



**SAP White Paper
SAP Manufacturing**

A MANUFACTURING IMPERATIVE: ENTERPRISE SERVICE-ORIENTED ARCHITECTURE

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CONTENTS

- Executive Summary 5
- Enterprise SOA: The “Home Theater System” of Information Technology..... 6
- Innovation and Standardization Become Teammates 8
- Enterprise SOA in Manufacturing 9
- SAP Pioneers Enterprise SOA Approach 11
- Immediate Benefits for Manufacturing**..... 12
 - Single Investment in Integration 12
 - New and Improved Business Processes 12
 - Decreased Costs per Service..... 12
 - Semantic Interoperability..... 12
 - Middleware Eliminated 12
- Next: The Partner Ecosystem** 13

EXECUTIVE SUMMARY

Every manufacturing plant needs to operate as efficiently as possible within the limits of its budget. In the past, reaching this seemingly simple goal was almost impossible for most manufacturing sites because of the lack of integration between plant systems and business systems. Plants were forced to fly blind, resulting in less-than-optimal production output and inventory levels.

The reason for this discrepancy? Most plant information systems were designed to run a plant, and connectivity to any other system or application was an afterthought. Until the last five to seven years, few manufacturers even mentioned that they needed the automation layer, the manufacturing execution system (MES) layer, and the enterprise resource planning (ERP) layer to be able to talk to each other.

However, as the need grew to share data among plants within a distributed manufacturing network, IT developers cobbled together direct links between the different layers of applications. This kind of point-to-point integration made sense at the time, but it has resulted in a cobweb of hundreds, even thousands, of brittle interfaces. The complexity of linking large and disperse landscapes has literally crippled the health and flexibility of most manufacturing IT architectures and hence business performance. Adapting those systems and applications to communicate can take so long that entire generations of business opportunities can grow old while the IT department fiddles with the wiring.

Over time, more innovative industries, such as electronics, have solved the same problem deviling IT by implementing standardized ways to assemble components into a product, enabling parts to be replaced and extended – plug and play. This process is now actually taking place in the IT industry. In this instance, software called composite applications is built by assembling components that can be exchanged and upgraded at will.

The underlying concept is enterprise service-oriented architecture (enterprise SOA), which allows you to change and improve your business processes without an expensive IT integration project. With enterprise SOA, you can simply replace or add components to create new processes: the software version of plug and play.

Enterprise SOA goes beyond the fundamentals of a service-oriented architecture (SOA). SOA is a distributed software model that uses independent Web services to support business processes, but the enterprise SOA approach – as defined by SAP and its partners and customers – elevates the design, composition, and management of Web services through the use of enterprise services.

This white paper describes enterprise SOA and the business opportunities it creates for manufacturers. To clarify this concept, we begin by describing the parallel paths followed by software and electronics developers into the new era of plug and play.

ENTERPRISE SOA: THE “HOME THEATER SYSTEM” OF INFORMATION TECHNOLOGY

Why is an enterprise service-oriented architecture (enterprise SOA) critical to manufacturing today? It’s all about the flexibility and adaptability that enterprise SOA gives you to integrate the factory floor with enterprise applications and to make needed changes to your processes without the enormous cost and time of creating new interfaces.

The home theater system and its evolution provide a striking analogy to information technology’s trek to enterprise SOA and the required technology platform. Consider what you can do with today’s home theater system. You are blessed with very

sophisticated, yet easy-to-use techniques to connect your TV, music system, DVD player, iPod, and other components to your home theater. You do not need to know in detail how they work, nor do you need to call technicians at all these vendors to install them. In fact you probably would be upset if such technical support was needed. Today all system components support a set of standard input and output connection points and corresponding adapters. Through the Internet or your vendor, you can obtain a manual of each component, which lists the supported adapters and how to connect all these systems (see Figure 1.)

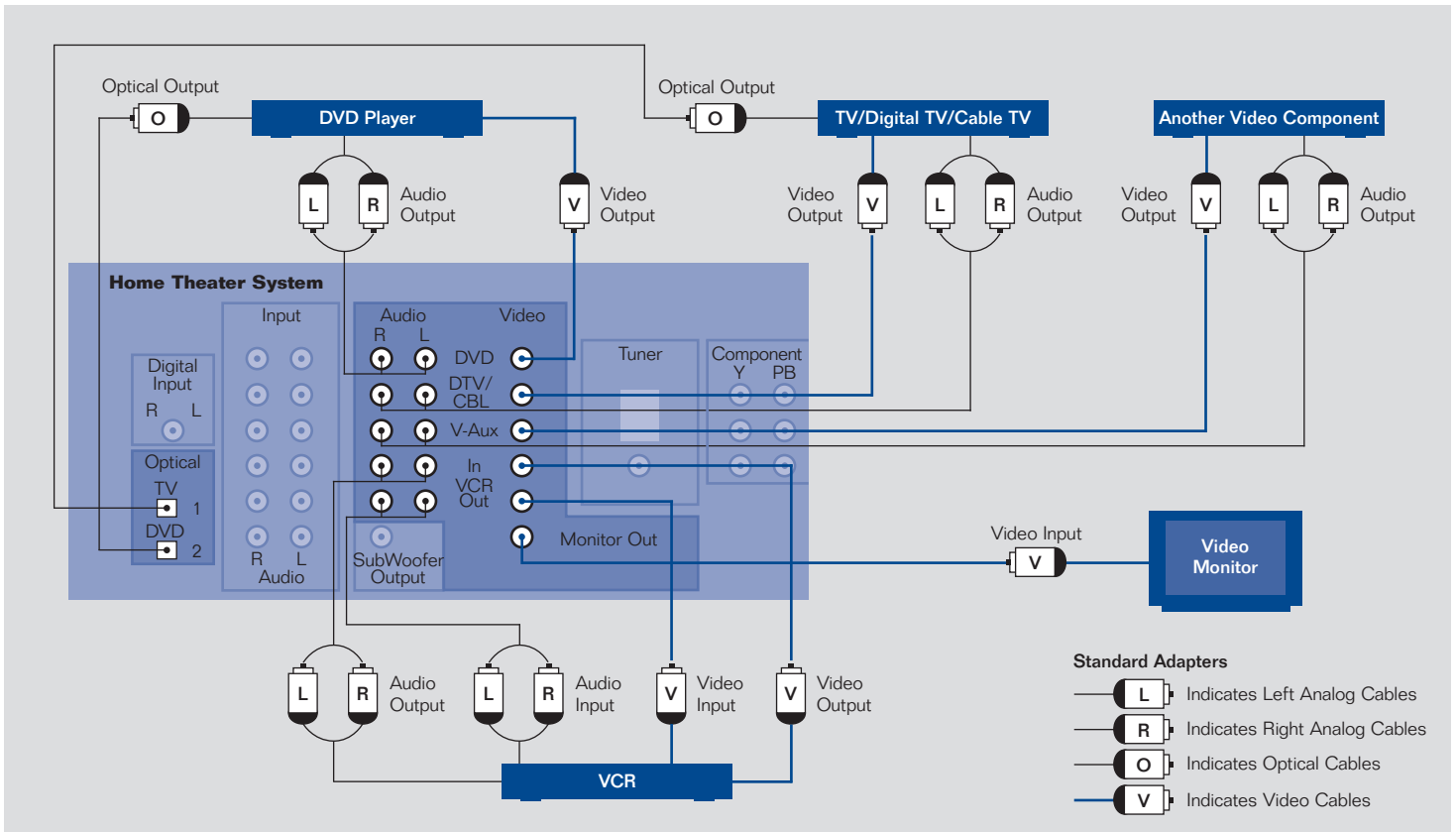


Figure 1: An Enterprise SOA Analogy: Home Theater System

As shown in Figure 1, you can go through the manual provided by the vendor of the home theater system and easily connect other equipment without knowing how each component is designed. What matters here is the clear connection point and type of the adapter, no matter which vendor provides the adapter. All your audio and video components, regardless of their differences, appear as an integrated unit. Using the remote control, you can switch between components, for instance, from the DVD player to the VCR, to use the whole unit in a different way.

Enterprise SOA is your home theater system for software. It provides standardized adapters – enterprise services – to link your software components and enable you to switch from component to component. A central enterprise services repository contains all the information needed to assemble a software application and has the ability to execute. Like the home theater manual, this repository describes all software objects available, the definition of the basic components holding those software objects, the services offered and implemented by those components, and a process description on how to use and assemble these services into a software application.

Far more than a manual, however, the enterprise services repository provides extensive functionality, managing the service interfaces and coordinating the process flow. The result is the composition, meaning the plug-and-play assembly of components, which appears as an integrated software application unit – even though the components work differently internally and are provided by different vendors. You can easily switch between components in order to create a new software application supporting a different business process. This is done by replacing the “plug” from one underlying component to another one, based on the information available in the enterprise services repository.

INNOVATION AND STANDARDIZATION BECOME TEAMMATES

Enterprise SOA and composition bring together innovation and standardization as teammates rather than opponents. This is critical today, because the fiercely competitive and changing environment in most industries, particularly manufacturing, is demanding that you be highly adaptive and able to change your business models and processes quickly. Global visibility and workflow across all internal operations and beyond are also mandated – an achievement that requires extensive integration and use of industry and enterprise-wide standards.

We have emphasized that by using enterprise SOA composition rather than static software application units, you have the ability to innovate quickly by reassembling and adding components to support the new business process you need. And you can achieve this without wreaking havoc on the IT infrastructure and your IT budget.

Enterprise SOA also enables you to layer standards on top of enterprise services or even build standards into the service itself. You can also extend these standards to services from different enterprise repositories, while still maintaining the main paradigm of a plug-and-play assembly of applications.

Among key industry standards enabling enterprise SOA are the ISA-95 standard for integrating manufacturing control and enterprise systems (developed by the Instrumentation, Systems, and Automation Society, which is accredited as a standardization body by the American National Standards Institute), Chemical Industry Data Exchange (CIDX) and Petroleum Industry Data Exchange (PIDX) eBusiness standards, and RosettaNet standards for business process interoperability across the global supply chain.

A core value of enterprise SOA is that it helps you overcome a long history of business and IT problems. Standardization, while offering significant cost benefits, has been anathema to change. This is because in many of its forms – which range from simple software interfaces and the use of standardized applications to outsourcing of an entire process – it has virtually cast processes in concrete.

Why? The technology issues are legion. The IT industry began with native application programming interfaces (APIs) to connect one application to another (analogous to the printed circuit boards of the electronics industry, each of which came with its own set of proprietary connection points or adapters). APIs required deep expertise in the individual functions and resulted in the scattered landscapes that are still very common in today's manufacturing world.

The next phase was the development of vendor-specific standards, which allowed other applications to be connected, but still required technical expertise to integrate systems. In most cases, a “leading” application dictated how all other components had to be integrated. The shortcomings of vendor standards left major problems unsolved. Changing processes or vendors, or even upgrading to the next software version, continued to create havoc with the IT infrastructure and budget.

As a result, to this day, companies typically have only used standardization for business processes that are or have become liability processes – costing more than the value they generate, such as payroll – and seldom require major change. Or the process no longer provides a competitive edge because of parity, that is, industry-wide adoption of the process and its enabling technology. The main focus in these cases is on cost saving and keeping the underlying IT infrastructure running as efficiently as possible. This has its advantages, but as we are finding, yesterday's liability process, such as procurement, can become an asset, a differentiator.

The bottom line: with enterprise SOA, you can implement standards and innovations without disrupting the IT infrastructure or restricting flexibility. This means that as your priorities change, you can more easily move a process into the cost-saving, highly standardized category or make it a more competitive differentiator. You are free to move around the world.

ENTERPRISE SOA IN MANUFACTURING

Enterprise SOA, its enabling technology, and new standards such as ISA-95 are critical to major innovations and performance improvements in manufacturing.

Consider the information that typical plant managers require. Their core responsibility is to make sure that production plans and execution are aligned with the sales forecast and order volume and are staying within the plant's budget limits and feasibility of production.

Such responsibilities require information from many different applications, including forecasting and order data from customer relationship management (CRM), production planning data from enterprise resource planning (ERP) and supply chain management (SCM), inventory-level data from warehouse systems, personnel availability data from human resources, and transportation data from logistics.

Therefore, today's manufacturing landscapes are a complex set. You may have several versions of ERP and multiple distribution, sales execution, and MES applications. Most of these applications have been designed for a specific purpose with only limited support for integration.

The underlying business process, however, requires them to be at least partially integrated with one another. This discontinuity is tackled today by two main methods. One is the person serving as the human integrator, receiving the IT output in reports, Microsoft Excel sheets, and other forms and manually integrating them, a laborious, error-prone process. The other method is to integrate all applications involved into a lead IT application. Integration on the system level is highly specialized, needing ongoing support for the APIs. It also only connects applications to exchange data, and does not integrate the user-interface layer, which would be a separate effort. In addition, this integration is static, not allowing any changes without major rework from the IT department.

Consider what you face if you have multiple plants, each using an MES from a different vendor and separately integrated with the ERP application. The integration required you to create a set of hard-coded connections just to support the data exchange (see Figure 2). This works at the system level, but it isn't a complete solution, leaving you with many problems and voids.

For instance, any information that needs to be displayed to your personnel is still scattered and different for each plant. When you want to switch to another MES vendor or add another factory, you must start a new integration project. In addition, if your plant manager needs to enhance the scope of the business processes by including data from warehouse applications, you have to implement an additional set of custom-designed connections. As more applications are brought into the picture, IT issues and problems become more complex, resulting in higher maintenance costs.

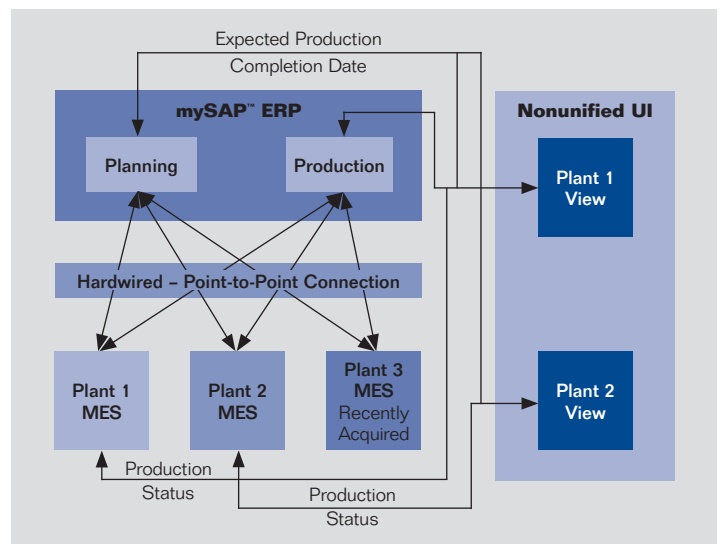


Figure 2: Typical Manufacturing IT Landscape: Inefficiencies of Point-to-Point Integration

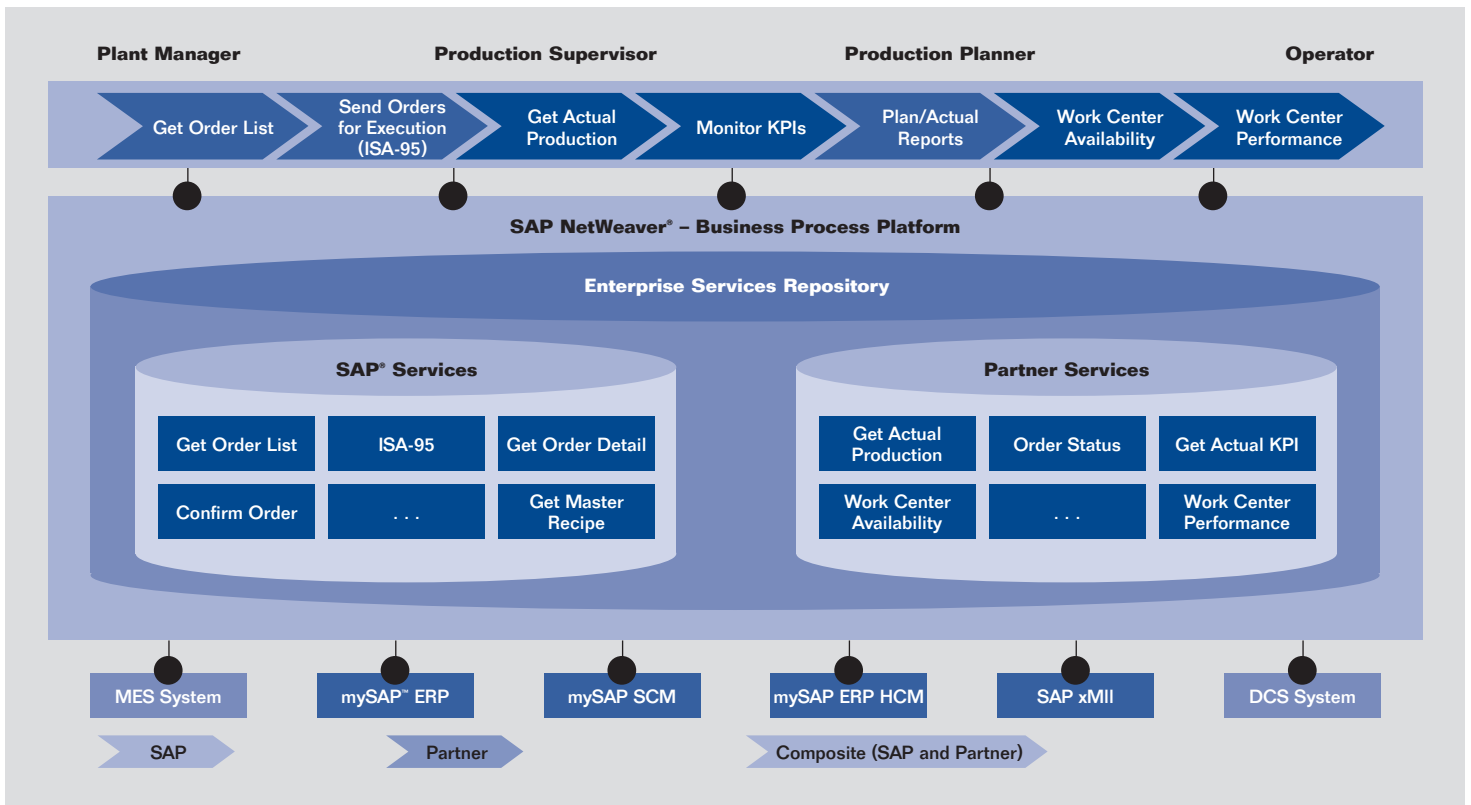


Figure 3: Integrating Manufacturing Systems with Enterprise SOA

An enterprise SOA approach eliminates the problems that impede the enterprise-wide visibility of your manufacturing data, the integration of all relevant applications, and your business adaptability. Enterprise SOA exposes (describes, registers, and provides connection points to) the necessary functionality in each of your components and applications by creating a service interface that provides any application with information on the functionality available and how to access it.

As a result, for example, the same functionality that provides your production completion dates and production results to the MES in one plant is available as services to any other manufacturing or business application, using the same standards and protocols. You would proceed in the same way for all other services needed from ERP, MES, SCM, or CRM applications. All services are listed in a services repository. A relatively small

application that supports the user interface resides on top of those services, ultimately mapping the business process.

Figure 3 illustrates how the enterprise SOA structure can enable such a process. An application can be composed to form a composite application based on the available services from different manufacturing systems. Once the services are available in the repository, users do not need to bother about the source of the content or the application into which the services are tied. The technical implementation of such a composite application requires significantly less technical skill, because the IT person only needs to go through the service repository to identify the corresponding services and then stitch the services together to form the composite application. Today a wide variety of user-interface technologies are available for forming composite applications.

SAP PIONEERS ENTERPRISE SOA APPROACH

SAP, a pioneer and thought leader of enterprise SOA, has developed the platform that supports this architecture and the industry standards that make it possible. This is the SAP NetWeaver® platform.

Figure 3 shows SAP NetWeaver in a futuristic manufacturing scenario, supporting an enterprise services repository consisting of SAP and software partner services that integrate the factory floor, MES, and business applications. This repository consists of such services as Get Order List, Get Actual Production, and Work Center Performance. In this example, SAP and its software partners provide these services through a variety of software applications, such as mySAP™ ERP, and composite applications, such as SAP® xApp™ Manufacturing Integration and Intelligence (SAP xMII).

To understand the processes enabled, consider what your production supervisors, oblivious to the application source, would be able to access and execute in doing their jobs:

- Through the Get Order List service, they obtain the scheduled orders for a shift, which reside in mySAP ERP.
- Through Send Order, they can send the orders, based on priority, to an MES for execution. This is accomplished through an interface that is based on the ISA-95 standard, which resides in the standards layer on top of enterprise services and provides a “B2MML_ProductionSchedule” message.
- For the running orders, they use the Get Actual Production service to access the production order status.
- Using Get Actual KPI, production supervisors can monitor different key performance indicators (KPIs), such as throughput rate, temperature, and pressure, coming from a shop floor application.
- Plan/Actual Reports for different KPIs can be monitored in real time. They are provided by different services coming from SAP and shop floor systems.

- In parallel, via the Work Center Availability service, production personnel can monitor work center status.
- Work Center Performance provides them with real-time performance or overall equipment effectiveness (OEE) measures.

All in all, for each individual role, you can easily implement a single application that provides a window into the current status of the plant, critical data, alerts, analysis, and drill down needed for manufacturing performance.

The SAP NetWeaver platform makes this work. It unifies technology components – SAP or non-SAP software – into a single platform and is preintegrated with business applications, enabling change and reducing the need for custom integration. For linking your factory floor to the enterprise, SAP provides SAP xMII, which delivers a single ISA-95 compliant layer enabling mySAP ERP connectivity into real-time plant floor applications and a real-time analytics engine that aggregates and delivers unified visualization of events, alerts, KPIs, and decision support to your production personnel through role-based dashboards.

Your production personnel can see the whole picture on their dashboards, drill down for more information, and act upon it. At the same time, other personnel in your plants and business offices can access current production information and be alerted to exceptions, such as equipment breakdowns that may affect customer deliveries.

IMMEDIATE BENEFITS FOR MANUFACTURING

An enterprise service-oriented architecture offers enormous promise for achieving the adaptability you need in the ever-changing world of manufacturing. The deliverables begin quickly. Here are several significant and immediate benefits of the enterprise SOA approach for developing new and improved applications.

Single Investment in Integration

This architecture requires a single investment to expose all those services. Once the investment is made, this same service can be accessed by any application **in any possible combination** as long as this application can browse the service repository to access the services.

New and Improved Business Processes

Exchanging applications or enhancing the business process support is only a matter of linking one additional application and its services to the repository. In most cases, you might even be able to support a new business process completely by just assembling the right components. Pure integration between applications is now performed by allowing the underlying components to directly consume services from other components.

Decreased Costs per Service

The enterprise SOA approach is vastly different from the traditional method, which requires a new pair of connections to be custom designed for each application. With enterprise SOA, the more connections, the lower the price per connection. This opens up significant IT dollars for more innovative applications – a major benefit for companies as they increasingly distribute manufacturing and each of their plants runs its own applications.

Semantic Interoperability

Under enterprise SOA, each software component exposes a service in a standardized way to enable semantic interoperability with other components. For example, an application using the XML dialect from vendor A will not necessarily understand the XML dialect of vendor B, so both must agree to expose a service via a common standard.

Middleware Eliminated

Because standards enable direct interaction among services, traditional middleware applications are no longer required.

These are the benefits that will give you business and manufacturing flexibility, adaptability, and visibility – without wreaking havoc on your IT infrastructure and budget.

NEXT: THE PARTNER ECOSYSTEM

Once you have decided to adopt enterprise SOA, the next step is to expand and change your relationship with your software vendors to create a new partner ecosystem. The enterprise SOA strategy is significantly enhanced and moves to the next level of flexibility when you include your partners – all the software providers whose applications support your business processes.

Consider what will happen as you make these services and the repository available to your partners and you populate the repository with services that they create. Your IT department and, in some cases, business users will be able to use visual tools to assemble many new user applications without having to write code or having detailed knowledge of the underlying systems. As you increase the number of services available for assembly, so too will the operational, competitive, and financial benefits of enterprise SOA. This makes a common platform and a new relationship with your software vendors mandatory.

Contact SAP to learn more about how you can build your road map to an enterprise service-oriented architecture. For additional information, please visit our Web site at www.sap.com/netweaver or www.sap.com/platform/esa.

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