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Rewiring for global integration

Connecting the
electronics value chain
with SOA

Application Innovation
Services
Electronics



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Rewiring for global integration

Connecting the electronics value chain with SOA

By Henry Dao and Jay DiMare

Forces in the electronics industry, marked by constant price pressures, heavy global competition and extremely short product lifecycles, are driving more electronics companies to be more globally integrated. Global integration enables electronics companies to position themselves as highly efficient and unified enterprises, and true global integration impacts the full spectrum of their value chain. We believe technology-enabled collaboration, facilitated by the adoption of service-oriented architecture (SOA), is a key to allow for increased collaboration within the enterprise and business ecosystem.

Introduction

Over the past decade, marketplace dynamics have changed dramatically. Globalization, deregulation, commoditization – and, in particular, the impact of the Internet – have been significant drivers of business transformation. This is particularly true of the electronics industry, which creates products both for end users (such as consumer electronics) and other manufacturers (such as office equipment providers and network equipment providers). With so many manufactured products now incorporating electronic components and the pace of commerce so rapid, the industry has not only grown quickly – it has also become far more competitive.

The breakneck pace of technology development has put incredible pressure on electronics original equipment manufacturers (OEMs) to deliver unprecedented innovation as a matter of course, on a tight schedule and at ever-lower prices. For example, companies are not only incorporating innovative technologies that will boost the performance of the next phone, camera or computer, but they are also trying to make the products more affordable at the same time, especially in the current environment of decreased consumer spending. As many organizations are learning, traditional, siloed business models can no longer keep pace with the changing and increasingly high expectations of both customers and end-users. In order to best meet consumer and customer needs, companies need to find ways

to bring their best offerings to customers and consumers, regardless of geographic location. Unfortunately, parent companies with multiple global subsidiaries often lack the seamless integration that enables them to take advantage of specific needs in local markets.

To meet today's business challenges, an electronics OEM should operate as a single, globally integrated organization – with fully integrated processes and systems across the enterprise. The benefits of doing so can position them to:

- Achieve cost-saving operational efficiencies through economy of scale
- Capture global (and growing) market opportunities
- Achieve faster time to market by leveraging global scale, expertise and resources
- Optimize support functions for greater efficiency
- Better serve the needs of global clients
- Create the flexibility to quickly respond to change.

In order to reap these benefits, companies need to first overcome disparate, inflexible, poorly integrated IT architectures, a lack of process coordination and insufficient collaboration, which pose as significant challenges to becoming truly globally integrated.

Service-oriented architecture (SOA) provides a clear path to overcoming these challenges by introducing an insulating layer of standardized, technology-agnostic service components between front-end applications and back-end systems. This can dramatically simplify the integration of information, processes and technology across the enterprise. Furthermore,

SOA enables organizations to rapidly and efficiently create new applications and processes, which, in turn, can improve business responsiveness and flexibility.

As a key enabler of the globally integrated enterprise, SOA can become an important part of the response to the primary imperatives facing the electronics industry. These include:

- *Enhancing customer experience and loyalty:* Increasing competition and brand visibility requires electronics OEMs to improve the way they are perceived by the marketplace.
- *Speeding time to market:* The only way to shorten product life cycles – arguably one of the most important competitive success factors in the electronics industry – is to enhance the effectiveness of the development process.
- *Lowering costs and improving efficiency:* Strong downward price pressure in the electronics industry has long been a fact of life, and shows no sign of abating, particularly in the current economic environment where value-driven products are the norm.

What is SOA?

Service-oriented architecture (SOA) is a style of developing and integrating software. It involves breaking an application down into common, reusable “services” that can be used by other applications, both internal and external, in an organization – independent of the applications and computing platforms on which the business and its partners rely. Using this approach, enterprises can assemble and reassemble these open, standards-based services to extend and improve collaboration among existing applications, build new capabilities, and drive innovation at every point in the value chain.

Rewiring for global integration

Connecting the electronics value chain with SOA

SOA can help electronics companies overcome some key business challenges, add more value to the enterprise and remain competitive in a constantly changing global marketplace. The following three scenarios demonstrate how SOA can help electronics companies to cope with these challenges:

- Improving the online shopping experience
- Enabling collaborative product development
- Facilitating demand-driven collaboration.

Improving the online shopping experience

OEMs are witnessing two important trends in the retail electronics marketplace. First, decreased consumer spending, strong pricing pressure and shrinking margins are driving the need to find new sources of revenue. Second, increasingly tech-savvy consumers, who are careful with their limited spending in the current recessionary environment, are turning in ever-growing numbers to non-traditional sales channels to compare prices and promotions, and procure goods and services. As an example, online sales of consumer electronics are rising at three times the rate of traditional offline sales.¹

New direct sales channels – OEM online and branded brick-and-mortar stores – are becoming increasingly prominent due to their inherently strong profit margin for the manufacturer. But an additional, highly significant benefit that OEM direct channels can offer is improved customer value. By facilitating direct control over the quality of the user experience, direct channels enable OEMs to deliver what customers demand most. Research by the IBM Institute for Business Value indicates that

*a positive customer experience is a key driver of loyalty:*²

- Some 79 percent of consumers commit to a deeper brand relationship, and 82 percent will recommend the brand after a satisfying experience.
- Just one bad experience in one channel will cause up to 59 percent of consumers to stop doing business with the brand.
- Senior executives agree that the total customer experience is critical to driving loyalty: 85 percent say that differentiation in price, quality and delivery is no longer enough.

The fundamental goals of OEM online sales channels are in many ways different from those that underlie general retailer sales channels. OEM sales channels are as much about generating brand awareness and loyalty as they are about actually selling products. On a basic level, however, all sales channels, regardless of who runs them, must provide four broad classes of function and content:

- Product content, including product descriptions, images, attributes and new product updates (increasingly this can include user-generated content, such as customer reviews)
- Product pricing, including variations such as package deals and promotional discounts
- Ordering, including rapid, intuitive and effective order procedures and processing, status information and tracking.
- Marketing, including customer information and additional product and services marketing, such as product support and customer service.

Inadequate integration contributes to many of the challenges OEMs face in enhancing the customer experience.

The details will, of course, vary depending on whether the direct channel systems are customer-facing (e.g., online storefronts) or employee-facing (e.g., call centers or retail store POS systems).

OEM channels today

Most of the challenges facing OEMs that seek to enhance the customer experience through direct sales channels are related to inadequate integration. Data is often fragmented and difficult to synchronize because it resides in multiple and/or disparate enterprise resource planning (ERP), customer relationship management (CRM) and content management systems. Poor integration between front-end systems and back-end systems also complicates effective order management.

Let's consider a scenario where the OEM has its own e-commerce site. These sites require some of the same data that is provided to its retail channels, some that is tailored or specific to the OEM brand and the usual e-commerce data such as order information. Product data should be the same as provided to the retail channels. Pricing data may need some additional business rules applied. Marketing data will be specific to the OEM business objectives and policies.

Today, integration between the e-commerce application and other backend systems is accomplished in a variety of ways. A common approach is to load data required by the e-commerce application as needed. Data management solutions vary, and the use of extract-transform-load (ETL) solutions make the job easier. But moving data from the

source to the e-commerce application adds complexity. It also adds processing time, and the data cannot be easily changed in realtime.

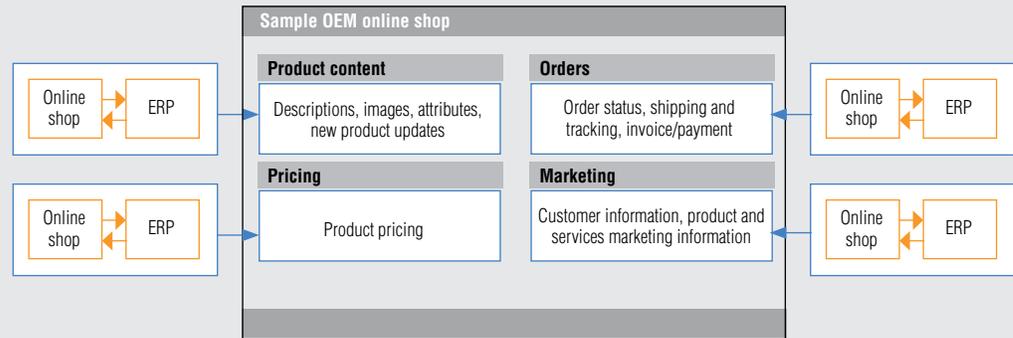
Given the high-profile nature of branding on an OEM storefront (online or brick-and-mortar), providing accurate product information is critical. Limited integration, along with time-consuming, manual content management processes, can lead to outdated and inaccurate information appearing in the system. This can cause a great deal of damage to the brand image.

e-Commerce and channel collaboration using SOA

Building an e-commerce site that avoids the problems above, as well as the shortcomings of today's point-to-point solutions, requires a different approach to systems integration. SOA presents a way to build the application using realtime access to data. Focusing on our e-commerce application, Figure 1 shows the type of systems interaction required to build and operate the site.

In Figure 1, the e-commerce site would collect data from one or more ERP systems. The information would be requested in realtime, as it is needed, without the need for copies of the data. While there are a number of different ways to achieve this level of integration, there are some key attributes of an SOA approach to focus on. First and foremost, how the data is accessed by the OEM for the purposes of online commerce would have the same access requirements as any retail partner. In addition, some of the data needed (such as price and promotion) would benefit from realtime access. Ideally, the OEM would main-

FIGURE 1.
Building the e-commerce site with direct access to source systems.



Source: IBM Institute for Business Value.

tain control over product information such as specifications and images. And some information, such as prices, will require some level of security, as well as qualifying information, in order to provide the correct values (in other words, “who is asking for the price” and “who is the price for.”)

SOA supports these attributes using a standards-based approach. This technique for allowing applications to communicate is similar to a telephone call. The e-commerce site “calls” the ERP system and asks for the order details. The ERP system answers, and the call is over.

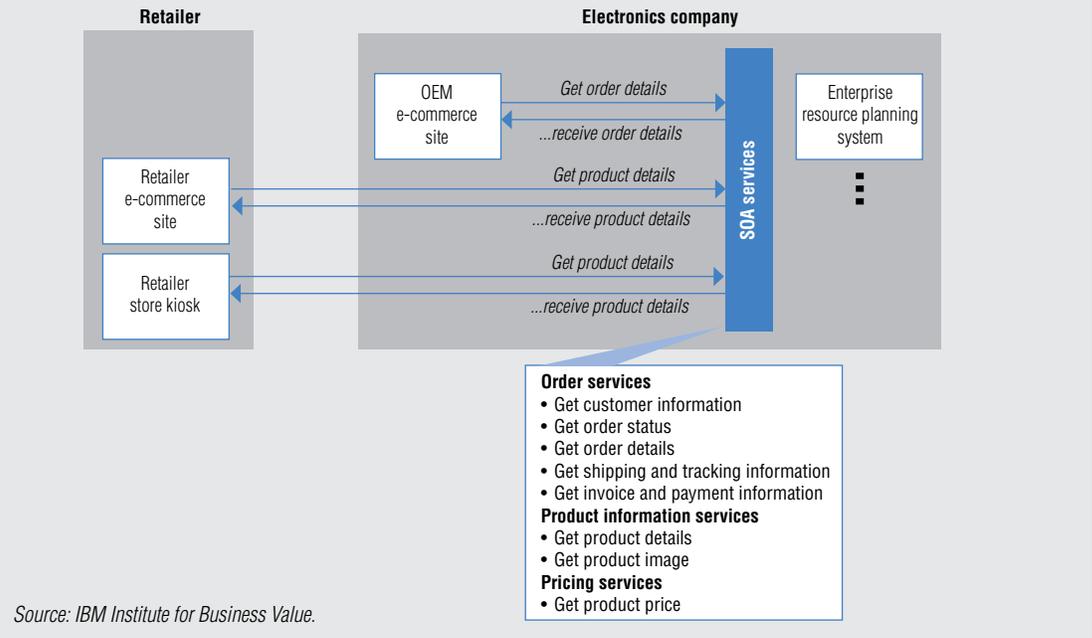
With service-oriented architecture, the four basic parts of the shopping portal in our example are accessing different data from the same source through a defined set of SOA services. By introducing a single, unifying layer of services between multiple front-end portals and multiple back-end systems, an SOA solution can help negate the problems caused by multiple, point-to-point solutions.

For the OEM, the same set of SOA services used to build the e-commerce site can be used by external partners. All retail partners can access the same information through the same connection. To aid the OEM in the design of SOA services for this application (e-commerce), organizations such as the Association for Retail Technology Standards (ARTS) are creating models specific to retail that can expedite the design and implementation process. ARTS recently released the SOA Blueprint for Retail, a comprehensive, vendor-neutral approach to applying SOA in retail.³

The unified nature of the SOA services layer facilitates transparent integration, since the details of the underlying back-end systems no longer matter to the applications that sit on top of it. For example, as shown in Figure 2, the basic process of requesting order details – accessing customer information, order status, shipping and tracking information, and invoice and payment information – is fundamentally the same, regardless of the sales channel or

SOA facilitates transparent integration as the details of the underlying back-end systems no longer matter.

FIGURE 2. Using SOA services for e-commerce.



originator of the request. Since much of this information resides in disparate systems, coordinating and integrating it is clearly difficult if each front-end application has to accomplish the task separately.

The value to the business

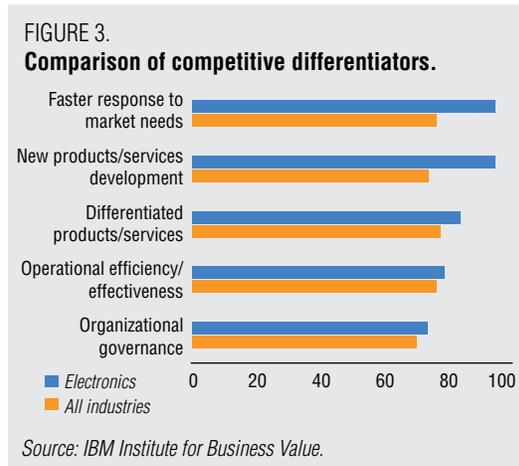
The resulting improvements in product information availability, timeliness and accuracy, as well as the more efficient and effective processing of orders, are what drive the most critical benefit for OEMs. This allows the OEM to greatly improve the customer experience and, thereby, strengthen the brand. Information used on the OEM e-commerce site will be the same as used for the OEM store or outlet. The same information is also provided to the retailers. Since the information is taken from the source system that maintains it, the data is taken in realtime, yielding the most current and accurate information at the time of the request. Nowhere is real-time information more critical than in the access of price and cost information for e-commerce applications.

SOA can facilitate the reuse of services and simplify the exchange of data among systems. Reuse increases quality of code, as previously tested and operational interfaces are used by new retail partners, or for new uses within the OEM's environment. Development and integration times are shorter as design, development and test of applications using existing services is reduced – resulting in a shorter time-to-market.

Beyond this improvement in efficiency, SOA helps the OEM through the effective integration and synchronization of information in realtime across the value chain. After the first retailer is connected using SOA services, additional retailers and other partners can be added more easily. This sets the stage for business collaboration in other parts of the OEM operation.

Enabling collaborative product development

Competitive advantage created by going to market first with innovative new products – be they feature-rich or value-driven – is critically important in the electronics industry. Market demands shift very rapidly in electronics, and expectations are invariably high. IBM research clearly indicates that electronics companies feel these forces more than other industries, as shown in Figure 3.⁴



Electronics OEMs are having difficulty bringing new products to market as fast as they need to, primarily due to three realities facing the industry:⁵

- Nearly two-thirds of products take more than 100 days to bring to market.
- The majority of products are delivered late. Only a quarter of new products are launched on or nearly on time.
- The later a product is launched, the less revenue it generates over time. In fast-turning industries, such as electronics, this effect is magnified.

Electronics OEMs, as well as those in other manufacturing industries, have made dramatic reductions in the product development cycle time through the adoption of product lifecycle management (PLM) systems. PLM covers the entire product lifecycle – from planning to concept development, to design, production and testing, to maintenance and support and, finally, to retirement and disposal. The aspects of the lifecycle that are the among the most important to bringing new products to market are concept development and design, which encompass software, as well as mechanical and electrical components.

Despite the improvements brought by PLM, the development process remains inefficient. The key issue is integration between PLM systems and other business systems, which is needed to support collaborative innovation. Also, the complex development environment impedes information-sharing, which, in turn, increases cycle time.

This is a multifaceted challenge. Critical enterprise applications, such as requirement management and product portfolio management, are often isolated from one another, and user access is similarly fragmented. There is limited integration of authoring applications and needed data. Product management systems that span the enterprise, such as product data management (PDM) solutions, are not well integrated with other business systems.

Compounding this lack of internal information-sharing is poor integration with other business divisions or external partners and their enterprise systems, which can affect parts requirements, ordering, supply and delivery.

How the process works today

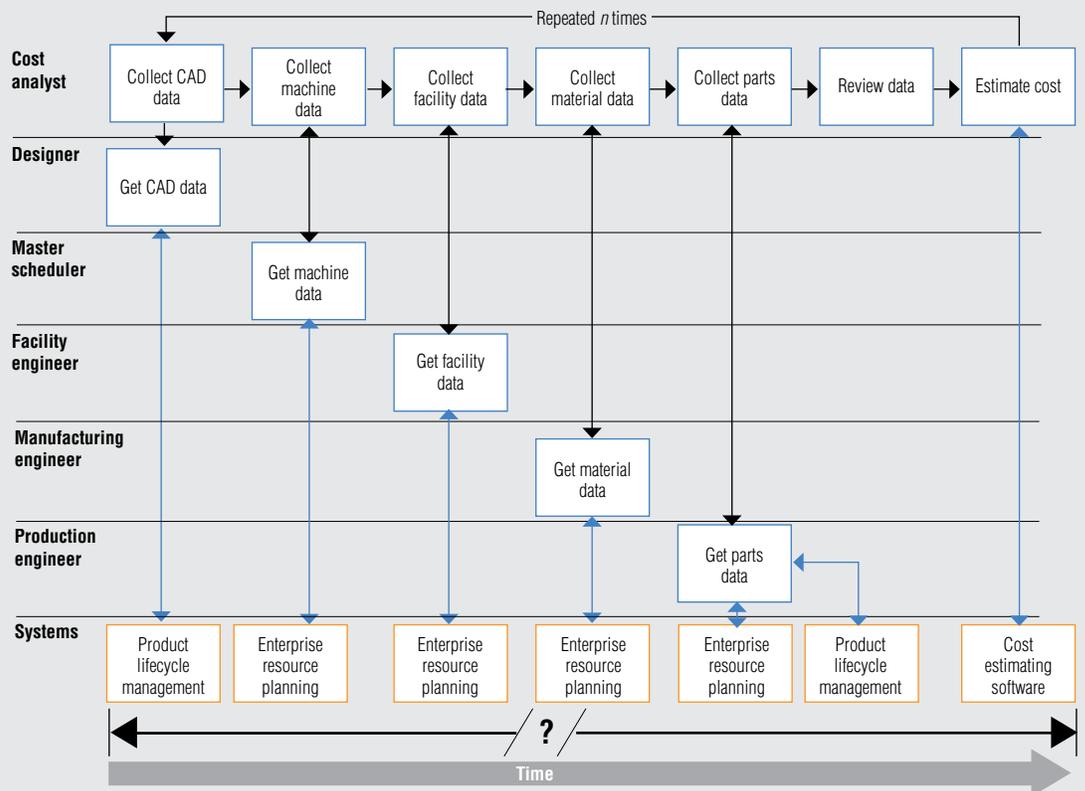
To illustrate the nature of the PLM integration challenge, it is instructive to examine the typical responsibilities of an OEM cost analyst. The work performed by this individual is important to the enterprise because timely and accurate cost estimates have a significant downstream impact.

The analyst would need to meet with all participants in the design and manufacturing process to estimate costs. Starting with the designers, information from the latest computer aided design (CAD) models is needed. Meetings with master schedulers would be needed for machine lists, labor

rates, work center schedules and rates, as well as routings and routing rules. There would be meetings with facility engineers to obtain facility data, including processes, defaults and overhead information. There would be meetings with manufacturing engineers to obtain material data lists and rates. And there are production engineers that would provide parts data, production quantities, production materials and production times.

All of the data for each of these groups is developed and managed in their own system. In most cases, these systems are not integrated. In our example, illustrated in Figure 4, the cost analyst has his or her own software for managing the cost estimate.

FIGURE 4.
Typical data collection process for developing cost estimates.



Source: IBM Institute for Business Value.

Information needed by cost analysts is collected in realtime, helping to eliminate unproductive work steps.

This essentially manual process, which can involve several people in different roles, is iterative; it is repeated many times, since one part of the process affects the others. Due to a lack of timely information updates – a situation caused by poor integration and the probability of human error – cost estimates are often late and inaccurate, requiring rework and duplication of effort. Most significantly, the process is slow, which can result in long cycle times.

The important aspect of this illustration is that the overall process is necessary even with a PLM system in place, since the data needed by the cost analyst is spread among several isolated systems.

Streamlining the process with SOA

The preferred solution to this endless loop of data collection and reentry of data is for the cost estimating software go to each system to get the data needed for the overall cost estimate. Ideally, this would be in realtime, so that the latest information at that point in time is used in the calculation. If this level of integration was possible for a reasonable level of

effort, the cost-estimation process could be highly automated, as shown in Figures 5.

All of the information that the cost analyst needs is automatically collected by the cost estimating software in realtime. This helps reduce unproductive work steps and rekeying of information. The SOA solution integrates all of the back-end systems involved in the process, thereby connecting the PLM systems with other business systems, such as ERP. From the point of view of the cost analyst, there is no distinction: the needed information is simply made available to the cost estimating software.

Given the variety of information in a typical PLM system or ERP system, the question remains how to implement such a level of integration. For those cases that are integrated today, most often these are point-to-point custom solutions that impede future business changes. SOA offers a standards-based approach to expose information currently in PLM and ERP systems to other applications in need of the information (see Figure 6).

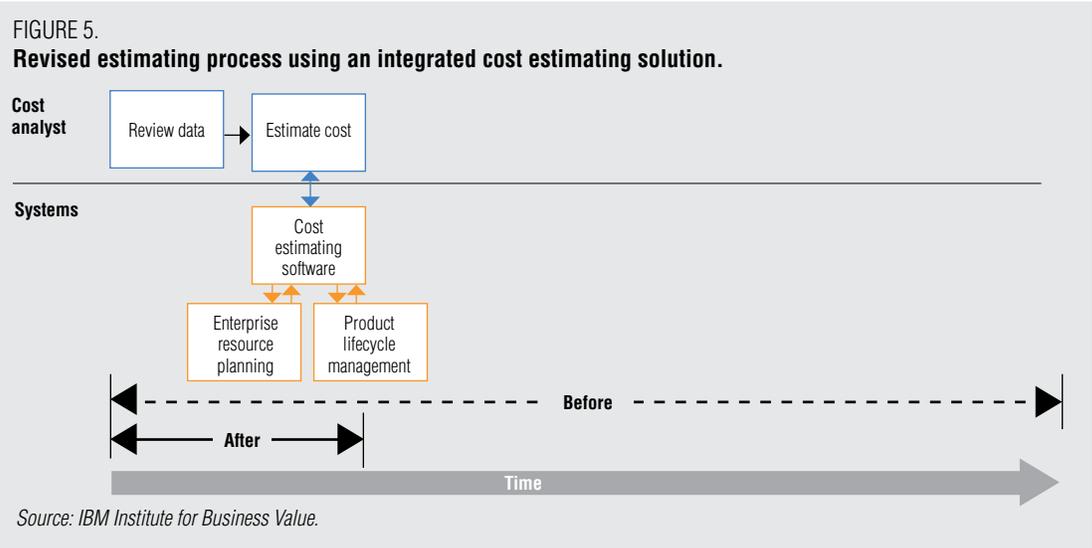
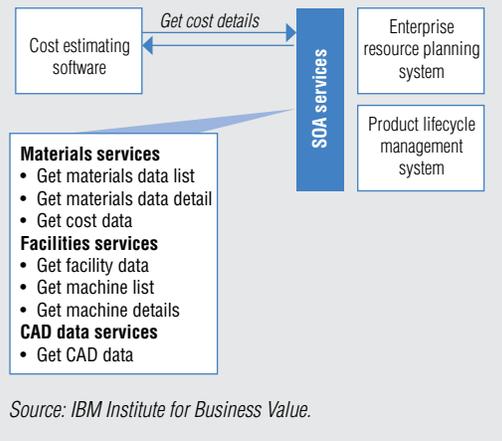


FIGURE 6.
Integrating cost estimating software with SOA.



Source: IBM Institute for Business Value.

To implement this type of integration, the OEM would build a layer of services supporting each of the existing source systems (in our example, the PLM and ERP systems). The services would be designed as granular as needed to get at the appropriate cost or other data needed for the cost estimation process. As mentioned, the services are used by the cost estimating software in a manner similar to a telephone call. The cost estimating software would “call” the PLM software to “get materials data,” the data would be returned to the cost estimating software and the call would end.

The value to the business

By enabling the automation and consequent improvement of the cost estimation processes, an SOA solution for collaborative product development yields the ability to coordinate business decisions and eliminate rework. The above example demonstrates a shorter cycle time with more accurate information and with a lower probability of error.

SOA also provides specific technological benefits that can directly impact efficiency and accuracy. Improved integration of information is made possible through the enforcement of standardized protocols, synchronization of information among systems and the use of a centralized database. Information is updated in realtime and stored once by the “owning” system, but is available to all other systems through the SOA services layer. This helps make sure that the latest data is consistent and always available on demand. SOA, through automated data transfer and the enforcement of common data formats, helps eliminate errors because there is no longer a need for manual data transfer or rekeying.

Through this degree of automation, the OEM is able to improve development efficiency and avoid costly downstream errors. This helps to speed time to market and time to value, which, in turn, can yield a critical competitive advantage.

Facilitating demand-driven collaboration

The watchword in the electronics industry is volatility. Electronics OEMs constantly find themselves in a reactive posture – forced to respond quickly to a wide range of dynamics. Today’s economic climate, with doubledigit declines in the sales of semiconductors and LCDs, only further emphasizes this reality for electronics companies.

Electronics is more globalized than many other industries, which magnifies the effect of supply and demand shocks. The extended global supply chain introduces vulnerability to supply constraints and cost changes. For example, the availability of certain kinds of electronic components can affect everything from cell phones to televisions to computers to toys.

On the other side of the equation, demand shocks are created by an ever-changing marketplace defined by record low consumer confidence and sharp drops in consumer spending, as well as rapidly shifting customer preferences and the exercising of pricing power. These factors combine to squeeze electronics OEMs – compressing product life cycles and forcing them into drastic pricing actions in order to maintain a competitive edge.

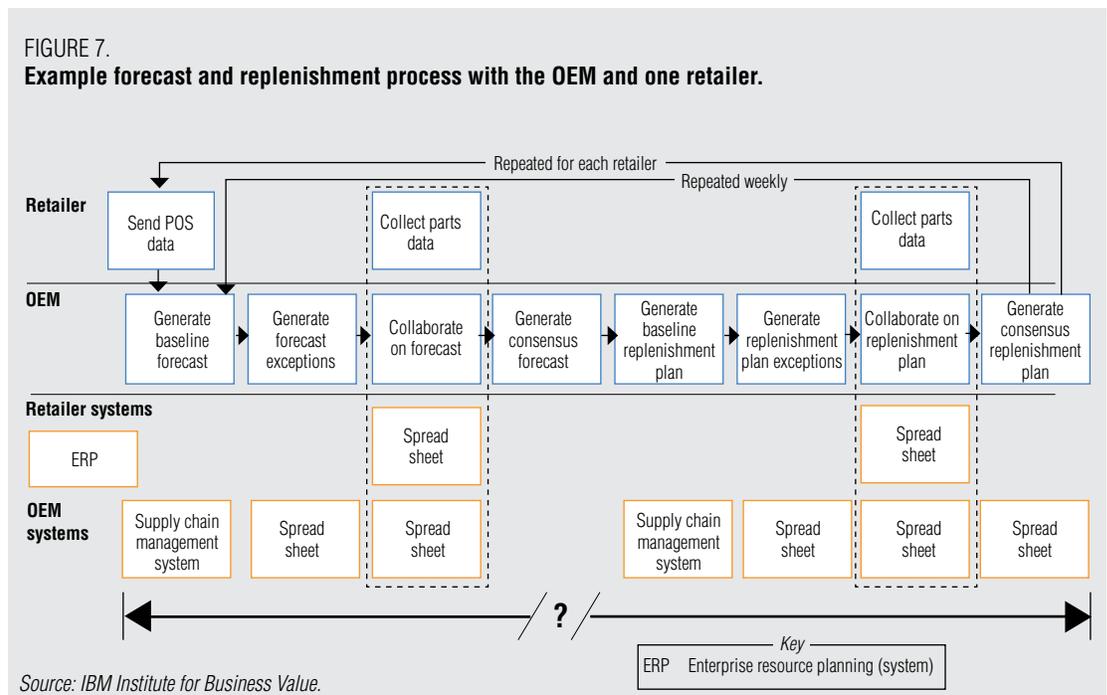
In the face of this harsh reality, survival in today's market and positioning the company for future revenue growth remains a top agenda item for industry CEOs⁶ The lowering of costs and improvements in efficiency is seen as the key components of surviving the global recession and emerging stronger than competitors for future growth when the economy recovers. Yet poor cross-enterprise collaboration inhibits companies in the value chain from effectively working together to cope with changing market conditions.

There are inherent roadblocks to enabling transparency among supply chain partners, which will always use information to gain an advantage. For example, a retailer may manipulate sales forecast figures in order to obtain a greater allocation of a scarce product. Beyond this, there is a lack of collaboration and integration between the OEM organization and its suppliers, which makes planning difficult. Even inside the enterprise, disparate systems often have trouble communicating at the pace at which business information changes.

Using an example

For many OEMs, planning and forecasting processes are currently based on the manual exchange of information between OEMs and retailers. One example of such a process using spreadsheets and paper is illustrated in Figure 7. The entire process is repeated weekly for each retailer. It's easy to see that scalability across many retailers around the globe can become a significant problem.

FIGURE 7.
Example forecast and replenishment process with the OEM and one retailer.



SOA helps automate collaboration and facilitate exception-based information access, which can, potentially, dramatically improve the forecasting and planning process.

A number of issues occur with this arrangement. Retailer processes and systems vary, which leads to more complexity and additional management costs for the OEM. The scalability and optimization of a spreadsheet-based system in our example is severely limited. The OEM has to repeat this process weekly for each retailer, and will often deal with many retailers and distributors world wide. The cycle time is long and the process is error prone.

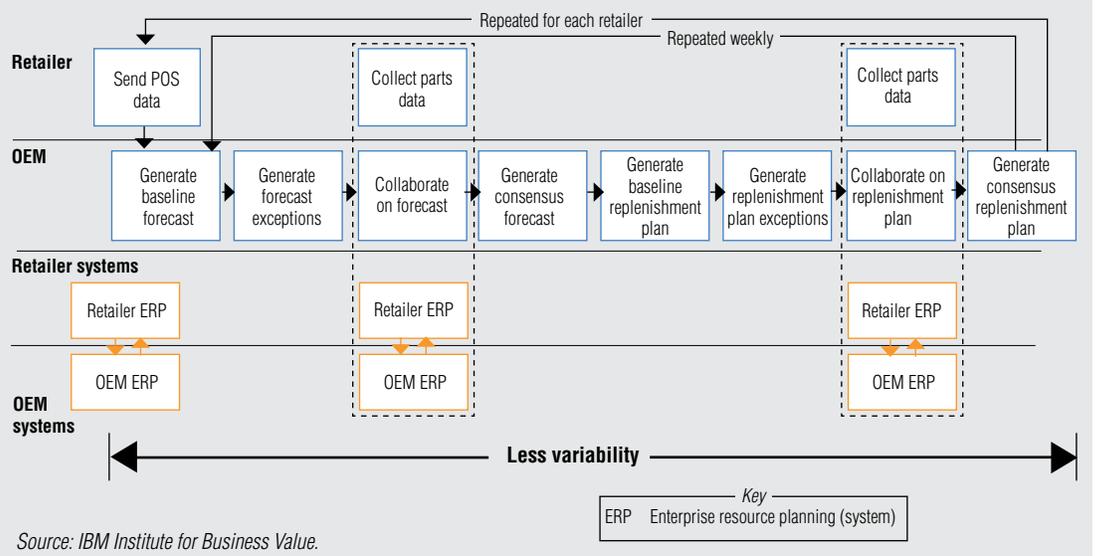
These factors can drive up inventory levels to compensate for inefficiencies, generate high price-protection expenses for OEMs (due to lack of transparency), create poor customer service relationships and produce manually intensive, duplicated efforts across supply chain partners.

Automated collaboration with partners

SOA offers the potential to dramatically improve the forecasting and planning process across many retailers by automating collaboration and facilitating exception-based information access. As shown in Figure 8, the OEM-side process remains the same. However, the interaction between the retailer and the OEM is drastically simplified.

In our example, the manual creation, updating and exchange of data via spreadsheets is eliminated. In its place, SOA provides the automated electronic exchange of data between retailer ERP systems and the OEM ERP system. This standardized, modular process and system now relies on automated exchange of information and applies to all retailers, making scalability much easier.

FIGURE 8. Revised planning and forecast process with SOA connectivity.



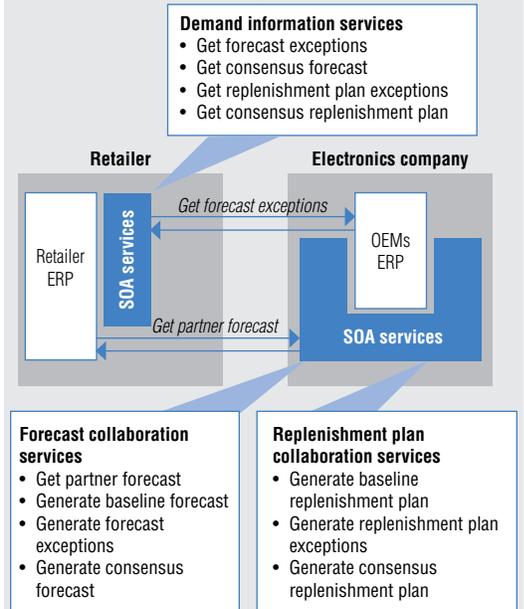
The challenge for the OEM is how to enable this level of collaboration in a cost-effective manner with any number of retailers at a given time. What's more, the retailer often initiates this process and must participate. Ideally, improvements must be made without drastic process change. This leaves the individual activities and the systems that support the process. Point-to-point, custom integration approaches will not suffice. SOA offers an approach to build one interface and make this available to any retailer. In our example, by improving the connectivity between the systems supporting the process allows for systematic exchange of information. Figure 9 illustrates the architecture of the solution.

To implement this solution, the OEM firm would develop a set of services that allows the retailer's systems to programmatically collect forecast and replenishment information from its own ERP systems. Like the above scenarios, the services would be designed to allow access to authorized information by authorized users. This provides an inherent level of security as part of the design.

Figure 9 shows communication in two directions. Not only does the retailer "get partner forecast" from the OEM ERP system, but the OEM can "get forecast exceptions" from the retailer's ERP system. There are many business options for this alternative. Certainly, the OEM can take the leadership position and build this layer of services for the retailers in their value chain. There are many benefits for the retailer to implement such services and "expose" them to the OEM and others. Or, the retailer could design and build the service and allow

FIGURE 9.

Integrating OEM and retailer ERP systems for demand forecast exchange.



Source: IBM Institute for Business Value.

the OEM to use them. There are many related uses for an SOA infrastructure – and the retailer is equally motivated for system collaboration with its suppliers.⁷

The value to the business

The SOA solution provides an overarching business benefit by improving business processes that help coordinate business decisions between the OEM and its partners. Doing away with inconsistent manual processes can also help eliminate errors and duplication of effort. Execution is faster and realtime alerting becomes possible. This helps improve supply chain visibility and fosters trust and collaboration.

SOA supports this transformation by providing a standards-based solution that can be used by the entire OEM value chain. Our example focuses on the retailer, but the OEM must also deal with suppliers. The same SOA infrastructure can be used to support SOA services for supplier collaboration. In some cases, the same services would be reused. By providing timely, consistent information and automated data interchange among systems, SOA can improve transparency and reduce errors. The technology-agnostic nature of SOA also makes the solution flexible – easy to integrate with the variety of systems used by retailers.

The result for the business is faster execution, reduced channel inventory, improved resource utilization and better customer service, which, in turn, can optimize the efficiency and profitability of value chain relationships.

Conclusion

For companies in the electronics industry, becoming a globally integrated enterprise is critical to maintaining a competitive advantage. It is a way to keep pace with the tough economic times companies are facing, as well as the inherently fast-paced market for electronic products. Technology plays a fundamental role in forming and maintaining this kind of environment, which must support the effective integration of information, processes and systems. This, in turn, helps drive efficiency, collaboration and, ultimately, innovation.

By breaking down organizational and technological barriers, SOA provides a key technological advancement – enabling cost savings, faster time to market, greater flexibility and greater responsiveness.

SOA alone is not enough to achieve the critical levels of integration needed by the electronics industry. Without underlying support and organizational change to leverage the technology, it cannot provide the needed benefits. By exploiting its capabilities internally, as well as with external entities of all kinds, institutions can forge new connections and support new levels of collaboration and innovation. There is simply no limit to the number of connections and configurations – with benefits that promise to reshape not only a business or an industry, but a whole economy – even the global economy. In this way, we believe, SOA is potentially as transformative as the Internet.

But precisely because of its range and power, SOA can be a little daunting to the organization that has yet to use it. Like anything else of this scale, it must be employed responsibly and intelligently – with a sense of vision, purpose and strategy. Through our own use of SOA and in thousands of SOA engagements across the world, we have gained a good sense of how to proceed with SOA:

- Focus on a business problem and use SOA to solve it. SOA is a means to an end – not an end in itself.
- If possible, start with revenue-generating capabilities. For electronics companies, this might mean improving the online shopping experience or focusing on demand-driven collaboration.
- Start small. Use your first SOA project to “learn the ropes.” If it is successful, show it to other parts of the business to demonstrate what can be done with SOA.

- Begin to build new human capabilities. SOA requires some specialized skills that entail a learning curve. It is best to instill these skills now.
- Think long-term. The hardest, most prolonged and most expensive part of SOA is building the initial architecture. Once that's in place, additions or changes – new channels, back-office functions or business lines – can be made much faster and less expensively. Over time, the return on this initial investment can be dramatic.

Whether you build, buy or evolve to an SOA infrastructure, the time to start is *now*. The shift to an SOA-based, globally integrated enterprise is not a simple one for OEMs seeking to pursue this path. The ability to overcome internal resistance and effectively manage change, strong leadership, adequate up-front investment and an understanding that integration is not limited to back-end systems are all requisites for success.

Through the carefully managed execution of powerful solutions, SOA can become a key enabler of the globally integrated enterprise – helping electronics OEMs to meet the stringent challenges of today's volatile global marketplace and to emerge from the economic downturn stronger than their competitors.

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Henry Dao is a Senior Managing Consultant in the Supply Chain Strategy Practice of IBM Global Business Services. He has over 15 years of consulting, manufacturing, operations and project management experience. As a subject matter expert in the areas of supply chain strategy and transformation, Henry specializes in developing and implementing supply chain solutions for a wide range of industries including electronics. He is a certified Project Management Professional by the Project Management Institute and a certified Lean / Sigma Consultant. Henry has authored multiple whitepapers on supply chain strategy, sales and operations planning, and service-oriented architecture business solutions. Henry can be contacted at henrydao@us.ibm.com.

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