service offering captured in the *business structure model* is delivered using in-house capabilities or those of its business partners, Apparel Company has to set operational goals for the new production-planning service, including service performance metrics that will help evaluate achievement of these goals. The operational goals (e.g., Create and Manage Flexible Production Program) are derived from the business goal of increasing revenue growth by using subject matter expertise and evaluated by using KPIs (e.g., Turnaround Time per Order) and other metrics described by the *business performance model*.

Step 5. Identifying key business artifacts—Achieving the operational goals of the Production-Planning service requires designing the operations of the service. Using the MDBT technique, service operations are modeled by identifying key business artifacts within the *business structure model* and analyzing their life cycles. For Apparel Company, the production plan itself serves as the key business artifact to model the operations within the Production-Planning component and contains all information required to evaluate progress toward achievement of the service operation goal of creating and managing a flexible production program.

Step 6. Modeling service operations—In the MDBT technique, the service operation model is defined in terms of states through which a business artifact defined in the *business structure model* progresses during its life cycle in achieving the service operational goals. For Apparel Company, the Production-Planning service operation is modeled in terms of the life cycle of the Production-Plan business artifact. Some of the business tasks within

the *business behavior model* responsible for the state transitions include Start Production Plan (resulting state: Open), Communicate Material Plan to Suppliers (resulting state: Supplier Commitment Pending), Compute Supplier Responses (resulting state: Supply Committed or Supply Shortfall), and Finalize Production Plan (resulting state: Closed).

Step 7. Locating resources for business tasks—Completing the business tasks associated with the production-planning service operation requires use of several resources, such as ERP (enterprise resource planning) systems with production-planning features, skilled employees performing various business roles, and services from other service providers. Apparel Company has a choice of leveraging its in-house ERP system to plan production, leveraging ERP systems available from application service providers, or outsourcing parts of the production-planning service operation to business partners. Such "make-versus-buy" analysis can be supported by CBM analysis and VNA techniques that leverage elements within the *business value model* and *business structure model*. Should the service operational goals defined in the *business performance model* change to create a production plan within one week, then Apparel Company may choose to identify outside service providers that can meet the requirements captured in the business specification of the service as described within the *business behavior model*.

The above scenario illustrates the interdependencies that exist between various business domain models which should be recognized and supported by tool designers and business-transformation solution developers. Identifying only specific interrelationships that are relevant to individual business situations can result in the development of a set of independent models that can be difficult to reconcile, integrate, and manage. A core business architecture, providing an extensible framework for introducing new attributes as necessary and spanning multiple business domains, is an important prerequisite for advancing business architecture-related concepts, techniques, and tools.

CONCLUDING REMARKS

In this paper, we introduce the concept of core business architecture for a service-oriented enterprise. We submit that the integrated metamodels spanning multiple business architecture domains are important to business reasoning, integrating business modeling tools, and supporting end-to-end business transformation engagements without loss of the original business intent. Although our discussion is by no means complete, we hope that the ideas will be embraced and enhanced by standards groups such as the Object Management Group and made available as industry standards in the future. Various business modeling tool vendors could implement domain-specific extensions to the core business architecture elements and yet still import and export project data based on metamodels compatible with the core business architecture to support integration across disparate tools. Much work remains to advance this concept and spread it through various communities. In the meantime, we plan to use the core business architecture as a teaching aid for explaining concepts relevant to the business architecture of a service-oriented enterprise and to demonstrate its usefulness as a framework for business reasoning.

Many enterprises that are aspiring to become service-oriented enterprises have embarked on SOA-based transformation projects within their IT environment, which should help improve both the governance and as the reuse of services within the enterprise. However, integrating business services across enterprises still remains a challenge due to lack of standards in many areas including service message formats, service nomenclature, service interfaces, and so forth. Further standards should accommodate differing cultures and laws rather than trying to standardize them, even though this adds complexity. The role of industry standard organizations and governmental agencies in developing relevant standards for business architecture including business services is important, although the results may not always be available in a timely manner nor be accepted by all parties involved.

The interest in modeling and analyzing various aspects of service-oriented enterprises and globally integrated enterprises is growing in various communities. Economists are exploring how the new reality of global trade in tasks differs from the global trade in goods,[29,30] and business strategists are exploring how best to design business component boundaries and source business services for vertical disaggregation of business functions across borders. The core business architecture is but one of the facets of service-oriented enterprise design. We

expect that the debate over what should be part of the core and what should be an extension will continue and will help to further our understanding in this area.

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