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Automating the construction of supply chain key performance indicators

Thomas Gulledge
Enterprise Integration, Inc., Alexandria, Virginia, USA and George Mason University, Fairfax, Virginia, USA, and
Tamer Chavusholu
Senior Oracle Enterprise Architect, Point Roberts, Washington, DC, USA

Abstract

Purpose – This paper aims to automate the supply chain operations reference (SCOR) model as an enabler for process-oriented supply chain business intelligence.

Design/methodology/approach – The hypothesis is the following: SCOR model automation is possible using data that is directly extracted from integrated enterprise systems. To test the hypothesis, an alignment product that allows the SCOR model to be automated with information that is directly extracted from the Oracle E-Business Suite was developed.

Findings – In order to achieve the full benefits from the SCOR model, effective business process management and the SCOR key performance indicators (KPIs) must be implemented and used. Unless data collection to support KPI construction is automated, it is difficult to institutionalize the SCOR model as a measurement and benchmarking framework. We have demonstrated that automated support for KPIs is feasible and achievable.

Research limitations/implications – The E-Business Suite is a single enterprise solution, but we assert that the same procedures could be followed with other enterprise solutions or even applied in a legacy system environment.

Originality/value – The developed solution described in the paper can immediately be applied to the design, development, and deployment of corporate performance management systems.

Keywords Supply chain management, Business analysis, Electronic commerce, Modelling, Automation

Paper type Research paper

1. Introduction

Effective organizational management requires data to support decision making. Managers need data for measurement and control, similar to an aircraft pilot monitoring the cockpit displays (command, control and communications center for that unit). The pilot needs controls to navigate safely and efficiently. Although the airplane control system is a collection of complex subsystems, they are integrated to help execute the transportation process safely and efficiently. The pilot and his team rely on sophisticated instrumentation, technical data and qualified personnel to perform routine or major maintenance, based on the monitoring of prognostic and diagnostic measures. The analogy with enterprise management is addressed by asking the following question: how do managers measure the operational performance of their business processes and create the efficiencies and continuous improvements that ensure competitive advantage?

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To analyze the question, this paper focuses on supply chain management (SCM) process concepts that are defined in section 2. Section 3 draws on a practical dilemma faced in the practice of operations management today. The supply chain operations reference (SCOR) model is presented as a high-level business process reference model that can be used in designing the supply chain manager's "command center." The following section integrates business process management (BPM) and enterprise integration concepts to develop the foundation for technology-enabled SCM. Next, we introduce the i-SCOR methodology that combines the previously discussed concepts. This methodology places the power of real-time supply chain analytics and business intelligence in the hands of operations managers. We describe the tool that was developed to test the main hypothesis of the paper. The successful application of the methodology, using the tool, completes the test of the hypothesis. For further completeness, we provide a discussion on implementing the proposed solution in an enterprise by using a simple example. The concluding section examines the possibilities for future research using the i-SCOR methodology.

2. Conceptual framework

The American Production and Inventory Control Society (APICS) defines SCM as the "planning, organizing, and controlling of supply chain activities" (APICS, 1998)). The SCC defines supply chain activities as:

> [. . .] all customer interactions, from order entry through paid invoice; all product (physical material or service) transactions, from supplier's supplier to customer's customer; and all market interactions, from the understanding of aggregate demand to fulfillment of each order (SCC, 2007a, b).

When combined, the definitions describe the transformation from inward-looking materials, production and logistics management to product and information management across the multiple enterprises of suppliers, customers and partners.

SCM is the integration of activities related to the transformation and flow of goods and services, including their attendant information flows, from the sources of raw materials to end-users (Ballou *et al.*, 2000). In this conceptual framework, SCM is enabled by inter-organizational business-to-business connectivity, an absolute requirement for the extended enterprise. Each link or node within the paths of a supply chain network should contribute to the broader concept of extended enterprise integration. These concepts are shown in Figure 1.

With the availability of powerful collaboration technologies and the new shift to process-oriented thinking, many early SCM implementations focused on issues in managing supply chain networks and the benefits of supply chain integration (Womack *et al.*, 1990; Lee and Billington, 1992, 1993; Davis, 1993; Billington, 1994). Other research focused on improving supply chain design (Fine, 1998; Strader *et al.*, 1999; Ballou *et al.*, 2000) and integration. This paper builds on the earlier research as well as on an understanding of the practitioner's needs for further enhanced SCM. Figure 2 shows a view of how the conceptual framework has been enhanced through enterprise systems that connect the front- and back-office.

As shown in Figure 2 demand-supply matching can be described as a value chain, or more generally as a business process network. Activities within this network are designed to generate value for all supply and demand chain claimants. It is helpful to

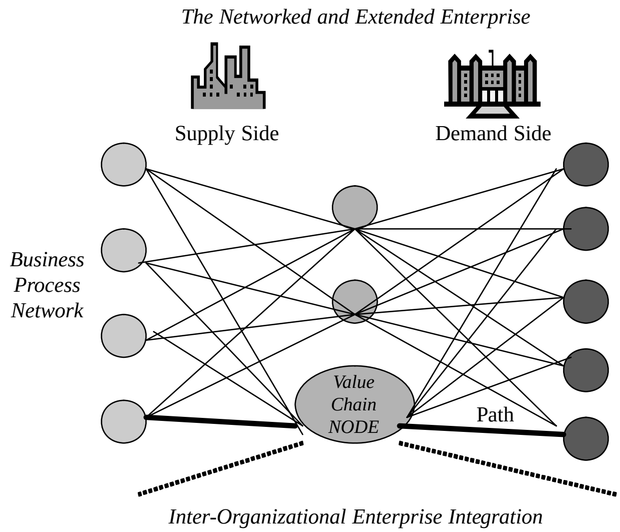


Figure 1.
Value chain layers and node dimensions

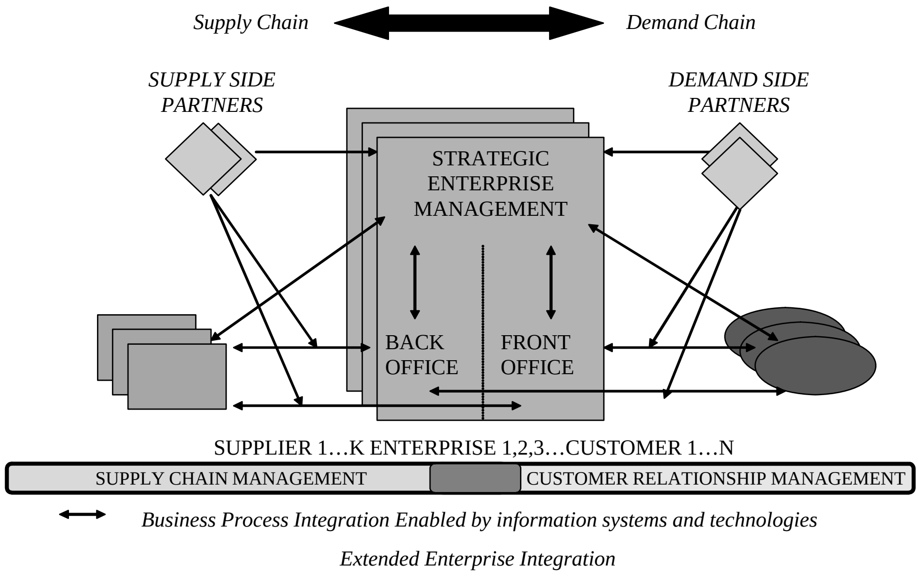


Figure 2.
Value chain management in perspective

study the intersection between front- and back-office activities. From a process flow perspective there are activities (e.g., order management) that can be implemented as both SCM and customer relationship management (CRM) processes. In addition, information flow from the demand-side is critical for supply-side effectiveness and *vice versa*. Although "chain" is the widely accepted semantic, suppliers and customers positioning themselves in other, possibly competing, "chains" result in more of a web- or network-like enterprise.

This research sheds light on three components of state-of-the-art supply chain architectural design: product, process, and organization. We review the management challenges that fall into each area, and examine how our proposed methodology can contribute to addressing these challenges. In this review, information technology is viewed as an enabler within the business process infrastructure and is constrained by allocated organizational resources.

3. The strategic enterprise management dilemma

Strategic Enterprise Management (SEM) refers to decision support concepts designed to enable the measurement of financial and non-financial performance of key business process segments. These measures allow managers, if they so choose, to focus on deriving increased shareholder value by acting on the information that is provided as Business Intelligence (BI). Without integrated enterprise systems, collecting and analyzing enterprise-wide data for BI is cumbersome, costly, time consuming, and error prone. The second half of the 1990s witnessed an explosion of Enterprise Resource Planning (ERP) software system implementation projects[1]. Other enterprise initiatives such as SCM, CRM and e-commerce systems followed and continue to this day[2]. Currently, the need for strategic management approaches is even more urgent than before for two reasons:

(1) Few companies met their objectives for technology initiatives and satisfactory results (BCG, 2000). In order to leverage the full value of their investments, performance measurement and application tuning methods, based on reliable data was identified as being necessary.

(2) For the first time managers were able to gather cross-functional data for their internal operations, as well as for the extended enterprise operations across the value chain. This held the promise of alleviating competitive pressures in the presence of rapidly fluctuating (fast-clockspeed) customer preferences.

The value of SEM cannot be understated, and current research even suggests that the concept should be extended to include the monitoring and management of intellectual capital as well as common business indicators (Jussupova-Mariethoz and Probst, 2007). Li *et al.* (2006) also show that higher levels of best practice in SCM can have a direct and positive impact on organizational performance.

Ballou *et al.* (2000) describe three managerial requirements in the supply chain:

(1) a new set of *metrics* (beyond normal accounting measures) for capturing inter-organizational data;

(2) an *information sharing mechanism* for transferring information about cooperative benefits among channel members; and

(3) an *allocation method* for redistributing the rewards of cooperation in a way that all parties benefit fairly.

In his "clockspeed" research, Fine (1998) emphasizes benchmarking; understanding, mapping, assessing, and analyzing the supply chain; and implementing three-dimensional concurrent engineering and competency development for successful SCM. His last point exploits ideas from the "lean production" paradigm (Womack *et al.*, 1990) and the Theory of Constraints (Goldratt, 1997). Will the SCM discipline provide its practitioners with tools and methodologies that provide the requisite information to be more proactive using reliable integrated performance measurement in the extended enterprise? Competitive interdependence demands understanding the needs of the whole supply chain and working towards a common goal. How are common goals defined and communicated in a consistent language? How are the strands of the interdependencies identified? And can the performance of the internal and external supply chain operations be monitored and improved?

Our research hypothesis is the following:

> An integrated and real-time enterprise SCOR view enables managers to better align supply chain applications with their business processes and strategic objectives, and supports a more effective implementation of SCM process improvement initiatives.

This hypothesis is tested with our i-SCOR methodology as implemented in the i-SCOR Toolset. A complete and successful test of the above hypothesis demonstrates efficiencies in SCM processes, effective technology deployment and management, and a financial impact on corporate balance sheets. This paper tests the above hypothesis in a limited way because we only demonstrate that one such alignment is possible. The long-term impacts on technology deployment, revenue growth, asset utilization and cost reduction can only be assessed as more data becomes available with of other implementations. At this stage of the research; however, we do apply the methodology and toolset; therefore demonstrating that this line of research is feasible and potentially rewarding.

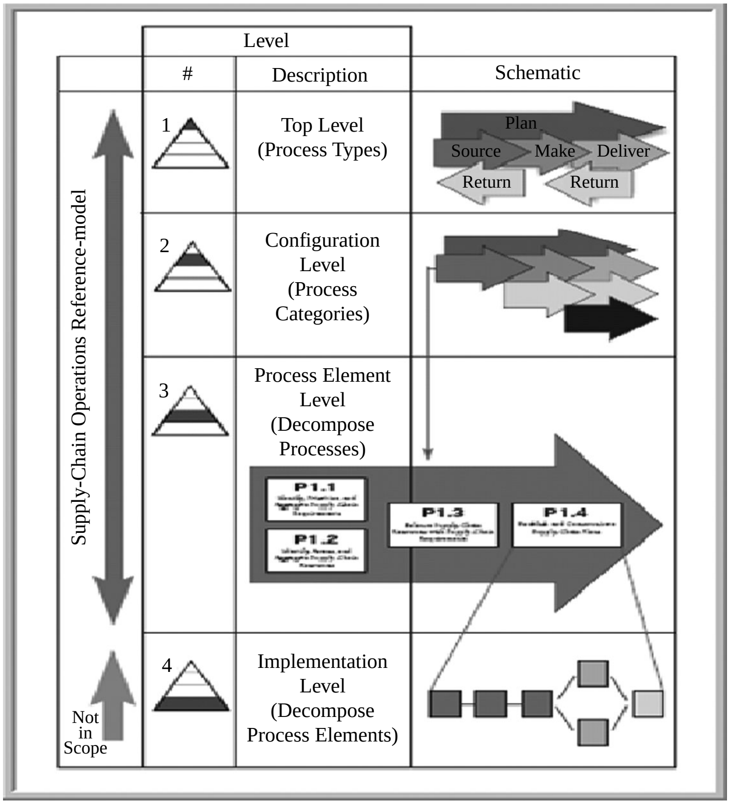
4. The SCOR model for effective SCM

The SCOR model was the output of an industry grassroots initiative in SCM. Industry visionaries founded the Supply-Chain Council (SCC) in 1996 as a professional forum on the emerging integrated management concepts in the extended enterprise. The SCOR model became the SCC's key knowledge contribution to the field at a time when functional barriers still challenged the practice. Since then the model has been revised a number of times, and the latest release continues to shape how many in the field approach SCM improvement projects. The membership of the Council has reached over 700, mainly consisting of practitioners, along with technology and consulting services providers, government and academic organizations.

Rather than a vertical- or technology-specific approach, SCC's aim was to produce a high-level business process reference model. The model can be applied to any and all product and information flow in the supply chain at high-levels of modeling abstraction, and then be used as a mechanism for extracting standardized KPIs from any company's supply chain processes. Since KPI definition and construction was standardized, benchmarking was possible. To realize this benchmarking objective company specific processes are linked to the lowest layer of the SCOR model (Level 3) during the implementation phase. The company specific processes comprise Levels 4 and below of what is called a SCOR model implementation project. This layering and linking of levels is shown in Figure 3.

We discuss the model's approach to supply chain design and management in the section below.

An understanding of industry's response to the SCOR initiative is important for understanding the significance of the SCOR model. As the SCOR model is more



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Source: *Supply Chain Council*

Figure 3.
Levels of the SCOR model

widely accepted and implemented, it gains critical mass, converging on a *de facto* standard for supply chain measurement. This means that the benefits derived from a *de facto* industry standard are realized. The process management and performance measurement related benefits derived from such wide usage are discussed below.

4.1 The business process reference model

The SCOR model describes high-level business processes associated with all phases of satisfying customer demand. At the highest level, the SCOR model is organized around five business process types:

(1) Plan.

(2) Source.

(3) Make.

(4) Deliver.

(5) Return.

These business processes represent the vertical-neutral abstractions from all demand/supply planning, purchasing/procurement, manufacturing, order entry and outbound logistics, and returns processing activities. For our research, we have focused primarily on the Plan, Source, and Deliver processes. We have some limited results on the Make process, but it is more difficult to automate in a generalized way due to the variations in detailed manufacturing processes. We have not yet extended our research to include the Return process.

The model, therefore, provides a business process framework with standard descriptions and interdependencies among processes. The aim is to meaningfully map supply chains and supply chain activities with varying complexities across multiple industry-verticals.

The hierarchical process framework decomposes to the third level. At Level 3, the process element level, activity definitions are still generalized[3], so they still apply to a variety of product and information flows (including services). The model, for the top three levels, provides the framework for analyzing, designing, and implementing actual operational supply chain planning or execution processes. The hierarchical structure of the SCOR model is shown in Figure 3.

A best-practice and enabling technology catalog is also linked to the process elements in the SCOR model, and they can be used to guide implementation. The model's business process framework provides a common language to facilitate horizontal process integration across different business units and players in the value chain. This framework is a strategic tool for describing, communicating, measuring, implementing and controlling, and fine-tuning complex SCM processes (Figure 4).

4.2 Performance measurement and benchmarking using the SCOR model

In addition to the management process template and a best practices index, the reference model includes standard performance metrics for measuring process performance. In our opinion, the measurement framework provided with the SCOR model is its most important feature. The metrics are defined in their specific layered structure. Level 1 metrics are used to measure five areas of strategic enterprise supply chain performance:

(1) reliability;

(2) responsiveness;

(3) flexibility;

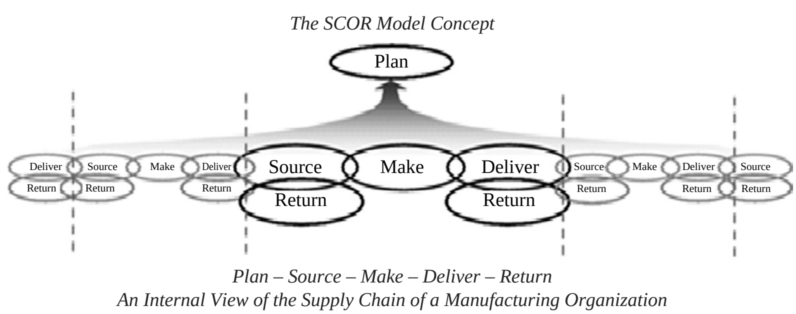

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Figure 4.
Single supply chain path or "thread" in SCOR terminology

(4) cost; and

(5) asset management.

These metrics decompose into lower level metrics that are linked to one or more process elements in the model. The concept is to use widely accepted and meaningful measures at appropriate levels of the organization to support strategic decision-making. The developers of the model used an approach similar to a variety of researchers, including Kaplan and Norton's Balanced Scorecard (Kaplan and Norton, 1996) that emphasizes a horizontal end-to-end view of the enterprise.

Industry-wide acceptance and the cross-functional nature of the SCOR performance view make it an ideal candidate for supply chain focused work in SEM. There are many cases that illustrate the value of consistent internal and channel-spanning performance measurement. For instance, a manufacturer of scientific products continuously received low marks from a customer on delivery (Anderson *et al.*, 1997). The company's internal measures indicated that performance was superior. The problem was that the customer and the company were not measuring the same thing. The customer accepted only full truckloads, i.e. anything brought the following week because it would not fit onto the truck was deemed backordered. From the manufacturer's perspective, however, "orders" were being shipped as promised.

While there is much academic work that addresses the SCOR model, the analysis of actual implementation approaches is limited. As presented at various SCC events, industry applications are mainly comprised of *ad hoc* performance measurement at Level 1. This, we believe, is a direct result of a lack of SCOR-enabled analytical and monitoring software tools. It becomes too costly to collect both high-level and detailed metrics on a periodic basis, let alone real-time, especially when functional or organizational boundaries are crossed. Automated measurement also requires that as-is enterprise process logic is well documented and data can be rolled up from these processes into the SCOR view. Our research responds to this challenge by developing new methodologies and tools.

In review, the SCOR model approach is aligned with the academic and professional work that promotes supply chain architectural design, performance measurement using reliable and consistent data models, and communication of business process blueprints. However, the scope of SCOR model implementation projects remains limited to internal operations or to a few nodes up and down the chain. There is a clear need for enterprise knowledge-enabled tools and methodologies that roll-up reliable data periodically or even in real-time into the model and communicate supply chain performance across the value chain. The SCOR model provides a consistent framework that enables effective and collaborative SCM.

5. Enterprise applications and process management

In the days when computing power was scarce and costly, enterprise automation was limited to specialized manufacturing, logistics and accounting systems. Interfaces among these systems consisted mainly of manual data entry and re-entry. In the 1990s, the development of client-server architectures for computer systems, along with the doubling of processing power every 18 months, paved the way for a new breed of enterprise solutions. ERP systems integrated fragmented operational data around business processes, and it became possible to track a customer's order from entry to manufacturing, and from delivery to accounts receivable using one integrated packaged software solution. Although intuitively straightforward, such tasks required complex and expensive software systems. In addition, how these systems are configured and implemented determined whether returns on these investments are actually realized (Davenport, 1998).

Much has been written on the issues and challenges related to ERP-enabled intra-enterprise integration. Extended enterprise integration, which includes business-to-business e-commerce, is even more challenging. In the next section, we highlight the current literature in enterprise applications and focus on one specific solution package to show the concepts behind the alignment of enterprise applications with the SCOR model.

5.1 Packaged software solutions

Software solutions can be grouped into four areas based on the general functions they perform:

(1) transactional/back-office;

(2) execution;

(3) planning; and

(4) strategic decision-making.

After reviewing these concepts, we focus in the next section on how SEM tools can be effectively aligned with planning, execution and transactional systems; therefore providing valuable information to support strategic decision-making. We use Figure 5 as a reference visual to support the discussion.

Modern back-office applications are implemented as standard software solutions. The market leaders for standard software are SAP with the SAP ERP suite and the

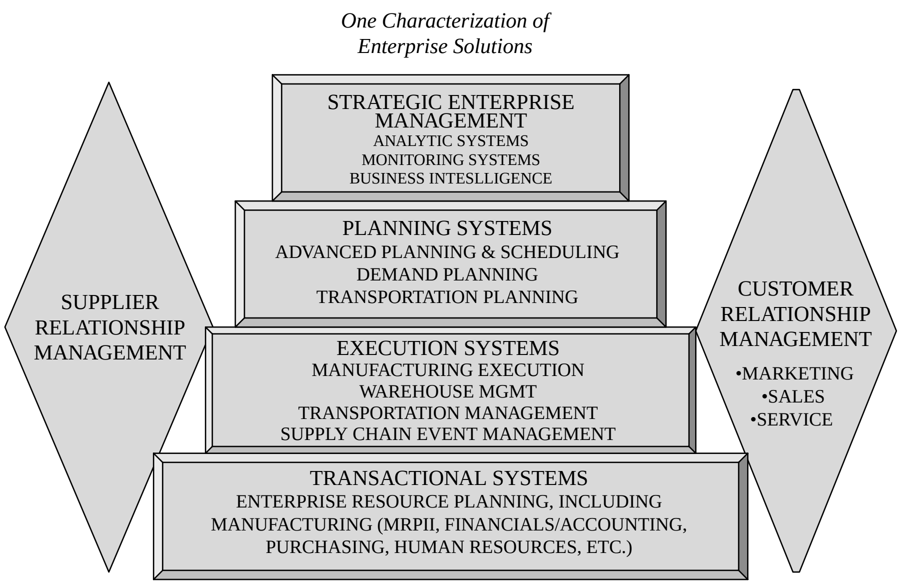


Figure 5.
Enterprise applications

Oracle Corporation with its E-Business Suite. There are many additional vendors offering varied functionality for varying levels of scalability, especially for mid-market implementation projects. By efficiently tracking all resources across end-to-end business processes, reliable data can be provided to execution, planning and strategic decision-making applications. In the early years of ERP, execution and planning systems were mostly "bolt-ons," not fully integrated into the software offerings. Through the years, the leading application vendors have increasingly included execution and planning functionality within their systems, and some have even enabled planning and execution on a single data model.

The successful deployment of enterprise applications has created value by reducing cycle times, raising customer responsiveness, and improving asset management. In addition, legacy system support and interoperability costs were reduced. Organizations also benefited when they redesigned their business processes to align with best-practice software configurations. On the one hand, by providing universal, real-time access to operating and financial data, the systems allowed companies to streamline their management structures; creating flatter, flexible, and more responsive organizations. Information became more centralized, and business processes became increasingly standardized. Enterprise applications imposed their business process logic on companies' strategies, cultures and organizational structures (Davenport, 1998). The new paradigm required a solid vision and commitment to change management. Failure to invest in up-front strategic analysis, an inability to understand business capabilities and requirements, and an inability to monitor and reevaluate progress were some of the reasons for unsatisfactory results (BCG, 2000). Along the same lines, the attention given to SEM tools was limited to analytical approaches through data marts or data warehousing using traditional cost and organizational stovepipe-focused metrics (Smith 2000). This narrow focus denied decision-makers of end-to-end process-oriented and near real-time performance measurement information. We now examine BPM and the development of enterprise Knowledge Bases (KBs) as an accelerator for implementing enterprise applications.

5.1.1 Oracle E-Business Suite. The Oracle Corporation is best known for its database management system, but Oracle also became a major player in the enterprise applications market in the second half of the 1990s. Oracle was able to develop or acquire and then integrate end-to-end business processes in what was known as Oracle applications, and is now known as the Oracle E-Business Suite. At a time when seamless enterprise application integration is still a technically elusive and costly goal for many organizations, Oracle has extended its solution once again through its Fusion middleware to offer a componentized service-oriented solution. The Oracle E-Business Suite provides improved visibility along supply networks, making it a good candidate for testing the hypothesis of this paper.

The Oracle E-Business Suite is designed as a function-oriented architecture *vis-à-vis* the more structured business process-oriented approach of SAP. Although affording implementation flexibility, complexity increases when translating business process requirements to realized business processes in the software. Oracle and third-party implementation consultants have released methodologies that speed up the undertaking and improve the probability of successful implementation. As an end-to-end fully integrated solution in the enterprise applications marketplace, the Oracle E-Business Suite is the selected enterprise solution for testing this research hypothesis.

However, we assert without testing that the methodology developed here can apply to other enterprise applications as well.

5.2 Process knowledge management

BPM emerged as the focus of academic and professional attention in the early 1990s (Davenport and Short, 1990). The constant quest for competitive advantage, supported by integrated applications, unleashed the private sector management transformation that is still underway today. Davenport and Short state that:

> [. . .] thinking about information technology should be in terms of how it supports new or redesigned business processes, and business processes and process improvements should be considered in terms of the capabilities that information technology can provide.

Davenport and Short go so far as to call this new approach to process management "The new industrial engineering". Many of these transformational ideas are included in Sommer (2004).

BPM, as considered in this research, includes:

- documenting processes to obtain how work flows within the enterprise to generate value;
- assigning process ownership in order to establish managerial accountability;
- managing the process to improve or optimize measures of process performance; and
- improving processes to enhance product quality and stakeholder value.

The achievement of competitive advantage through effective process management has been well documented in many research papers in a variety of organizations, and is not repeated here.

There have been a number of methodologies developed to represent business processes, such as Petri nets (e.g. Peterson, 1981; van der Aalst *et al.*, 2000), event-driven process chain diagrams (Scheer, 1999a, b), and specializations and coordination theory representations (Malone *et al.*, 1999). Studies have documented that the use of software tools improves effectiveness of business process redesign and improvement projects (e.g., Im *et al.*, 1999). These tools vary greatly from basic flow chart modeling functionality to integrated formally defined modeling of business processes, organizational models, and object (information) models that can generate function and data models used in CASE tools.

In addition, while most of these tools have static analysis capabilities, a few use simulation techniques for dynamic evaluation and improvement. "Process Compass," developed at Massachusetts Institute of Technology (MIT), and later commercialized as Phios is an example of using web-enabled authoring over a model repository database (Malone *et al.*, 1999. This research and development project at MIT also produced a "Process Handbook" of generic and specialized business processes. The aim was to make a variety of process designs available, to help managers redesign existing business processes and invent new processes by sharing a KB. Although this approach provides insight as an extensive "Handbook", it lacks the functionality to facilitate information system alignment. The ARIS methodology (based on Scheer's implementation of event-driven process chains) is a good example of an integrated process management methodology (Scheer, 1999a, b; Kirchmer, 1999). Organization, function, and data models are integrated around business processes and provide comprehensive modeling and analysis capabilities, including simulation.

In this research, we use the INCOME suite of tools, which is based on the Petri nets modeling language. Beyond simple visualization, Petri nets provide the structure for the analysis and validation of business processes (Desel and Erwin, 2000). INCOME Process Designer by PROMATIS implements Petri nets as behavior models that describe business processes (PROMATIS, 2007). The process models are hierarchical, representing high-level activities (process elements), which are decomposable to specialized tasks. The objects are inputs and outputs to the business processes. The information objects that are linked to the processes (e.g., invoices or purchase orders) are described in the object models. The resources required by these activities are defined in the organization model with additional information such as availability or cost. All model elements are stored in a model repository. The models are used for analysis (static and dynamic), process monitoring, evaluation, and continuous improvement. The INCOME toolset also includes functionality that integrates the models developed in the INCOME Process Designer to all phases of an enterprise application implementation methodology, beginning with feasibility studies and ending with computer-aided software engineering (CASE) development and user training (Figure 6).

PROMATIS has also developed generic business process reference models, called "Knowledge Bases." These reference models contain end-to-end processes that are supported by specific Oracle E-Business Suite modules;, e.g. purchasing, financials, manufacturing, etc. The goal is to accelerate all implementation stages, thereby reducing implementation cycle-times. Using integration cartridges, the Oracle E-Business Suite can be configured to align with business process requirements. The next section refers to this functionality in more detail, while explaining how this methodology may be aligned with the SCOR model for supply chain business intelligence.

BPM requires up-front planning and documentation; however, its advantages have been demonstrated in the professional academic literature. A consistent modeling

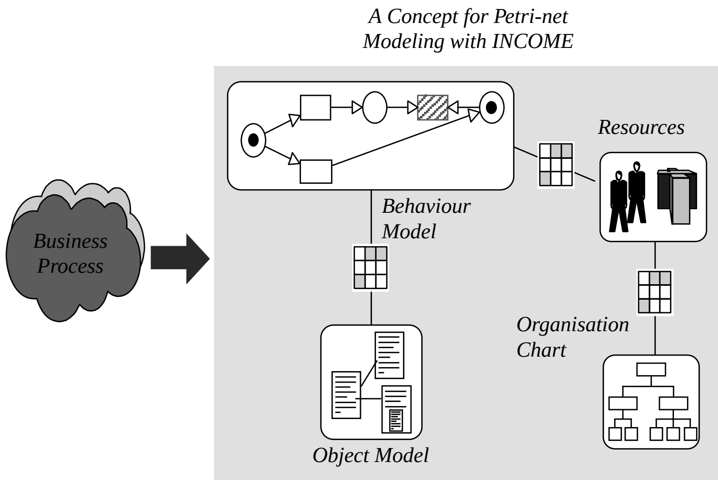


Figure 6.
Petri-net modeling using INCOME process designer (PROMATIS)

language and usable documentation enables identification of bottlenecks and interdependencies by visualization and static evaluation as well as simulation. Dynamic evaluation and enterprise applications alignment are major benefits derived from these BPM tools.

5.2.1 Knowledge-based Oracle applications implementation with the INCOME methodology and toolset. The uncertainty of achieving success in enterprise application implementation projects is often attributed to the managerial and technical complexity. These challenges led to innovative and practical solutions to address the problem. Scheer's (1994) business process-oriented ARIS approach to SAP implementation, based on the SAP reference model, is one such example. INCOME KBs that use best-practice reference models for implementing the Oracle E-Business Suite applications is another similar approach. The INCOME KB approach forms the foundation of the i-SCOR methodology developed in this research and presented in the next section.

By using the INCOME methodology and KB reference components it is possible to develop clear target business process requirements, perform a gap analysis, and implement the solution. If add-on functionality is required, it is developed using the Oracle Designer and Developer tools. The PROMATIS implementation methodology results in an enterprise application deployment that aligns with the organization's strategic objectives (Figure 7).

The benefits of this approach extend beyond the implementation project. Proactive BPM fosters continuous improvement. Process models support integration of workflow functionality based on Oracle's workflow engine, and will eventually be supported by the modeling capabilities within Oracle Fusion. With INCOME, the system documentation is clear, accessible, and easily maintainable. System upgrades

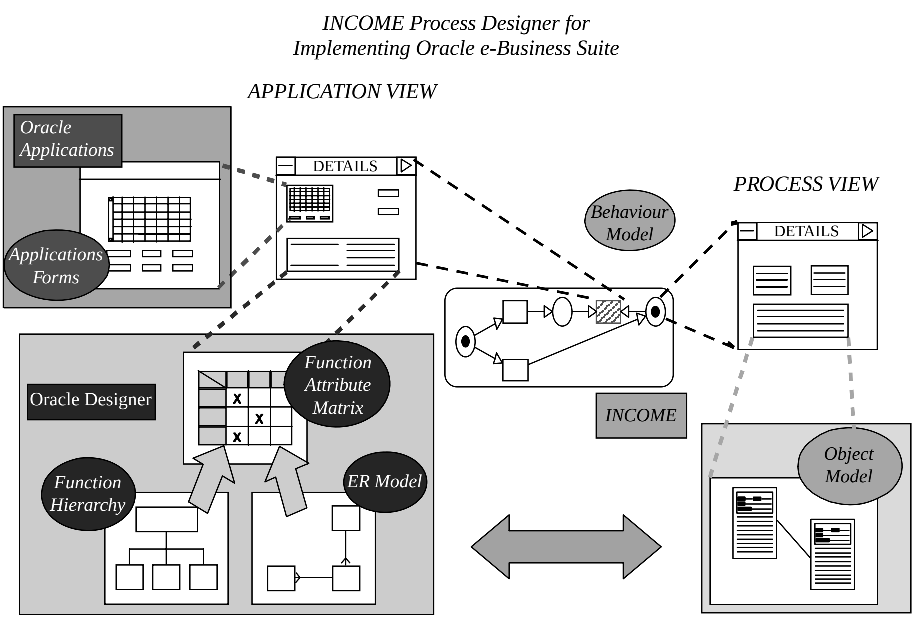


Figure 7.
INCOME process designer for implementing Oracle e-business components

or fine-tuning becomes less cumbersome with the aid of the KB. Training material is part of the documentation, and graphical models provide users with a process-oriented view of Oracle's software solution. In the next section we will examine how the process management approach enabled by INCOME tools supports business intelligence solutions for SCM.

6. The i-SCOR methodology

Business process-oriented thinking, including the development of the SCOR model, has significantly influenced enterprise management. The remaining question is: how is the SCOR model aligned with enterprise applications? The i-SCOR methodology and the associated i-SCOR toolset were developed to address the question and to test the main hypothesis of the paper.

6.1 General concept

As discussed earlier, value chain intelligence is often aggregated in data warehouses and data marts. The complexity of analytics sourced from these environments introduces a latency that can be detrimental to managers of "fast-clockspeed" supply chains. The traditional metrics used in these data warehouses are often not easily applied to end-to-end process-oriented management. Therefore, we turn to the second and emerging approach for value chain analytics, referred to as distributed query management. This approach combines the business process models, On-line analytical processing (OLAP) servers connected to enterprise applications, and real-time monitoring and analysis based on strategic objectives. The results are displayed to managers through a web-based (HTML) front-end called the i-SCOR SCM-C^3 (Command and Control Center) (Figure 8).

Although the real-time performance monitoring is the most innovative feature of this approach, the basics of BPM still apply. The following section, by specifically

Business Process Performance Management

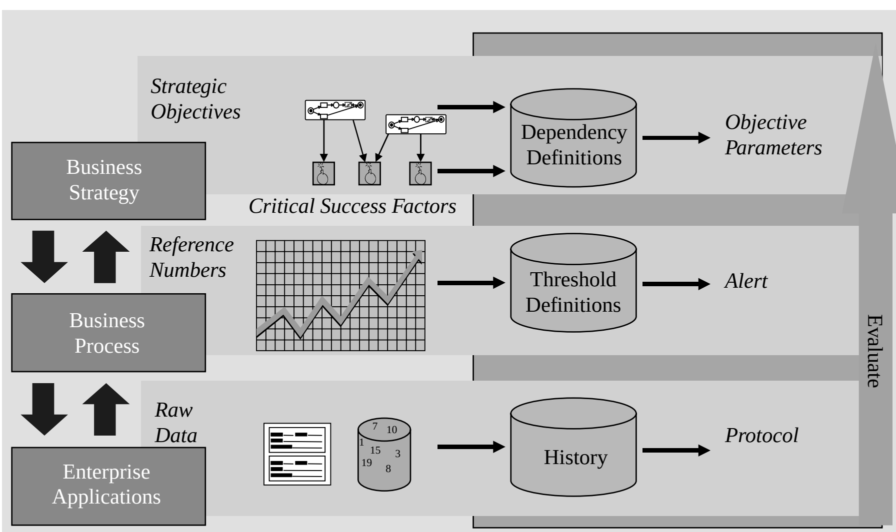


Figure 8.
Business process-oriented strategic enterprise management monitoring

focusing on SCM, describes how the INCOME Process Designer tool, combined with process KBs, establishes the foundation for the business process oriented performance management.

6.2 i-SCOR and SCM-C^3

i-SCOR is built using the INCOME Process Designer. This affords i-SCOR the functionality to design and manage business processes, while linking organization and information models in a distributed development environment. Supply chain managers can use the tool to model inter- or intra-organizational business processes. The graphical, easy-to-use, yet formally defined modeling language that is implemented in INCOME provides static and dynamic process evaluations, hence helping to identify opportunities for improvement. Such analyses provide supply chain professionals with the insight to migrate to improved supply network designs for internal and external operations. Supply chain initiatives benefit from the awareness disseminated across all levels of the organization, as well as other value chain partners.

i-SCOR consists of one key KB. This KB is a complete representation of the SCOR model using INCOME Process Designer. All three levels of the SCOR model business processes are modeled using INCOME Process Designer. Performance metrics and best practices are linked to process objects (input/outputs) and represented in object (information) models. Organization models and related resources and roles can be populated during an implementation. The whole model can be modified as needed to represent the supply chain operations of the organization implementing the SCOR model. The approach that we adopt is similar to that adopted by Röder and Tibkin (2006) for product and process documentation, but our focus is on the automation of the complete value chain by developing pre-configured middleware to automate the collection of value chain data directly from enterprise software applications.

A key functionality of the i-SCOR KB is the pre-configured decomposition link to the implementation layer. That layer is referred to as Level 4 in the SCOR model, the first level that the Supply Chain Council does not define. The i-SCOR methodology requires that Level 4 be developed and linked to Levels 1-3 in the SCOR model. In the i-SCOR methodology, Level 4 consists of relevant business process models from INCOME KBs that are constructed using best practice business process models. The INCOME KBs for the Oracle E-Business Suite that link to the SCOR model business processes are purchasing, manufacturing, projects, and order management. Figure 9 shows, as an example, a process element (SCOR Level 3) from the SOURCE process. It decomposes into one or more process elements in the Purchasing KB.

The same structure applies when a process element from the MAKE process decomposes into Manufacturing or Projects KBs, and from the DELIVER process into the Order Management KB.

The i-SCOR KB includes only the first layer of the four related KBs; however, all KBs could be bundled into i-SCOR if desired. That, in turn, can produce time and cost savings in three areas:

(1) Process design and analysis through the use of existing reference templates, allowing managers to develop models more expeditiously than starting from scratch.

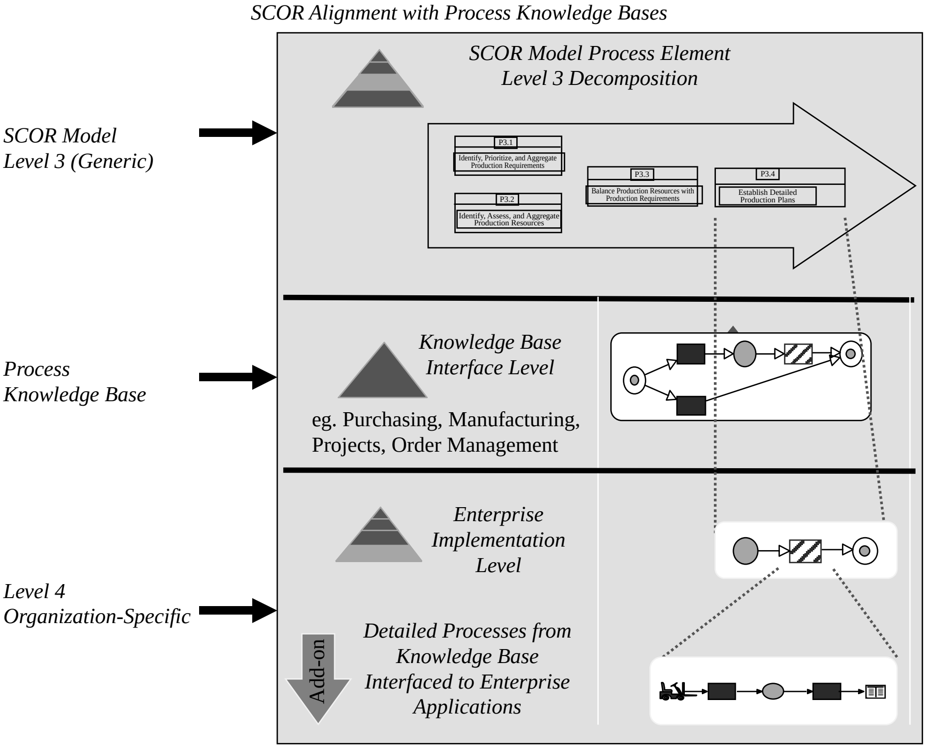


Figure 9.
i-SCOR KB interface

(2) Performance data aggregations using the detailed business process models, i.e. the alignment of SCOR metrics with business processes enhances metric applicability and accuracy.

(3) Oracle E-Business Component configuration and implementation using the INCOME KB methodology.

The monitoring engine that i-SCOR uses is the INCOME Monitor. This is a process monitoring tool that:

- manages master data, i.e. definition of performance indicators;
- receives values to produce the indicators from various data sources, including manual and OLAP databases; and
- supports analysis and reporting functions for the metrics gathered.

Therefore, when SCOR metrics are defined based on their strategic impact on the enterprise, and the related database query is defined, continuous monitoring and reporting of the SCOR metrics is possible. The monitoring can be set to discrete time intervals, or may even be real-time. Threshold levels can be established for the metrics, and when the thresholds are violated, INCOME Monitor distributes notifications via e-mail. With this approach, once i-SCOR is set-up with monitoring functionality, the waiting period that often renders performance data obsolete is minimized.

The benefits of monitoring are not limited to internal operations. The extended enterprise map (i.e., the value chain network model) is the graphical product flow diagram generated using INCOME Process Designer. SCOR metrics and other performance measures can be identified, implemented, and monitored. This type of value chain intelligence and visibility, as supported our earlier literature review, empowers supply chain managers with the information to be proactive. All implemented functionality is accessed through a web interface called the i-SCOR SCM-C^3. Executives and other stakeholders can personalize this web portal for supply chain visibility.

6.3 Proactive value chain management with the Oracle E-Business Suite and other enterprise applications

As noted, the INCOME KB methodology facilitates effective deployment of end-to-end business processes that are enabled by the Oracle E-Business Suite. We also discussed the value that integrated packaged software provides in terms of tracking resources and planning how resources should be utilized. The i-SCOR methodology provides SEM and decision support functionality using reliable, real-time data extracted from enterprise applications. Shah *et al.* (2002) provide justification for bringing these research streams together, and one of our contributions is a product-based merging of SCM with enterprise information systems. When the selected enterprise application is the Oracle E-Business Suite, the INCOME KB provides a direct mapping to the relevant data sources to support process oriented performance management. The business processes in other standard software or legacy systems could be mapped to their relevant data source, hence offering described benefits. However, the monitoring engine must be configured, and this is a challenge. In both cases, BPM is supported by process-based performance metrics at the SCOR level.

7. An i-SCOR example

In this section, we provide an example of how the i-SCOR methodology is actually applied. For reference purposes, a high-level view of the i-SCOR architecture is produced in Figure 10.

Figure 10 is instructive in showing how the i-SCOR KB provides the linkage between the SCOR model and the Oracle E-Business Suite. This linkage is the critical contribution of this research that provides the capability to automate data extraction.

Figure 11 shows the top-level of the SCOR model in INCOME process designer, focusing on source, make, and deliver.

For example, purposes, the “Source” object is decomposed to Level 2. This is shown in Figure 12.

At this level, the manufacturing orientation of the SCOR model is evident in the three types of products for sourcing: purchased make-to-order (MTO), and Engineer-to-Order (ETO). Any of the SCOR objects could be decomposed in the same way as the “Source” object, eventually yielding a complete representation of the SCOR model in INCOME Process Designer. As previously mentioned, the i-SCOR KB contains this complete representation. We continue the example by selecting the “Source Purchased Product” object and decomposing it to Level 3. The resulting model is shown in Figure 13.

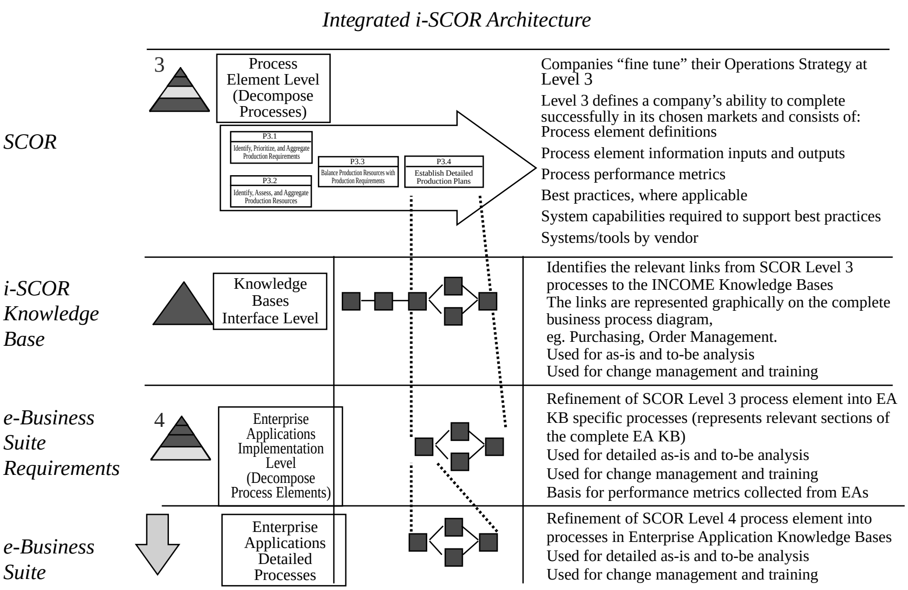


Figure 10.
i-SCOR architecture

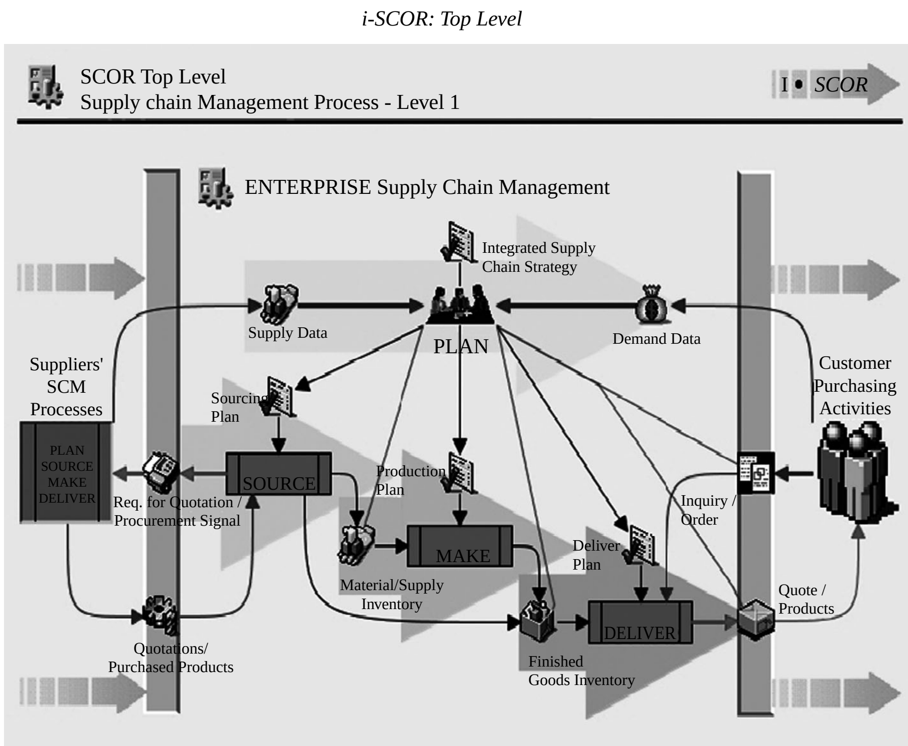


Figure 11.
Top-level SCOR model in INCOME process designer

i-SCOR: Source Business Process (Level 2)

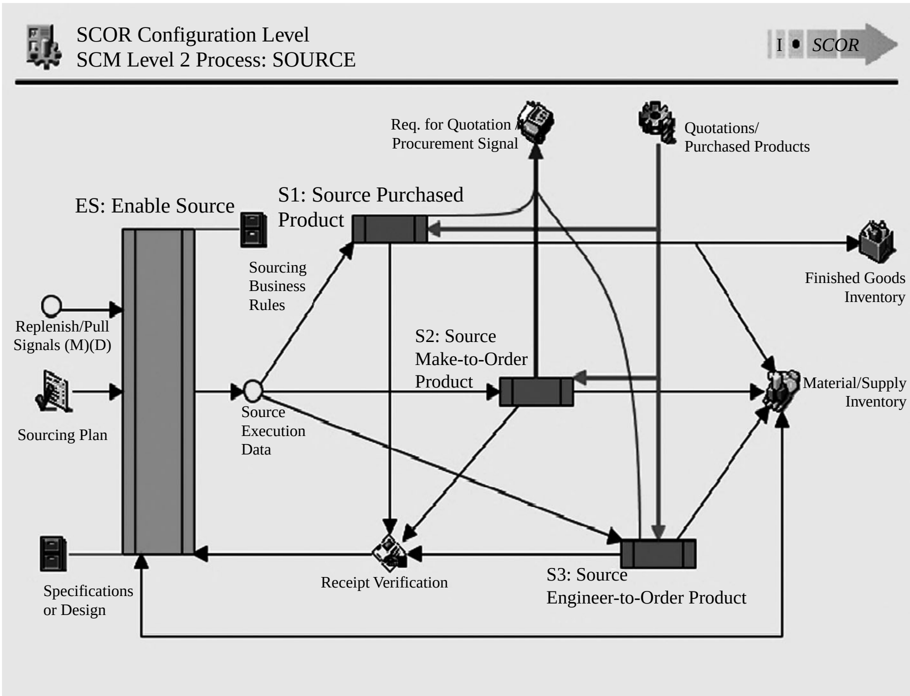


Figure 12.
Level 2 i-SCOR model in INCOME process designer

Level 3 is the lowest level in the SCOR model, and the process elements (e.g. Receive Product) is then integrated into the Oracle E-Business Suite using the i-SCOR KB. The KB alignment/integration is shown in Figure 14. The linkage to the Oracle E-Business Suite is accomplished in this step, which for this example is a linkage to "Schedule Product Deliveries."

The SCOR Level 4 as it ties to the "generic" enterprise application processes is shown in Figure 15

As a final step the mapping can be extended to the data element level for the automated extraction of the relevant data from the E-Business Suite production database. This final mapping is shown in Figure 16.

The data is now available for aggregating in accordance with the KPIs provided with the SCOR model. The i-SCOR mapping may not provide complete data, since it is dependent on the configuration of the E-Business Suite, but given the completeness of the Oracle product, this limitation is not constraining. If one were relegated to the legacy environment, each mapping would be unique and the data still may be unavailable. So, one is better off by far with high quality data being extracted from the Oracle production database, even if there are some gaps in the SCOR KPIs

The final product is shown in Figure 17 as a SCORcard, summarizing the SCOR-based KPIs at the highest level. This summary card is a primary view in the Command and Control Center.

i-SCOR: Process Element Level (Level 3)

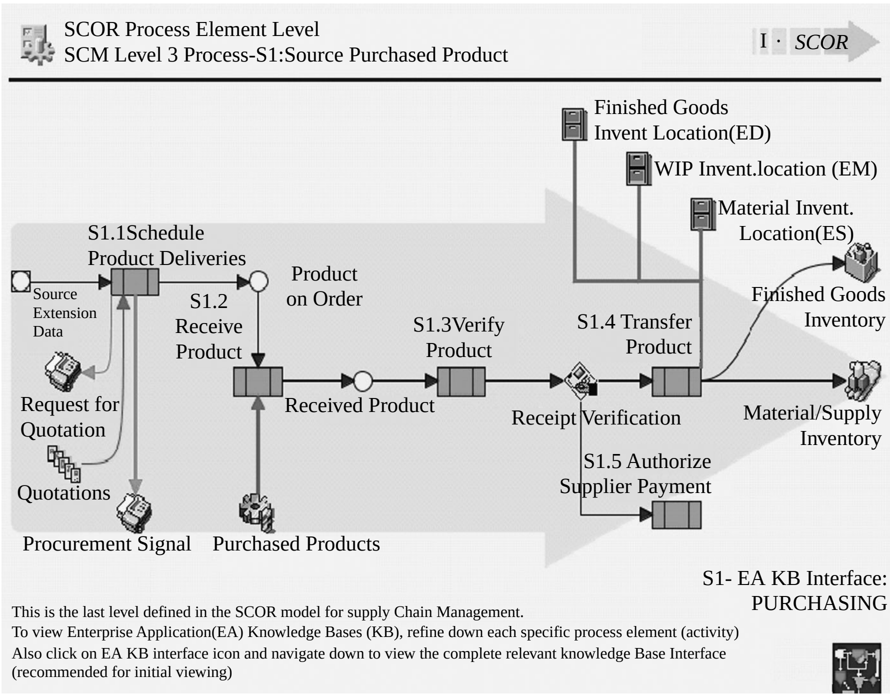


Figure 13.
i-SCOR Level 3

While this example is simple, it does provide an abbreviated view of the complete i-SCOR process. It must be noted, however, that this is not an out-of-the-box solution. Implementation requires knowledge of the Oracle E-Business Suite and an ability to align the i-SCOR KB with the Oracle configuration. Automation comes with a cost, but the benefit is a monitoring solution that is institutionalized.

8. Conclusions

Our goal was to test a hypothesis through product development and demonstration. We presented a conceptual framework for value chain management, which includes SCM. Then, we introduced components that guide our research efforts: the SCOR model, enterprise software applications, BPM, and business intelligence concepts. Finally, the i-SCOR methodology and associated toolset were presented. We argued that:

- business process oriented performance management benefits the enterprise;
- tools that enable business process oriented performance management can improve managerial effectiveness;
- reference business process models such as the SCOR model can be and are used to improve process management efficiency and effectiveness;

i-SCOR Alignment with Oracle Applications (Knowledge Base Interface)

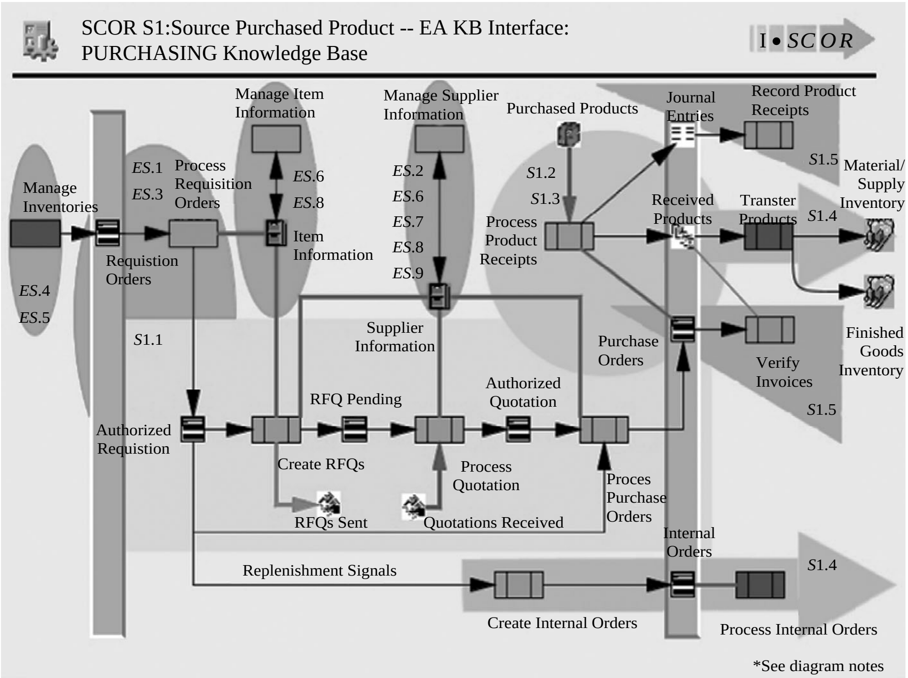


Figure 14.
i-SCOR KB interface

Oracle e-Business Components

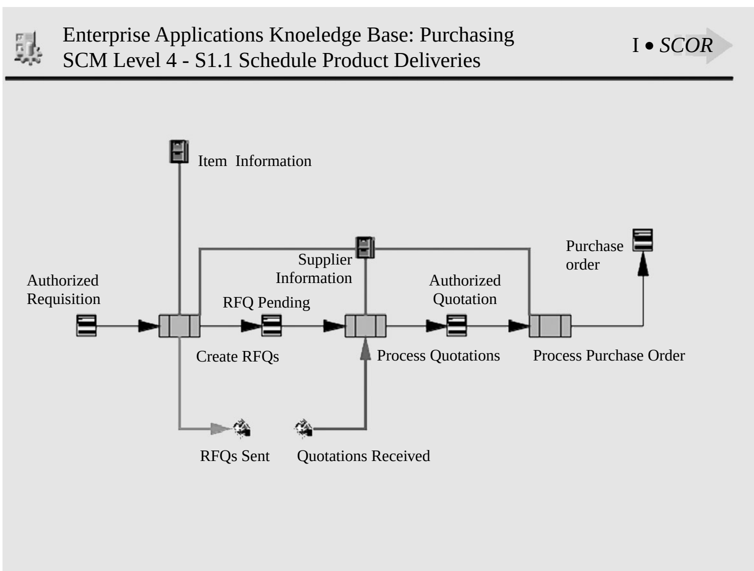
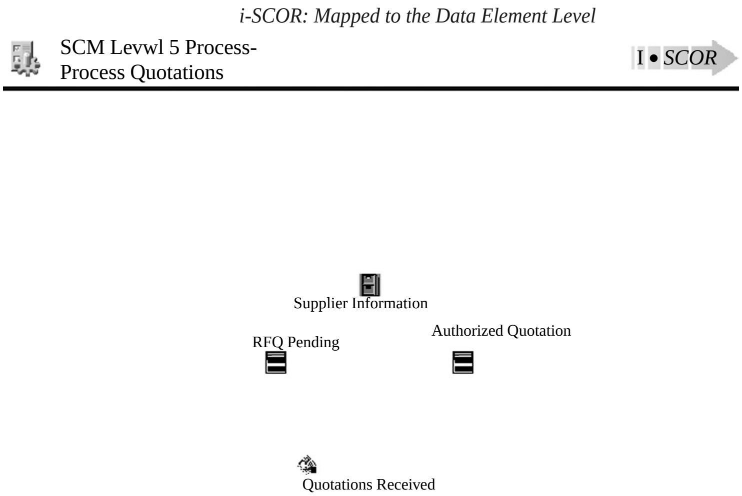


Figure 15.
Oracle E-Business Suite process as i-SCOR Level 4



Insert here and in below levels Enterprise Applications specific lower level process models (eg. ORACLE Applications, INCOME Business Component) and their Set-up tasks.
Then save as the Level 5 diagram of the desired execution process (S1, S2, S3)
The objectr stores from Level 4 are for reference

Figure 16.
Data element level mapping in the Oracle E-Business Suite

Rapid Implementation-SCORcard

SCORcard				*Actual Performance Versus Consumer Packaged Goods Benchmarks*			
		SCOR Level1 Metric	Actual	Parity	Advantage	Superior	Value from Improvements
Customer Facing	Delivery Reliability	Order Fillrate	98%	76%	87%	97%	Need To Maintain Superior Performance
		Line Fillrate	N/A	90%	96%	98+%	N/A
	Flexibility & Responsiveness	Fulfillment Leadtime, (Order Receipt to Customer Receipt)	5 - 12 days	3 days	2 days	1 day	*Opportunity for Competitive Advantage*
Internal Facing	Cost	COGS, (Cost of Sales % to Net Sales)	34.7%	60.0%	TBD	TBD	Need To Maintain Superior Performance
		Warranty/Returns, (Returns as% of Net Sales)	16.0%	TBD	TBD	TBD	*Opportunity for Performance Improvement*
		Total Supply Chain Cost, (As a % of Net Sales)	-----	8.0%	7.0%	5.0%	*Opportunity for SG&A Reduction*
		Order Management, (Customer Service Allocation + Freight + Fulfillment)	8.5%	4.0%	3.0%	1.5%	*$2.5M estimated Home Delivery opportunity*
		Material Acquisition	Very Low	3.0%	2.0%	0.5%	Need To Maintain Superior Performance
	Assets	Cash to-Cash, (Inventory days of supply + days sales outstanding - average payment period)	7 days	65 days	40 days	20 days	Need To Maintain Superior Performance
		Net Asset Turns, (Total gross product revenue/ Total net assets)	TBD	2.5	5	7	TBD

Figure 17.
i-SCOR SCORcard

- managing by process-oriented performance measures improves end-to-end enterprise management;
- enterprise applications, including SCM Applications, are powerful management solutions; and
- supply chain success is enhanced by supplier network design, information sharing, visibility, and proactive measurement and monitoring.

The literature suggests that these six assertions are true, and the i-SCOR methodology was developed under the same assumptions. While there is little new in the assertions, implementation has been problematic because of the data requirements for supporting an end-to-end SCM business intelligence solution. Therefore, we asserted that automated data collection would enhance success. Since the organization's enterprise systems are a primary source of high-quality data, we focused our research on automated data collection from these systems. We asserted that automated data collection is possible, and we formulated a testable hypothesis that stated the same. We tested the hypothesis using the SCOR model and the Oracle E-Business suite by demonstrating that automation is indeed possible. We continue to analyze, disseminate and improve upon the concepts discussed in paper, and we are also committed to providing methods and tools, including i-SCOR enhancements, that will empower managers to make better SCM decisions.

Notes

1. See Moon (2007) for a review of the relevant literature.
2. SCM systems providing various solutions are pervasive. While consolidation has occurred, there are many options and overlaps available.
3. This is a strength of the SCOR model, which has helped in gain wide acceptance in private industry. However, to apply the SCOR model properly, Levels 4 and below must be developed. Otherwise there is no way to link the SCOR model to internal business processes.

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Corresponding author
Thomas Gulledge can be contacted at: gulledge@gmu.edu