A Model-Based Management Dashboard

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I. Introduction

A conventional *executive* dashboard provides a window on key measurements of the operation of the enterprise. The dashboard is generally implemented for a particular viewpoint with access to current operating data to support that viewpoint. When the executive observes a change of concern, or the dashboard raises an alarm based on monitoring certain variables, the executive will likely turn to a staff person to look into the situation since the dashboard does not have the detail of related variables or more specific business operations.

Unfortunately, the data and exceptions of interest are not always the same, and not everything that deserves attention can be addressed by top executives. Managers throughout the enterprise require data and awareness of exceptions within their own sphere of influence if the enterprise is to be managed most effectively. A management dashboard system should be a tool to support management of an enterprise at all levels. It should provide data about current operations and highlight exceptions that require attention. Furthermore, in order to avoid working at cross-purposes, managers need a common understanding of the current state of the enterprise and how it works.

This paper proposes development of a model-based dashboard capability. While managers throughout the enterprise have their own domains of interest, their individual views will be aligned through a shared model of the enterprise. The proposed model is defined using VDML (Value Delivery Modeling Language). The model is linked to sources of actual operating data that provide each manager with the data and alerts of interest to them. The dashboard interface enables them each to define those interests and, as required, to probe deeper into the operation of the enterprise to understand the source of variances, anticipate the consequences, collaborate and explore remedial action.

Implementation of this dashboard capability would require a major investment to meet the occasional and somewhat unpredictable needs of an executive. However, a model-based, adaptable dashboard that meets the information needs of business leaders throughout the enterprise will pay off with improved efficiency and innovation. The model will support analysis of corrective action and operating improvements. This can empower each manager to innovate within their area of responsibility. The model clarifies when they should collaborate with other managers on shared challenges and opportunities with a shared understanding of their impact on the rest of the enterprise.

In this report, we will first discuss the concepts and facilities of VDML for modeling the enterprise. We will then examine the requirements of a model-based dashboard system that provides current operational data based on a VDML model. Finally, we will consider the evolution of an enterprise that will be both promoted and supported by a model-based dashboard and associated business modeling capabilities.

II. VDML modeling concepts

VDML (Value Delivery Modeling Language) is a robust business analysis and design modeling language for business people. It incorporates concepts from a number of business modeling and analysis techniques. It supports business analysis, design, decision-making and transformation planning from an enterprise, value-driven perspective.

Work on VDML started when the Object Management Group (OMG) issued a Request for Proposals in the Spring of 2009. The focus of the initial submission early in 2010, was value chain modeling in support of capability analysis. This offered the opportunity to evaluate business operations in terms of customer value and to identify potential improvements to capabilities as well as operating strategies. This scope was enhanced by participation of the NEFFICS project (see http://neffics.eu/) and participation of additional business modeling experts. The result is a modeling language that incorporates business modeling concepts from such techniques as value chain analysis (Porter, 1985), value stream analysis (Martin 1995), capability analysis (Scott, 2009), Value Network Analysis (VNA) (Allee, 2003), Resources, Events, Agents (REA) (McCarthy, 1987), e^{3}Value (Gordijn and Akkermans, 2003) , Possession, Ownership, Availability (POA) (Scheller and Hruby, 2011), the Business Model Cube (Lindgren and Jørgensen, 2011) and Business Model Canvas (Osterwalder, 2004). The VDML metamodel specification is stable, and current work is focused on refinements to notation (graphical displays) and reconciliation with related OMG modeling specifications.

The VDML objective is to provide a modeling language that is business oriented and supports analysis, design, and transformation with a focus on optimization of both customer value and business operations from an enterprise perspective. Modeling of the creation of value is a distinguishing feature of VDML. VDML provides a representation of the design of the enterprise that is meaningful to business people and provides a basis for collaboration on challenges and opportunities.

A VDML model represents the design of the enterprise with measurements of operating variables and value contributions. These measurements are the basis for assessing the effectiveness of the business operation. Changes to the design or variables will be propagated to changes in measurements that describe performance and customer satisfaction. Different scenarios can represent different operating circumstances, different product mixes or different customer market segments and the impact on values.

Some of these same measurements provide or support the key performance indicators that a manager wants in his or her dashboard. A VDML model with current data can then support an adaptable dashboard and also support more in-depth analysis and resolution of concerns raised by the dashboard.

A VDML business model is composed of modeling elements representing a number of fundamental concepts. The following sub-sections will discuss those concepts and their relationships. This will establish a general understanding of the VDML business modeling capabilities both for support of the model-based dashboard and for support of related problem-solving, planning and transformation efforts. Throughout this discussion, we will use a hypothetical, small manufacturing company, Hypo Manufacturing, to illustrate VDML modeling.

A. Collaborations and roles

The fundamental, structural concept of a VDML model is collaboration. A *collaboration* is defined as a group of participants, working together for a shared purpose. An enterprise involves many, networked collaborations including collaborations with customers and suppliers. Roles within a collaboration define how each of the participants contribute to the collaboration. A participant can be an actor (person or automaton), a supporting collaboration or another role, for example., a manager (role) of an organization (collaboration) can be assigned as a member (role) of a task force (collaboration).

There are four specialized types of collaboration in VDML: an organization unit, a business network, a community and a capability method.

1. Organization unit

An *organization unit* is a collaboration that is relatively stable with associated resources including people, facilities and intellectual capital. The roles in an organization unit may be filled by people and/or other organization units thus representing an organization hierarchy. However, there are typically other organization units in an enterprise, such as project teams and committees that do not fit the conventional organization hierarchy pattern. Also there may be individuals that have roles in multiple organizations.

Figure 1, Hypo Manufacturing organization chart in VDML

Figure 1 illustrates a partial organization structure for the product development activities of Hypo Manufacturing. Each rectangle represents a collaboration. The fork icon indicates that it is an organization unit collaboration. The three-arrows icon (left side) indicates a business network where representatives of the Plastic Supplier and Hypo Manufacturing collaborate. An oval indicates a role: the large oval contains the role name and is connected by a solid line to its collaboration. A small oval indicates that the attached collaboration is in a role of the collaboration connected by the solid line; the role name is next to the small oval. A dotted-line arrow indicates that the role at the arrow tail fills a role at the head. So the Manager role of the Electronics Group fills three other roles as members of the Electronics Design Liaison, the

Design Review Committee and the Manufacturable Committee. The person in the manager role is a member of these other collaboration because s/he is manager of the Electronics Group.

Organization units typically have defined capabilities based on their resources, facilities and intellectual capital. The activities required for an organization unit to perform a specific capability can be modeled with a *capability method*, discussed later.

2. Business network

A *business network* is a collaboration among economically independent business entities. This may represent customer relationships and relationships with suppliers or other business partners. Business networks focus on the exchange of products, services, money and related values such as product quality and availability of field support.

Figure 2, A business network for a Hypo Manufacturing line of business

Figure 2 illustrates a VDML view of a business network for a Hypo Manufacturing line of business (LOB). Each oval depicts a role in the network and each square depicts a value proposition. A value proposition represents the values offered by a provider to a recipient (more about value propositions, later). The LOB provides a product to the customer and the customer provides payment. The LOB acquires Plastic and Electronic Parts from the two suppliers and provides payments to them. Each of the participants in a business network must perceive that they receive more value than they provide or the network is not viable. In this case the cost of the product offered by each of the suppliers and the LOB is less than the payment each receives in return, but each product recipient considers the product(and related values) to have more value than the price paid.

3. Community

A *community* is a loose association of members such as a professional association, an industry standards group, a market segment or employees with a common interest who share ideas. In Figure 2, the customer role represents a typical member of the community of customers. A particular business network transaction will engage one customer from the market segment community.

4. Capability method

A *capability* is the ability to perform a certain kind of work. A *capability method* is a collaboration with defined roles and activities for applying a business capability to deliver a particular result. An organization unit may have a general capability, but it typically delivers more specific capabilities using its resources, facilities and intellectual capital. Its capability methods define activities and resources required to perform the more specific capabilities.

A capability method can represent any form of repetitious, organized behavior including adaptive processes that perform some activities only part of the time. Measurements associated with activities each represent an average per unit of production, so an activity may be engaged

for only once for one unit of production, and could be engaged multiple times for another unit of production.

Figure 3, Capability method supporting the business network

Figure 3 illustrates activities of a capability method performed by the LOB in the business network of Figure 2. Activities are the boxes with rounded corners. The inverted pyramids represent stores of orders coming in and products going out. Each of these activities has an expansion icon, a small box with a plus (+) sign, that indicates that it delegates to a participating collaboration.

A capability method may be defined and maintained by the same organization unit that provides the capability or a by a different organization unit so the specification can be shared. We will discuss capability methods in greater detail in connection with activities and capabilities, below.

B. Activities, deliverable flows and stores

Within any collaboration, activities define what the participants do in their roles within the collaboration. Activities produce deliverables that are consumed by other activities, or stores. Most deliverables are consumed by activities or stores in the same collaboration, but some are the outputs to other collaborations, including external business entities.

Each activity requires a capability. The activity defines how that capability contributes to the particular collaboration. Each activity has a role that is assigned to one participant that is the provider of the required capability. The role of one participant may be associated with multiple activities in the collaboration. The participant must meet the capability requirements of each of the activities associated with that role.

A role may be filled by an actor (a person or automaton), or, where the work of the activity requires multiple participants, it may be filled by an organization unit with the required capability. The work performed by the organization unit may be defined by a capability method that is engaged by the activity through *delegation*. In Figure 3, the Order Fulfillment activity delegates to the capability method of Figure 4.

Where an activity delegates to a capability method, inputs to the delegating activity are passed to the performing capability method, and results are returned for further use within the parent collaboration. This mechanism supports structuring of complex undertakings and can represent the use of shared services.

Figure 4, Capability method for Hypo Manufacturing Order Fulfillment

In Figure 4 (as in Figure 3) the arrows represent *deliverable flows*. The elements that flow are *business items* that include parts, orders, raw materials, tools, machines and other things used or consumed. A business item can also identify an actor that has been identified in the parent collaboration to participate in a role of the engaged collaboration. The inverted pyramids

represent stores—holders of business items. The sideways pyramids represent input (on the left) or output (on the right) of the capability method through delegation.

From Figure 3, we see that the input to Order Fulfillment is an order and the output is a product, corresponding to the input and output of Figure 4. There are additional inputs from stores: plastic, electrical parts, fasteners and packaging materials. These stores are supplied by outside suppliers or by other organization units. The suppliers of plastics and electrical parts are depicted in the business network of Figure 2.

C. Values and value propositions

Activities produce deliverables and they also add values not shown on an activity diagram. Value adds contribute to value propositions and may be positive or negative. An activity, such as Injection Molding, may consume raw material and produce a part conveyed by a deliverable flow as depicted in Figure 4. Associated values may be the cost-per part, the probability of defects, the duration of the activity or other characteristics that ultimately may be of interest to a customer or other stakeholder. Other values such as the durability or flammability of the plastic may come from the supplier. Each value-add contribution is expressed with a measurement, and for each type of value, measurements are aggregated if they are contributed by multiple activities. The formula of aggregation will depend on the nature of the value.

Figure 5, Aggregation of activity value contributions

Figure 5 depicts the aggregation of value-adds of costs and defects. They are depicted with dashed lines since this view does not represent a defined VDML diagram. Value adds and value propositions will be typically displayed in tables. While each activity in this diagram is depicted as contributing to each value type, for some values, only certain activities may contribute. Where an activity delegates to another collaboration, the delegation returns the aggregated values of the activities in the collaboration. In the example of Figure 5, the aggregations are additions of cost and defect rates. Each of the contributions is from a delegating activity, so they each include value contributions returned from the delegation. The values of interest will depend upon the values of interest to the recipient of the value proposition as well as the values of interest to dashboard users.

In a normal VDML model, the value-add measurements are based on a unit of production, but are statistical measurements, not individual measurements. The cost of an activity is the average or a statistical distribution of costs for individual units. For the dashboard, measurements for individual units will be reported and compared to upper and lower limits to identify exceptions. Some of these measurements will contribute to key performance indicators of a manager's dashboard. Some measurements may only be of interest when there is a significant variance or exception and more information is needed to address a concern.

Value contributions support value propositions. A *value proposition* is a package of values and deliverable(s) that are offered to a recipient, typically a customer, but a value proposition can also be offered to other stakeholders such as business owners or internal "customers.". The

value proposition incorporates those value contributions that are of interest to the recipient. The value proposition expresses its values from the recipient's perspective. For each type of value, the aggregated measure is transformed to a level of satisfaction based on a formula for the particular recipient. An overall expected level of satisfaction can also be computed based on a weighted average of the value satisfaction levels.

Different customers or market segments may be interested in different values with different priorities, so separate value propositions can represent the levels of satisfaction for these different recipients. Value propositions may also be compared to the offerings of competitors to assess competitive position and evaluate changes that might yield competitive advantage.

D. Value stream

The activities, deliverables and values that contribute to a value proposition are characterized as the *value stream* for that value proposition. Essentially, value contributions and deliverable flows that feed the value proposition can be traced back to the activities involved and the capabilities they use to contribute to the value proposition.

Figure 5 also depicts a value stream for the Hypo Manufacturing LOB first represented in the business network in Figure 2. The value stream is derived from the VDML model by identification of the activities that contribute to the value proposition that is offered to the customer. Other value propositions (such as to other stakeholders) may define different, overlapping value streams.

The full value stream for the Hypo Manufacturing LOB includes the expanded delegations of these activities and the suppliers to the stores of plastic and electrical parts depicted in Figure 4. The value contributions of suppliers will be taken from the measurements incorporated in their value propositions since Hypo Manufacturing is not expected to have access to the design of their internal operations.

Some of the collaborations in a value stream may involve shared capabilities that are used more than once in the same value stream or in different value streams, potentially other lines of business. Consequently, when a shared capability is changed or suffers a disruption, the impact will be experienced by all of the value streams in which it participates. The values contributed by a shared capability will likely be different when the capability is used in different contexts. This difference is addressed in the discussion of measurements and scenarios, below.

When a value proposition indicates a poor level of satisfaction of a value, the value stream can be examined to identify the activities and thus the capabilities that contribute to that value and the analyst will look for potential improvements that could raise the satisfaction level. Again, if the focus is on a shared capability, there may be multiple value streams affected, and they may not all be affected in the same way.

Conversely, when a key performance indicator of an activity or a collaboration exceeds acceptable limits, the effects can be traced to all value propositions that will be affected and an

associated decline in level of satisfaction may determine the urgency with which the variance should be resolved.

E. Capabilities

As indicated earlier, a *capability* is the ability to perform a particular type of work. An enterprise will have many capabilities. VDML supports a capability library for specification of a capability taxonomy. The taxonomy addresses two important requirements: (1) it helps a business analyst or planner determine if the enterprise currently has a needed capability, and (2) it provides consistent definitions and identifies similarities that help determine if the same capabilities are being provided by multiple organizations and might be candidates for consolidation. Note that while the same capability may be provided by different organization units, each organization unit may have different qualities, such as location or capacity, that would justify the redundancy.

Figure 6, Hypo Manufacturing capability map

Figure 6 illustrates a capability map. This is a popular way to represent a capability hierarchy. A capability map is often used as a "capability heat map" where capabilities that require attention are highlighted. A capability hierarchy may have the appearance of an organization hierarchy, but these are distinct perspectives. In an enterprise with line-of-business silos, capabilities may be scattered across lines of business, and within a silo, the organization structure may reflect other influences such as sharing of resources, geographical locations, or management of a critical path. Consideration of capabilities independent of organization structure enables a more objective consideration of the work to be done and the values achieved.

In general, capabilities are offered by organization units that have the resources, facilities, intellectual capital and responsibility to deliver the capability. A capability definition in the capability library identifies the organization units that offer that capability. An organization unit may assign a person or assemble a team to respond to each request for a capability, and there may be no formal pattern to the way work gets done. However, if there is a pattern to the work, it should be defined with a capability method.

A capability method, as discussed above, defines the roles, the inputs, the activities, the stores, the deliverables and the value contributions for delivery of the capability. It is similar to a business process definition, but does not get into the decisions and flows of control for individual requests. Instead it identifies statistical measures of the activities, stores, values and flows over a number of occurrences. A capability method may represent work that is somewhat unpredictable— sometimes characterized as case management— where the same activities occur in different sequences and sometimes not at all. The dependencies between activities (deliverable flows) are important because they define the value stream and aggregation of value measurements. For example, time to deliver depends on the critical path of activities determined by deliverable flows.

F. Capability management

Any collaboration can have roles, activities, deliverables and value contributions. An organization unit generally has resources that can do more than one kind of work—provide more than one service under a general capability. Consequently, the activities, deliverables and value contributions of organization units can be specified with capability methods that describe each of the more specific capabilities offered by the organization unit.

A line of business (LOB) is an organization unit that delivers end products or services. Capability methods define the value streams for each of the products or services. In an enterprise that makes extensive use of shared capabilities, a LOB capability method will be primarily activities that engage shared capabilities.

Typically, a collaboration that fills a role of an activity is an organization unit that manages the capability required by that activity. If that role performs multiple activities in the parent collaboration, then the organization unit must have the capabilities required by each of the activities. For each offered capability that has defined roles and activities, the organization unit will use a capability method to define how that specific capability is delivered. The resources and facilities of the organization unit will be used by the capability method, and the capability method may further delegate some of its work to other organization units and their capability methods.

Figure 7, A capability management diagram

Figure 7 illustrates a VDML capability management display. The large boxes represent organization units that are named in the small rectangles at the top of each large box. The stretched hexagons represent capability offers. A capability offer indicates that the associated organization unit can provide the capability. The same capability can be offered by multiple organization units, and each will show a capability offer. A heavy dashed line connects a capability offer to the capability method that is used by the organization unit to provide the capability. Each smaller dotted line leads from a capability method to a capability offer used by the capability method through delegation from one or more of its activities.

An organization unit can offer and provide a capability but need not own the capability method. In Figure 8, Customer Relations is offered by Sales but the capability method is owned by the Fans LOB. That means that the Fans LOB defines the method but Sales receives the requests and assigns the resources to provide the capability.

G. Measurements and scenarios

VDML provides the ability to represent the same business model under different circumstances. The structure may be the same, but the measurements are different. We describe these different circumstances as scenarios. So the measurements of different product mixes might be represented with different scenarios. In addition, a capability defined by a capability method might be engaged more than once within a value stream. The measurements of the capability

method will likely be different in the different contexts. VDML manages the measurements separately for each occurrence.

For a management dashboard, the current state of the business would be one scenario. However, the state of the business at different times or for different product mixes can be captured as separate scenarios for comparison or future reference. In addition, if potential changes or hypothetical circumstances are being explored, they should be explored in separate scenarios so that the integrity of the dashboard is maintained.

For a dashboard, expected measurements should be expressed as upper and lower bounds. As a default, variances within six standard deviations might be considered normal, and measurements outside six standard deviations could be flagged as deviations.

III. Linking the Model to Reality

Elements of a VDML model represent the operational structure and associated measurements of an enterprise. For the model-based dashboard, these measurements must come from the actual operation of the enterprise. In order for the measurements to be timely, it is necessary to implement an automated linkage between the model and the operational business systems. For only one or a few executives, there may not be a large number of measurements to be monitored, so the dashboard can be designed to specifically query a number of different databases to retrieve the various measurements. However, the goal of the model-based dashboard is to provide not only the measurements of immediate concern, but to meet the needs of all business leaders as their needs evolve, and to provide supporting detail for a deeper understanding of problems and potential consequences of corrective actions.

The model driven dashboard should be available to all managers, and probably business analysts and architects, throughout the enterprise. The dashboard should provide current information about the user's area of responsibility. A user's area of concern is expressed by the performance indicators selected for his or her dashboard and by the target scenario selected for evaluation of variances. The user should be able to use other VDML modeling facilities to understand consequences and explore ideas.

Each of these users will have different interests, different key performance indicators and different ways of monitoring those measurements of interest. The benefits of timely and consistent access to data and business models by all managers will justify the investment in a model-based system.

Figure 8, Model-based dashboard system components

Figure 8 depicts the components of a model-based dashboard and business modeling system. The following sections will discuss each of these components.

A. The dashboard user interface

The dashboard user interface is primarily a graphical display. The graphical elements in Figure 9 are typical of graphical elements provided by dashboard systems.

Figure 9, Examples of dashboard graphical elements

The simplest graphical element would be a number with a caption, or a table with a column of captions and a column of measurements. Upper and lower limits can be displayed in additional columns.

Graphic (a) is essentially a meter indicating a current value within a range and with the current value in the box below.

Graphic (b) shows variation in the value of a measurement over time. The X-axis is time over which values have been collected—possibly hours since the most recent measurement was captured, and the Y-axis is the measurement value. Horizontal lines above and below represent the upper and lower limits of expected values. The most recent measurement is on the right, so the graph rolls to the left, showing measurements retained for a specified time period.

Graphic (c) shows a bar graph that compares multiple measurements. Each bar would be identified for the measurement it represents, and the measurements along the bottom would be scaled to contain the longest bar. This might, for example, represent the contributions to a particular value by a number of different activities in a collaboration or value stream—the longest bar representing the greatest impact and potentially the activity/capability with the greatest opportunity for improvement. Graphic (d) provides another form of comparison of measurements. The pie-chart diagram would have an associated legend for the pie segments.

Graphic (e) shows a bar graph where the bar represents the expected range of each measurement and the pointer identifies the value of the most recent measurement for each.

This is not a comprehensive set of graphics but illustrates some potential diversity. Each of the graphics should have a pop-up display for additional detail. Each graphic element may also specify an action to perform when a measurement exceeds limits, such as flashing, sounding an audible alarm or sending an email or text message to the user. This illustrates the types of displays that must be supported by measurements.

B. The VDML user interface

The current-state model scenario, the target scenarios and the what-if scenarios are all developed and managed in the VDML modeling environment. The previous section outlined the VDML concepts and some proposed displays. In addition, a VDML implementation will include various tabular displays of attributes and measurements to support analysis and data entry including tables for comparisons of equivalent measures over multiple scenarios. It is expected that implementers of VDML will define additional user-interface displays based on market demand and implementer innovation.

C. Business systems

Operational business systems, at the bottom of Figure 8, are the source of operating data to support the dashboard and detail of the VDML model. The measurements that appear in a manager's dashboard as well as the measurements that support the related VDML models will originate from heterogeneous data stores across the enterprise. This may include relational databases, object-oriented databases, hierarchical databases, more fundamental file structures and enterprise applications. These sources will have different data structures and data element specifications and names. Some will be batch processing systems that update their data stores periodically. Others may be updated as messages are received and activities are recorded. Operating activities may not be completed on a regular schedule. A dashboard must be supported by these diverse sources.

D. The query service

The query service retrieves operational data from various sources as required to update the dashboard. Queries may be issued on a periodic basis to update the dashboard, or they may be issued on demand when the user expresses an interest.

One approach to query support is to use an EII (Enterprise Information Integration) system. EII products have been available for the last ten years (Metamatrix, 2002). We will use the EII approach to illustrate the dashboard system requirements. Other system integration products may provide other mechanisms to access the heterogeneous sources.

An EII product provides a virtual database interface through which data from heterogeneous sources can be accessed. The virtual database is a consistent representation of enterprise data that supports a consistent expression of queries to heterogeneous data sources.

The data sources are modeled by the query service respecting their particular technology. The virtual database schema is modeled as a relational schema. The transformations between the virtual database and the data stores are modeled. The Common Warehouse Metamodel (CWM) from the Object Management Group provides the modeling standard for this transformation.

When a query against the virtual database is submitted, it is translated into queries for relevant elements in one or more of the data source(s). The responses to these queries are then integrated to conform to the virtual database schema and the original query specification. The use of standard modeling technology simplifies the implementation and maintenance of these EII services

The links from the VDML model to the query service should not only provide the appropriate measurements, but they should also provide access to business metadata—data about data. Business metadata should include properties of each data element such as source, date/time of origin and possibly a confidence level indication. Different sources may be more or less reliable, they may be updated more or less frequently, and there may be inconsistencies in the basis of measurements from different sources. For example, measurements may be based on inconsistent

units of production. When a measurement is computed, the metadata available to the business user should include the computation and business metadata for each element of the computation.

E. Event service

The event service (sometimes described as an event broker) conveys event notices to the current-state scenario to update its measurements. Events may originate from business transactions or updates of business systems. These events are typically communicated as messages specified with XML Schema (W3C, 2001)

Event services also have been available for a number of years as a component of enterprise application integration (EAI) and may exist in various forms in commercially available application integration products.

An event service receives notices of actions or data updates and delivers those notices to subscribers. For the dashboard system, there is seldom a need to receive updates for data that is not currently of interest, so subscriptions may only be posted for data of current interest in at least one dashboard. If some events seldom occur then they should always be processed so that the associated measurements have a current value without waiting for the next event to occur. Furthermore, only some data element updates will be available as events, and only some data elements are sufficiently significant to require real-time updates, particularly for top management. So use of the event service should be selective.

Business metadata associated with events should be available within the event notices forwarded by the event service.

F. The current-state scenario

The VDML current-state scenario is the central component of the model-based dashboard. It represents the current state of the business. The current-state scenario determines the measurements that are monitored. For data from the query service, it defines the query expressions and frequency of queries. For data updated by events, it initiates event notification by the event service. It holds the latest value (or sequence of values for a defined time period) for each measurement that is monitored.

The current-state scenario is shared by all users so that redundant updates are not required. Rather than constantly querying for every measurement, queries should be driven by the requirements of currently active dashboards and the dynamic nature of each measurement.

The current-state scenario should track measurements for which there is current interest—at least one active dashboard design. Certain other measurements may be identified for continuing updates while the remaining measurements may be retrieved on demand to support situation analysis. If a measurement is infrequently updated by an event, then it may be updated even though it is not currently of interest. When additional data is required by a user to support analysis, or when a new dashboard design is activated, then queries and event service subscriptions should be issued for the additional data.

It is also desirable to trace the value of a measurement over time. The need for such historical data is primarily a function of user interest, so it may be appropriate for the dashboard to maintain a history or initiate capture only for selected measurements being observed. However, there may be some measurements where a history is important even though the measurement has not been recently of interest. Consequently, it may be desirable for the current-state scenario always to retain a history for selected measurements.

For efficiency, individual queries may be used to retrieve multiple, related measurements. For batch processing systems, this should include data from business transactions that occurred since the previous batch processing cycle. Depending on the volume, data for all of the transactions may be held in the current-state scenario, or if the volume is high, then a sampling of the values over the period may be sufficient.

In general, it is preferable for measurements to be retrieved at an elementary level with computations for aggregation of measurements from more detailed activities performed in the VDML model. This has the benefit that (1) detailed data will be available when the root cause of a problem is investigated, (2) the structure of elementary capabilities tend to be stable even though the higher-level capabilities, and thus the current-state model, may be reconfigured. However, in the early stages of development, the detail of more elementary methods may not be available, so the dashboard can observe the measurements that are reported for the higher-level, delegating activities.

G. Target scenarios

A major challenge for dashboard designers is to present consistent data. A business does not deliver a product (including the result of a service) by simultaneous operation of all the activities in the value stream. When a product is delivered, the value stream consists of activities that contributed to that product perhaps days, weeks or months in the past, depending on the nature of the business. Consequently, measurements associated with the current product being delivered may be the result of contributions that do not reflect current operation of those long-completed activities.

Furthermore, the data available from heterogeneous sources may be captured at different times and reported for different periods or units of production. Some measurements may be reported as they happen. Some measurements will be reported as the result of an important event or at the end of a shift or other time period. What should appear on the dashboard?

The dashboard should focus on current operations and exceptions. Variances should be based on limits developed from statistical measurements of each operational variable during a typical time period. Exceptions are then defined as statistically significant variations. Upper and lower limits may be generated from the statistical measurements are used in a typical VDML model, or they may be set by the user, particularly for key performance indicators with targets that differ from actual experience.

In the model-based dashboard system, target scenarios are user-defined scenarios associated with the current-state model. Each target scenario may be created by a dashboard user to define targets for those measurements of interest to that user. The scope will typically be one value stream or a segment of the value stream of interest to that user. These are used as input to a dashboard design, when it is activated, to define the expected limits on measurements. The VDML user interface is used to view and modify target scenarios.

The comparison of current to target measurements has several advantages. (1) The user can compare current operating measurements (in the current-state scenario) to limits defined in alternative target scenarios if the current circumstances change. (2) The measurements are evaluated independent of the time basis of other measurements that may reflect earlier or later stages in a production process. (3) The measurements are independent of different units of production that may occur in different branches of a value stream. (4) If there is significant variance, then the associated operation is a concern even though the end product may not be delivered until long into the future. (5) Measurements will persist even though processes and organizational responsibilities change.

In order to measure variances against an appropriate target, different scenarios can represent the expected measurements for different classes of product. Thus the current measurements of an activity can be compared to a target measurement appropriate to the target product of that activity.

In order to support analysis of exceptions that occur later in the value stream, it may be desirable to capture a history of exceptions earlier in the value stream. A target scenario could enable a user to specify those measurements for which exceptions may later be of interest even though they may not be actively displayed on the dashboard.

H. What-if models

What-if scenarios are scenarios that represent alternative circumstances. These may be historical scenarios but more often they will be scenarios used to explore business changes or consequences of variances. These scenarios should be defined by users in VDML models that are separate from the model that supports the current-state and target scenarios. The current-state scenario and the target scenarios should not be altered to explore ideas. The user interface to these scenarios is the VDML user interface provided by a VDML modeling system provider.

The VDML user interface should support the creation of what-if models from the current-state scenario or one or more target scenarios. For example, a what-if model and scenario may be created as a copy of the current-state scenario for analysis and exploration of a current problem. A what-if model and scenario may be created from a target scenario to analyze statistical measurements for a value stream.

A broader what-if model can be created by combining the current-state scenario with target scenarios for different value streams. For a shared capability method, the what-if scenario will contain a set of measurements for each use of the capability method. Tabular displays should

support comparison of the corresponding measurements for each use of the capability method. Similarly, each value stream will have its own value proposition(s) within the combined what-if scenario.

Not all what-if scenarios should be implemented in the same VDML modeling environment. It should be expected that users may have personal VDML models and associated scenarios, independent of the dashboard system, to support their efforts.

Later, in the "evolving reality" section, we will consider some of the implications of using the VDML model beyond the scope of dashboard support.

I. Dashboard designs

The dashboard provides a display capability, discussed above, that can be tailored to the specific requirements of each manager. A manager should be able to configure his or her dashboard like painting a PowerPoint slide with the addition of some data specifications. A manager may have a number of dashboard designs in his or her library that may be useful under different business conditions.

A dashboard design will include the specifications for each measurement to be monitored by reference to the current-state model, along with the graphical form of the measurement and the placement of the graphical element on the dashboard canvas. The dashboard design will incorporate one or more target scenarios to define the upper and lower limits for measurements. The dashboard design might also specify email or text messages to be generated for certain events or exceptions. The dashboard will trigger queries to the query service and subscriptions to the event service through the current-state scenario.

J. Implementation

A complete dashboard system to cover the enterprise for all lines of business, business leaders and capabilities is a major undertaking. It should be undertaken in beneficial increments.

The first step toward implementation of a model-based dashboard should be to develop a VDML model for a selected value stream with manually entered measurements. The focus should be on measurements of the most important values. This provides a basis for understanding the modeling concepts and should provide benefit for the analysis of value delivery and the evaluation of potential improvements to specific capabilities. The granularity of the model will be a factor in both the time to develop the model and the benefit derived from it. In the long term, activities and supporting capabilities should be modeled at a level of detail where the most detailed capabilities are relatively generic and are useful as sharable value stream building blocks. Measurements from these capabilities can be aggregated to the more abstract levels. However, in the short term it may be more practical to limit the detail and use aggregated measurements observed for higher-level, delegating activities.

This foundation can then be expanded over time to model additional detail and additional value streams, providing support for consideration of consolidation and management of shared capabilities. This is all within the expected scope of a VDML model.

The next step involves implementation of the query service, the dashboard user interface with the dashboard designs and the target scenarios. This should begin with one value stream as well. The value stream model will identify the measurements that are needed and provide a basis for specification of accesses to the business systems by the query service. Once the pilot value stream is stable, additional value streams should be added for an expanded user community.

Implementation of the event service may be deferred depending upon the nature of data sources and the need for immediate updates. Generally, the managers closer to the actual business operations will need more timely data in order react in a timely manner. If executives are the initial users, it may be practical to defer implementation of event driven updates. However, coordination of updates with batch processes may still require that some queries be event-driven.

IV. The evolving reality

The use of VDML should not be limited to support for a management dashboard, but it should provide a modeling environment for on-going analysis, design and transformation of the enterprise. VDML can provide a better understanding of business relationships by modeling relationships that often do not appear on organization charts. Many existing enterprises operate in line-of-business silos with business processes optimized for delivery of their current products. VDML is particularly suited to development and management of shared capabilities, and optimization from an enterprise perspective. The modeling capabilities of VDML along with other changes in technology, markets and the business ecosystem will shape the evolution of the business (Cummins, 2011). Several aspects are discussed in the following sub-sections.

A. Capability consolidation

Consolidation of capabilities as shared services will drive separation of the management of shared services from line-of-business management. Shared services will support multiple lines of business. Management of those shared capabilities must be unbiased in their support for the different lines of business, and must focus on meeting customer requirements and achieving economies of scale.

Consolidation of shared capabilities may also lead to outsourcing. For non-mission-critical capabilities, an outsourcing provider can achieve greater economies of scale (across multiple clients) and will likely provide greater scalability to accept new clients and enable their clients to adapt to changes in market demand. VDML models will assist in defining the scope of outsourcing and in management of the relationship.

A shared capability may be used to provide multiple services to multiple, internal customers. The manager of a shared capability should have well-defined interfaces and service-level requirements (i.e., value propositions). The users of the shared capability should not be

concerned about how the service is performed except as it impacts the product of their value stream and the cost, timeliness and quality of their product.

The dashboard should be a primary tool for monitoring both line-of-business performance and performance of shared services—both internal and outsourced. Each of these has a value stream, and their value propositions should reflect the multiple measurements of their performance.

B. Accountability and empowerment

The dashboard provides every manager with knowledge about the current state of the business, the performance of subordinates, and the consequences of variances. Based on the VDML model, top management can trace problems with customer values back to sources of those problems and the responsible organization units. Thus accountability for problems as well as improvements will be more apparent. This accountability also clarifies the scope of authority of individual managers and their impact on the end products and services.

Consequently, a shared service manager has a well-defined domain in which to innovate, and a well-defined group of consumers for collaboration on changes that might affect the value propositions of his/her service. Based on VDML and his/her dashboard, the capability manager also has insight on the impact of the capability on end customers, and can identify justification for investment in improvements. This should enable managers at all levels to explore innovative ideas.

The same principles apply to outsourced capabilities. The outsource provider must have well-defined interfaces and value propositions. However, the outsource consumer does not have control over the implementation of the service or investments in improvements. The consumer must monitor and enforce the interface and value proposition requirements and negotiate any changes to requirements.

In either case, the consumers of shared services have primary responsibility for enforcing the service agreements and thus must devote some resource to that effort.

The clarity of responsibilities and the enterprise impact motivate and empower individual managers to improve their own operations and it clarifies where work with other managers is needed to resolve broader issues.

C. Risk management

Consolidation creates single-points failure. If a service of a consolidated capability is disrupted or fails, that will affect each of the lines of business that rely on that service. On the other hand, those factors that may affect a capability are no longer scattered across multiple lines of business, but can be mitigated in one place. This is particularly true for regulatory compliance as well as management of critical resources.

The primary method of mitigation is to provide redundancy. Redundancy can be achieved by having multiple capabilities, or it can be achieved within a consolidated capability with redundant facilities, cross-training, operations in multiple locations, reserves of critical materials

and other such means. These measures will increase costs. If the cost exceeds the benefit of economies of scale, there must be other factors to be considered. A former, fragmented capability may have carried unrecognized risks, or there may be diseconomies of scale that have been overlooked. For example, consolidation may result in increased transportation costs.

VDML can assist in risk analysis through consideration of the impact of each capability on the value streams. Deliverable flows and value contributions can be used to show the propagation of effect of disruption of a capability. Some capabilities may only affect certain products or services, and some may have mitigated the risks. Similarly, the impact of a disruption or failure can be reflected in the manager dashboard when it occurs.

The development of shared services and value propositions for services and lines of business clarifies responsibilities for risk awareness and mitigation. Each manager should consider risks to his or her operations and assess the impact they could have on each line of business their capability supports. They should also, in many cases, be the first to know of an adverse event or impending problem and take action to alert their management and mitigate the effects. A disruption-alert value measurement could be propagated down all affected value streams.

Furthermore, the VDML model can predict when a variance of an early activity will impact the end product or a critical later activity. Assuming that activities have a duration measurement, the durations of activities between the early variance and delivery of the end product provides an estimate of when the effect will be realized. Furthermore, if the activity is a shared service, then there will be consequences to multiple value streams.

Understanding of delayed impact on subsequent activities can also be used for risk mitigation. If an activity fails or a key resource is unavailable, then that activity and subsequent activities will stop unless there are inventories (VDML stores) in the value stream that enable subsequent activities to continue. Activities, such as transportation of materials, may frequently be interrupted, so stores of shipped resources can be maintained to allow for late or failed deliveries. Redundant capabilities may be maintained to absorb the lost production capacity of a failed capability, but then the redundant capability must have adequate capacity. A loss of capacity of a shared capability may call for consideration of priorities among lines-of-business considering differences in profitability and customer dissatisfaction.

D. Capacity management

While economies of scale can save money by reducing excess capacity, consolidation can also create a risk that increased demand from multiple lines of business will exceed the capacities of shared services. Such competition for shared resources may not be obvious when the lines of business are organizationally quite separate from the management of shared services. When these capabilities are within the individual line of business organizations, management may be more aware of the limitations, and may be in a better position to re-allocate resources or fund expansion than the manager of a shared service that has a smaller and more restricted budget.

VDML can assist in tracking capacity and demand. Changes in demand can be reflected in VDML scenarios for future time periods, and the effects from multiple lines of business can be identified for shared services. The implications of changes in demand can be traced through the value streams to identify capabilities that may be challenged to meet the needs of demand aggregated from multiple lines of business.

VDML can also help identify opportunities for sharing of resources across organization units. Where similar resources (e.g,, skilled personnel or specialized equipment) can be identified in different organizations, pooling of resources may reduce the risk that the aggregated need for resources will exceed the total available resources for the participating organization units. To facilitate this sharing, the organization units with similar resources may be brought together under a parent organization unit that can optimize workload balance.

E. Cost recovery

The cost of shared services must be allocated to the lines of business supported by those services to ensure that the lines of business are accountable for their full cost and to provide appropriate incentives and accountability to control the costs incurred by the shared services.

The cost of shared services should not be simply allocated as enterprise overhead. Some lines of business will make more use of a shared capability than others. If a line of business is not charged for the cost of services, this is an invitation for cost shifting, and top management will be unable to accurately evaluate the performance of each line of business or the shared services.

This does not necessarily mean that each rendering of a service should be precisely billed for resources consumed. In some cases, the cost of each service rendered should be billed because the costs vary significantly. For example, warehousing may be a shared service, but some lines of business may make considerable use of warehousing of parts or finished product while others that build to order may have minimal warehousing requirements. VDML and the managers' dashboard should reflect these cost differences as part of the value stream monitoring and analysis for each line of business. The VDML model should help define appropriate cost allocations.

Costing is an art. The benefits of some costs may be realized by multiple value streams but reasonable allocations may depend on the nature of the activities and/or the work products. For example, a premium product feature has an installation cost but addition of the feature reduces the cost of a related premium feature, so the cost of both premium features is less than the sum of the individual premium features. Or the cost of producing a base product may depend on how many premium products (possibly a different value stream) are being produced at the same time. Nevertheless, objective cost analysis will be increasingly important for management of an enterprise with shared capabilities and outsourcing.

F. Extended applications of VDML

The dashboard focus and the VDML discussion have focused on the value streams that produce products and services for end customers. As the benefits are realized from models developed for line of business value streams, the potential benefits will be recognized for application to other areas of the enterprise.

Close to the mainstream business are support services that sustain the operational capabilities. For example, production engineering, machine maintenance and materials management are essential to a manufacturing operation, but they do not contribute directly to the value stream. These activities can be modeled and their value contributions monitored and evaluated.

Traditional business support services such as accounting, purchasing, human resource management and information systems can have value streams and value propositions as well, reflecting the value of their services to internal consumers. Modeling can clarify the impact these services have on the mainstream business, and can help identify opportunities for improvement. This can help in consideration of outsourcing of such services, where it can provide the basis for interface specifications and service level agreements even though the implementation of the service provider may not be visible to the client.

Value streams can also be defined for internal activities to manage or transform the enterprise. A project is a collaboration—more specifically a capability method. Projects can be planned, incorporating existing capabilities and services, and they can be monitored in dashboards the same as high volume production processes. Such projects may involve changes to production facilities, strategic initiatives for changes to business methods or introduction of new products, or information systems application development projects. VDML can tie these undertakings into related aspects of the business and clarify the needs and accomplishments for additional collaborations.

V. Conclusion

A model driven dashboard can provide a current and consistent view of the state of the enterprise for managers across the enterprise. This will improve understanding and the ability to reach consensus on business decisions, and it will empower individual managers to improve their operations with an understanding of the impact on the lines of business they serve or are responsible for. Clarity in the way the business operates will expose opportunities for improvement and foster innovation ultimately making on-going business change a competitive necessity.

This operational visibility, along with the visibility of the business design, will improve accountability, capacity management and risk management, and will enable restructuring of the business, particularly consolidations of capabilities and possibly outsourcing to improve efficiency and agility. Clarity of the value streams and associated values may reveal opportunities from restructuring such as concurrent or batch operations.

Implementation of a model-based dashboard should be undertaken in stages, but with an understanding of the end solution. The first stage should focus on one value stream and dashboards for top management based on query access to priority data. As this is stabilized, the scope should be increased to include more value streams and more data access. Managers should first be exposed to VDML modeling and then implementation of their dashboards. As more managers become involved, particularly closer to data to day operations, an event service should be implemented to provide more timely update to the more volatile and time-critical data.

In the long term, managers throughout the enterprise will be more engaged in innovation and collaboration to improve their operations for the benefit of the enterprise. The enterprise will operate more efficiently and be able to more quickly adapt to challenges and opportunities.

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