How to Make Business Intelligence Actionable through Service-oriented Architectures

ZELJKO PANIAN
The Graduate School for Economics and Business
University of Zagreb
J.F. Kennedy Sq. 6
CROATIA
zpanian@efzg.hr http://www.efzg.hr

Abstract: - The main characteristics of Service-oriented Architecture (SOA) are explained, as well as the usage of Business Intelligence (BI) solutions as Web services in an SOA environment. With the evolution of BI, a focus is shifted from technology to organizational impacting factors, making Web services and SOA technologies more and more attractive. Organizations that choose a Web services and SOA strategy will be best positioned to deliver BI in a real-time or right-time manner, making their Business Intelligence capable of supporting appropriate business decisions and actions, i.e. making it actionable.

Key-Words: - Business intelligence, Service-oriented Architecture, Web services, interoperability, actionable business intelligence

1 Introduction

Service-oriented architecture (SOA) concept and implementations have increased in popularity over the last few years due to the promise this approach holds for reducing development and maintenance cost and making it easy to integrate disparate information processes. Web services are the first widely available standards that promote the use of SOA.

SOA concepts are primarily designed to achieve the vision of an agile, possibly real-time enterprise with a flexible IT infrastructure that enables a business to respond to changes in the best possible way [1]. As the business dynamics change and new opportunities emerge in the market, the IT infrastructure of an enterprise should be designed to be able to respond quickly and provide the applications needed to address the new business needs before the business opportunity disappears.

This is possible within reasonable costs only through reuse of existing investments. This is where SOA concepts come in; they are based on the principle of developing reusable business services and building applications by composing those services instead of building monolithic applications in silos.

On the other hand, business intelligence (BI) allows organizations to access, analyze, and share information and knowledge. This helps them to track, understand, target and manage their business in order to improve enterprise performance.

With the evolution of Web services, organizations are becoming more sophisticated in their goals for and requirements of this technology as it offers faster and more flexible deployment, customization and easy integration of BI solutions. Those organizations that choose a Web services strategy will be best positioned to deliver BI content across and beyond the enterprise, making BI accessible to everyone, wherever they work, at a lower cost and in more innovative ways.

2 The Need for Actionable, Operational, Real-Time Business Intelligence

2.1 What Drives the Need for Actionable, Operational and Real-time Business Intelligence?

Business intelligence system is a key component of companies' IT frameworks. It is a component that enables business users to report on, analyze and optimize business processes and operations to reduce costs and increase revenues. Most companies use this component for strategic decisions making where decision-making cycle may span a time period of several months (e.g., marketing campaign preparation or improving customer satisfaction).

At the same time that companies see business intelligence playing a strategic role, they also want to be able to use insights gained from their data for more tactical decision-making purposes. Enterprise value analytical capabilities, but they also want to be able to take action [2]. Interest in dashboards and scorecards has surged because companies want to monitor their

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performance, but now they wish to take that information to the next step and determine how to act on it.

For example, retail and manufacturing companies are interested in understanding how to use their supply chain information to make timely decisions. If they spot a problem in the supply chain, they want to know how they can act on that information in 'real time' to make improvements.

Defining business rules can help these companies develop step-by-step instructions on how to respond to the data they are getting from their supply chain and incorporate those instructions into their business intelligence and data warehouse systems. BI has a role to play in the operational functioning of the enterprise as well as the determination of its strategic direction.

Competitive pressures are forcing companies to react faster to changing business conditions and customer requirements. As a result, there is now a need to use BI to help drive and optimize business processes and operations on daily basis, and, in some cases, even for intraday decision making. This type of BI is usually called operational Business Intelligence [3]. The objective of operational BI is to make more timely business decisions, and, therefore, if has a close relationship to the subject of real-time BI processing.

2.2 Types of Application Processing

Generally, IT systems support three main types of application processing [4]:

- Business transaction (BTx) processing
- Business Intelligence (BI) processing
- Collaborative processing.

Business transaction processing drives day-to-day business operations and supports business activities such as order entry, inventory control and management, shipping, billing, etc.

Business intelligence processing reports on and analyzes BTx processing, and provides information about how well this processing is meeting business requirements.

This optimization process involves discussion between business experts about possible ways of improving business processes. In other words, the interaction between various business users is what is needed. Such an interaction is enabled by collaborative processing and an appropriate application framework.

Relationships between these types of applications are shown in Fig. 1.

In traditional BI environment, the time between events occurring in BTx systems and action being taken based on BI system output is relatively long – it is a matter of days, weeks or even months. The strategic decision making supported by traditional BI environment is reactive in nature and is based on summarized and historical data [5]. This long decision-making cycle allows the BI system to be loosely connected to related BTX and collaborative applications. Batch extract-transform-load (ETL) jobs can be used to extract operational source data and load it into a data warehouse. Reporting applications can be used to produce and burst reports and distribute results to users.

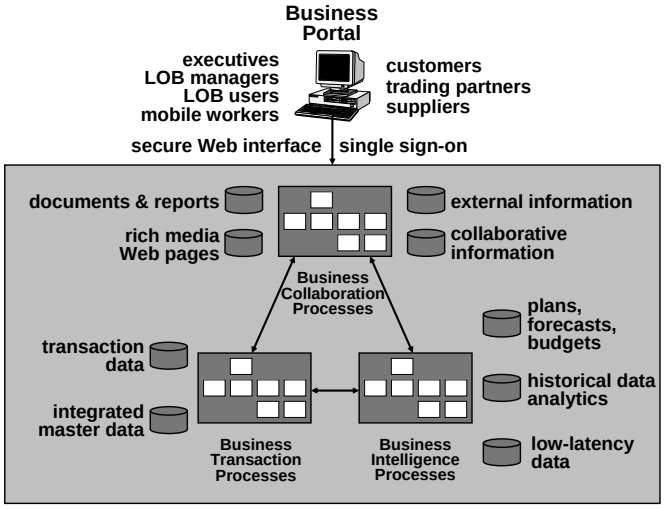

Fig. 1: Relationships between the three applications

The objective of an operational BI system is to react faster to business needs and to anticipate business problems in advance before they become major issues. This style of processing requires tighter connections between the BI system and its BTx and collaborative counterparts.

How timely this data needs to be depends on the nature of business processes and varies by company and application. For example, telephone and credit card companies using business intelligence to detect fraudulent transactions will need the data to be as close to real-time as possible, whereas the use of BI to optimize customer satisfaction is less time-sensitive.

2.3 A Process-centric Approach

Most designers and developers of business intelligence and data warehousing applications come from a data-centric background. In the operational BI environment, however, objective is to report on and analyze business processes and their underlying activities. It is very important, therefore, that BI reports, analyses and dashboards be process-centric, not data-centric.

Operational business intelligence is not only intended for business analysts, but also for executives, managers and line-of-business (LOB) users. For example, sales managers and customer support staff need information to be presented in a form that relates to the business tasks and activities they perform, but also workflows and

guided analyses that help them interpret, analyze and use this information. This requires a process-centric, rather than data-centric approach to business intelligence processing.

Operational business intelligence must be tightly connected to business processes. BTx application developers and vendors understand this need, but many BI developers and vendors, unfortunately, still are not.

The need to tightly integrate BTx, BI and collaborative processing raises some important organizational and political issues. Operational business intelligence applications can involve both the BTx and development group, and the business intelligence and data warehousing group. This can lead to demarcation disputes about who owns the project (and the budget!) and about the technologies and products should be used.

To overcome these problems, some companies have started to use Web services technology and service-oriented architectures.

3 About Service-oriented Architectures (SOAs)

3.1 The SOA Basics

The service-oriented architecture (SOA) has been held out for about two decades as a substantially more cost-effective and flexible strategy for constructing enterprise software systems than historical approaches including monolithic system design and tightly coupled client server models [6]. Many IT professionals and industry observers believe Web services technology, and the unprecedented universal vendor support of the underlying standards, will finally make practical the widespread adoption of the SOA approach.

In the past, enterprise software systems were complex, monolithic behemoths. The complexity of these systems made them difficult to fully understand and therefore leverage. There were limited integration points allowing reuse of the embodied business information and processes. This resulted in islands of automation with costly duplication of information across systems. Information flows between applications were limited, preventing the delivery of information to the people and systems that could best utilize it.

Even more damaging to the organization, these systems were difficult to change. Modifications, upgrades and enhancements were time consuming, costly and risky. Since these systems embodied the business processes of the organization, IT frequently became the bottleneck in attempts to adapt the business to changing market conditions.

The very systems that were built to bring automation and efficiency to the processes of the organization now *prevent* the organization from maintaining efficiency as business conditions change.

The service-oriented approach to enterprise software architecture replaces large, complex, monolithic applications with applications composed of loosely coupled collections of modular software components linked through well-defined Web service interfaces [7]. In other words, SOA is an architectural style that promotes loosely coupled interactions between software agents.

In its simplest form, the basic SOA is schematized in Fig. 2.

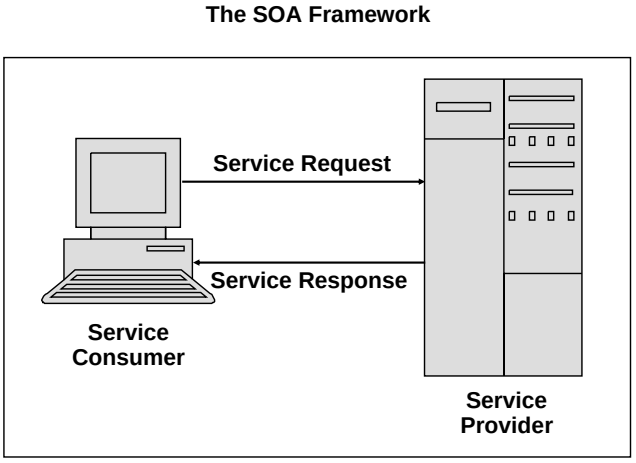

Fig. 2: The basic Service-oriented Architecture [8]

One of the best ways of enabling application developers to understand concepts and put them to use is by providing an application framework that provides the infrastructure needed while designing and developing applications based on those concepts.

It should be noted that there is no contradiction between the fact that interacting software agents are loosely coupled and the requirement for business intelligence itself to be tightly coupled with business processes. These issues simply do not have mutual influence.

3.2 Benefits to Businesses Achieved through SOA Implementation

Corporations are looking to bring structure to an increasingly chaotic IT environment and to better equip themselves for change. The past decade has seen unprecedented leaps in computing. Computers are applied to ever more aspects of the business. Additionally, the Internet has extended system interfaces to include connections with trading partners. Not surprisingly, the combination of these factors has

resulted in an unruly explosion of stovepipe applications, databases, and electronic connections. The challenge for IT today is to create and support an infrastructure that is capable of harnessing these diverse assets, and to deliver on new business requirements more effectively than with previous approaches.

Service-oriented Architecture provides the basis for this infrastructure and the promise of tangible business benefits.

For the business, the result of the Service-oriented Architecture implementation is movement toward what is often referred to as the 'real-time enterprise.' [9] Because applications have well defined service-based integration points, and because these services are built on standards embraced by every major enterprise software vendor, connecting software systems together will be orders of magnitude easier than in the past.

The ability to move the right information, to the right people and systems, at the right time, maximizes the ability of the enterprise to identify and interpret changes in its markets and to respond by adjusting its processes, operating models or structure [10].

The business response to changing market conditions often calls for modifying the information systems that run the business. Frequently it requires the creation or integration of entirely new applications. For the IT organization tasked with these activities, the result of SOA adoption is a decrease in the cost and a dramatic increase in the velocity with which these changes can be made.

Cost is reduced in the application development cycle because existing application modules and services can be leveraged as building blocks, eliminating the costly and repetitive exertion of effort that often slows today's initiatives. In addition, because application modules have well-defined service interfaces that facilitate plugging and unplugging, it is far easier to initially or eventually outsource an application component or to purchase and integrate packaged application logic.

Velocity improvements also follow from the SOA approach. Because application development becomes more like "application assembly" when building on existing services, development time is slashed [11]. Whereas application complexity was high with monolithic systems design, the modularity and relative simplicity of application components in an SOA makes them easier to understand and therefore to enhance and change. And in addition to lowering costs, the ability to outsource or purchase packaged solutions, and then easily integrate them into the application environment, also speeds change. Ultimately, the value proposition is that SOA helps companies to be more agile and to do more with the resources that they already have.

The key benefits of Service-oriented Architectures to businesses are summarized in Table 1.

SOA Feature	Business Benefit
Loosely coupled	• Increases organizational agility; allows companies to easily assemble and modify business processes in response to market requirements. • Provides a competitive advantage by offering greater flexibility in the way computer systems can be used to support the business. • Lowers implementation costs by increasing reusability; services can easily be shared across multiple applications. • Increases IT adaptability; changes—resulting from mergers, acquisitions, package application implementations, etc.—are integrated more easily.
Modular approach	• Enables incremental development, deployment, and maintenance; avoids the need to do costly and risky "big bang" software implementations- • Decreases development effort by reducing complexity (through a "divide and conquer" approach. • Over time, accelerates deployment of new application functionality; process becomes mostly assembly (of existing services) versus mostly new development.
Non-intrusive	• Allows existing investment in IT assets to be leveraged. • Lowers risk and development effort; avoids the need to rewrite and test existing applications.
Standards-based	• Platform independence allows companies to use the software and hardware of their choice. • Allows companies to engage in a multi-source strategy, reducing threat of vendor lock-in. • Reduces complexity and fragmentation resulting from use of proprietary technologies. • Lowers training requirements; increases available labor pool.
General purpose technology	• Delivers economies of scale; same technology can be applied to address a broad range of business problems.

Table 1 – Summary of SOA Business Benefits

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3.3 The SOA Infrastructure

An enterprise-class SOA infrastructure should fulfill the following needs:

- Promote architectural consistency by ensuring that Web services are deployed in a manner that is consistent with a service-oriented model.
- Facilitate the assembly of large-scale, dynamic systems from Web services.
- Provide a central point of management and monitoring of deployed services.
- Deliver the performance and robustness required for business-critical systems through features such as load-balancing and automatic fail-over between services.
- Provide mechanisms whereby services can easily locate each other, regardless of where they are deployed in the network.
- Provide a framework for creating and deploying infrastructure services (services that function between business-level services, e.g. filtering, transformation).
- Allow services to be provisioned dynamically as business needs fluctuate.
- Provide security across services, addressing needs such as client authorization.
- Offer various levels of logging—for example, Web services requests and responses, session-related information, security events, etc.—to support trend analysis, exception handling, and problem diagnosis.

Ideally, these SOA infrastructure services should be non-intrusive to the services themselves, and capable of operating either natively within supported platforms (such as an application server) and as intermediaries for non-supported platforms (such as a package application or service hosted by a third party). With this flexibility, an SOA infrastructure is able to bring all the services in a company's environment under a single management scope.

3.4 Service Reuse

The SOA is based on the deconstruction of yesterday's monolithic applications and infrastructure into a matrix of discreet, standards-based, network-accessible services. The process of transformation requires the organization, identification, repurposing, and, in some cases, retirement of elements and artifacts of the existing infrastructure.

The transformation to SOA begins with an analysis of the IT infrastructure to identify the applications, business processes, and other software assets that, individually and collectively, will become services, or will otherwise support the SOA. This process requires visibility into the portfolio of assets and the traceability of the assets within that portfolio.

Every stakeholder – from executive to developer – must have a clear, easily understandable view of these assets and of the relationships and interdependencies that connect the assets to each other, to the policies that govern their use, and to the projects that produce and consume them. When stakeholders can see which services and other assets are in development, which are on hand, and when, where, and how they have been (or should be) used, the asset portfolio is consolidated, redundancy is eliminated, and agility-robbing complexity is reduced [12]. This is governance at its most basic, but with far-reaching effects.

This visibility, when coupled with the ability to automatically track, measure, and communicate the value of asset usage and other key ROI metrics, provides the vital information necessary for accurate impact analysis and decision support with regard to project planning, resource allocation, asset retirement, and IT investment decisions in support of the SOA.

Software assets are the DNA of SOA. This is also true for Business Intelligence assets. Managing and assuring their compliance with standards and policies is essential. But so is the reuse of those assets. Reuse is a vital element of a successful SOA, but it should not be limited to the runtime reuse of services. The systematic reuse of compliant assets in the creation of a service makes that service an instrument of governance.

Leaving the reuse of these assets to chance breaks a critical link in the SOA lifecycle. The remedy is prescriptive reuse. Prescriptive reuse is a powerful governance practice. The process involves the selection and assignment of appropriate architectural standards, services, and other required assets during project planning [13]. Project members are notified of the selections, and the assets are delivered directly into the development environment.

In the past it was possible to maintain ownership and control over every aspect of the development of an application, from who had access to the application, to the data required, to how communication was established. The new service-oriented application development paradigm is defined by reuse and the abstraction of complexity, and by a dramatic change in the nature and scope of ownership and control.

The chief characteristic of SOA is the ability to share and reuse services over a network. The more those services are reused, the greater the business value of the SOA. But services may be produced by another development team, another division, or even an organization outside the enterprise. Regardless of its point of origin, a service must be made available to potential consumers, and those consumers must trust its ability to meet business requirements.

Proper policy enforcement and compliance tracking are essential in providing the information necessary to build this trust in the available services. Trust drives reuse, reuse drives agility, and agility drives business value. Establishing the necessary level of trust requires visibility into and control over service operation in the production environment.

Service reuse hinges on the definition, control, and tracking of the appropriate service levels over the course of a project. When implementing or reusing services, the need to review and analyze Quality of Service (QoS) metrics becomes paramount in order to plan for growth, minimize risk, and justify additional investments. This review and analysis must also include the proactive discovery and resolution of potential QoS issues.

Software reuse, as it occurs within an SOA, is black-box in nature. That is, applications can be created by combining individual services without adaptation or modification. This plug-and-play style of application development is made possible by SOA's ability to mask the complexity of the underlying architecture.

In an SOA, the ability to use services should require little or no knowledge, on the part of service consumers, of the supporting architecture. The focus is on the services themselves, which are discreet, self-contained chunks of fully operational, deployed functionality ready to be wired together into composite applications. The services within an SOA are already running on the network and can be shared by multiple applications. This fundamental change in the nature of application design, development, and deployment is what gives SOA its power.

But this change shifts the time frame for decisions regarding service access, data transformation, and routing to runtime. Policies governing these aspects are enforced only when a service request is made. In this scenario, simple changes in policy definition can affect application behavior. The application and enforcement of the relevant policies requires the appropriate service infrastructure.

3.5 The SOA Lifecycle

The survival and evolution of an SOA is completely dependant on governance over the *entire* SOA lifecycle. Governance must apply to the definition and development of services to ensure that no service is published until it is ready for prime time. Once services are published, governance must continuously manage and validate service performance to ensure that use of the services drives the business toward its goals.

The SOA life cycle is a food chain of sorts. Certain species of software assets are consumed during the development of services. Those services, in turn, are consumed during the creation of composite applications. Each of these entities, from the smallest, simplest software component to the most complex composite application, represents a different type of software asset. Each type represents an investment.

Understanding and managing the development and use of these services and assets – and how they relate to each other, to the overall infrastructure, and to business objectives – is the mission of SOA life cycle governance. That mission requires the visibility and traceability of assets throughout the entire SOA life cycle. It requires the creation, validation, and enforcement of policies across that life cycle. And it requires the means to measure and report on policy compliance as part of the metrics that will define and verify the business value of the SOA. The ability to holistically combine these activities is essential to the ultimate and continued success of the SOA.

3.6 The Most Popular SOA Application Areas

With business processes exposed as componentized services, and an SOA infrastructure in place to manage them, companies are then positioned to capitalize on a service-oriented approach to their business solutions and applications.

Some of the biggest opportunities are described below. While some of these pre-date the shift to Web services and service-orientation, they are significantly enhanced when able to leverage the capabilities offered by an SOA:

- *Business integration.* While companies have been using business integration (EAI) and business-to-business (B2B) solutions with great success independently of SOA, these solutions take on a much more significant and valuable role when they are plugged into the SOA infrastructure. With the right business integration solution, companies get the ability to extend their legacy (non SOA) systems into the SOA universe. With so much investment tied up in existing systems, this is the most expedient and cost-effective path to populating an SOA with the standards-based services that BPM tools, portals, and other service-based applications can leverage. The move to services also benefits downstream business integration initiatives through reusability and the reduced cost and complexity resulting from standardization.
- *Business Process Management (BPM).* BPM and SOA enjoy a natural synergy. BPM is about executing well-defined tasks in an organized fashion. SOA is about exposing application and system functionality as well-defined business services. The tasks in BPM correspond to the

services exposed in an SOA. When implemented in a top-down fashion (i.e. driven by BPM), the services that are developed to support one business process become available to be reused in other processes when they are deployed in an SOA. When implemented bottom up (i.e., the priority is on creating atomic services), the services in an SOA become part of the inventory that can be reused to accelerate future BPM implementations. Furthermore, flexibility arises from the fact that business process flows and the services they use are implemented separately, allowing the best tool (or set of tools) to be used for each purpose. As a result, with the underlying support of an SOA, companies can achieve the benefits of BPM more quickly.

- *Business Activity Monitoring (BAM).* BAM enables companies to become more responsive to significant events, changes and problems in their business. SOA serves the needs of BAM by providing visibility into business processes and a uniform way to access information from across the enterprise. BAM also has many obvious synergies with BPM and EAI/B2B. Like, BPM, BAM is centered around business processes. With the right infrastructure, processes that are orchestrated in an SOA automatically become candidates for BAM. EAI/B2B services provide the means to access data within existing systems, while infrastructure services within the SOA can be used to channel this data in real-time to the BAM solution. Because of these inter-dependencies, an SOA solution that combines BPM, integration, and BAM offers significant economies of scale.
- *Composite Applications.* As the inventory of business-oriented services within an SOA grows, it becomes increasingly easier to assemble custom applications to meet new business needs, or to create personalized applications for specific user requirements. Instead of building applications out of database calls and other proprietary APIs, SOA-based composite applications are able to use standard Web services. Furthermore, the abstraction provided by SOA— meaning the low-level technical details of a Web service implementation are hidden—empowers relatively non-technical staff to get involved in the construction of composite applications.
- *Actionable Business Intelligence (BI).* As a new opportunity offered by SOA, we see also generating actionable business intelligence. These opportunities will be discussed in some more details later in the paper.

While the path to service-orientation has been presented as sequential steps, the reality is that different companies will advance along the three fronts in different ways. Some companies will wet their feet with Web services before putting an enterprise SOA infrastructure in place, while others might take a more architectural approach and defer tactical Web services deployment. Other companies might look to their existing EAI or B2B capabilities as the starting point to SOA.

Whatever the strategy, one of the advantages of SOA is that it can be implemented incrementally for example, on a project-by-project basis. Big bang implementations are not necessary to start reaping the rewards [14].

4 Changing Nature of Business Intelligence

When it comes to intelligence about business, the problem statement is simple. If a piece of information is needed by someone and and it is not available, the person addressed does not have it. If a piece of information is needed now and it is not at disposal now, it is not available when needed. If these pieces of information are needed to solve a problem – e.g. figure out why a product isn't selling in certain markets – the problem cannot be solved. And if competitor does have this information about its business, he is in a great advantage.

The point here is the importance of knowing what information is needed and when it is need – what is the right information and when is the right time to look at it – and then ensuring a business can deliver it.

It is a story that lasts for decades – getting the right information to the right people at the right time in the right format. Companies are serious about achieving this goal in order to be smarter about the way they do business, a prerequisite for survival and success in today's competitive, global marketplace. Companies are under more spotlights than ever before – new government compliance regulations, highly-publicized customer-satisfaction surveys, and even news stories in addition to the traditional illumination of financial reports. Customers have high expectations; there is a shrinking margin for error and little tolerance for lack of good business intelligence.

To put it shortly, that what is needed is right-time, actionable Business Intelligence.

4.1 The Shift in Focus

Traditionally, Business Intelligence (BI) was considered as a layered technology tied to a specific database or data warehouse management system. The goal was simply to

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provide executives with reports and dashboard-like views of what departments were doing, how well they were doing it, and where opportunities for better performance and growth might lie [15].

But this approach limited thinking and support. Now, organizations are increasingly supporting BI so that diverse people can better use the information and analysis. This way, multiple users can lead, decide, measure, manage, and optimize performance to evaluate new sources of information and reap wanted financial and other benefits.

The current holistic view of BI encompasses business objectives, performance management, people, processes, analytics, reporting, online analytical processing (OLAP), and query technologies – all sitting on an information processing and management infrastructure. This BI is about using information and analysis to spur business growth and transformation.

To capitalize on the real value and potential of BI, users should turn more traditional approaches upside down – shifting the focus from technology that serves a small segment of decision-makers to much broader initiative that puts people, processes and business objectives first.

Leading BI initiatives are interactive, real-time, flexible processes that take into account the needs and skills of people within the organization. This means viewing BI as a continuum that spans diverse users – including managers, workers, sales representatives, customers, suppliers, and partners – where tools identify new business opportunities, integrate business processes, and build fruitful collaboration across the business.

To move to real-time – or right-time – proactive initiatives and transform the business, companies must change the way they implement and manage their information architecture and application portfolios, better integrate BI with business processes, and sharpen users' information-analysis skills.

But while these steps will go a long way toward making BI a core competency, most companies will still need to address critical factors that determine the business case and organizational priority for BI. Often, there are multiple buying centers for BI, each with its own agendas, initiatives, and goals. There may be additional requirements, such as a need to reduce cost of the infrastructure, to improve data quality, and to form the single version of the truth.

Meanwhile, it is not uncommon to have a large number of plans competing for the same, usually limited funding. Priorities vary widely among organizations, and decision-making process tends to be rooted deeply in the particular culture, value system, leadership, management methodologies, and skills. Consequently, the greatest challenge to BI lies not in technologies, but in the organizational dynamics that must be overcome.

4.2 Real-time vs. Right-time BI

Real-time BI optimizes the time latency between when a business event occurs and when an appropriate action is taken. The goal is to "right-size" the decision-making cycle, the time lag between knowing what is happening based on internal and/or external events, and taking appropriate action based on that knowledge [16]. Right-time takes into consideration the potential trade-off between time-to-action and the business value of the action. Making a decision today may have greater or lesser value than making the decision next week.

In the BI arena, however, optimizing the decision cycle typically means shortening it, or compressing it. It does not necessarily mean minimizing the time lag, or automatically assuming that every decision process must be completed in "real-time." The key is to define the "right" time for each decision cycle, one that reflects business realities and the trade-offs between risk and cost. It is extraordinarily expensive to create a completely real-time organization. Even if an organization can afford real-time decision-making, it may not be necessary or worth the cost.

The state-of-the-art in BI for a long time was a data warehouse (DW) and/or data marts updated overnight (within the traditional "batch window") with data from legacy operational systems. The overnight updates extracted operational data in batch, transformed the data into a format for analysis (e.g., denormalized data, multidimensional OLAP cubes), and loaded it into the data warehouse. This approach still works for businesses where analysis of daily data is "right time."

Over the past five years or so, however, organizations have explored technology to support more real-time data collection, analysis, and decision-making in a BI environment. The goal is to support intra-day analysis of up-to-date information with the ability to make immediate decisions about the business.

We understand right-time Business Intelligence as any BI data collection, analysis, or action that falls between once-a-day and real-time. It is BI used to run an organization's daily business with the ability to modify the business intra-day. Organizations can shorten the decision-making cycle in many ways to facilitate right-time business intelligence.

Current trends include [17]:

- Moving data from operational systems into the data warehouse more often than once a day or on a continuous basis.
- Integration of data to provide a current "single view" of the customer, of the business, etc. with up-to-the-minute business context for analytical information.
- Extending access to analytical tools and information across the organization, enabling the retail buyer in the store, the call center operator,

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or a dashboard to take advantage of right-time BI functionality.
- Encapsulating BI functionality as reusable services that can be called "on demand" by any application.

In subsequent sections of the paper we describe how the Web services and Service-oriented Architecture can contribute to make Business Intelligence solutions actionable. The strategic direction here is to seamlessly integrate BI functionality into business processes. This recognizes the importance of Business Intelligence as yet another "operational" system that adds value to the business

5 Key Enablers for Business Intelligence in the SOA Environment

5.1 Enterprise BI Repository

It is through the enterprise BI repository that an organization can govern the BI asset portfolio – the collection of services and supporting assets – to ensure alignment with architecture, and to prevent the SOA from becoming tomorrow's legacy nightmare. The enterprise repository must do the following:

- Provide the means to centrally manage the metadata for any type of Business Intelligence asset, from business processes and Web services to patterns, frameworks, applications, and components.
- Map the relationships and interdependencies that connect Business Intelligence assets to the SOA, and the SOA to business objectives.
- Support BI project planning, impact analysis, investment decisions, collaboration, and reuse by providing stakeholders with visibility and traceability of services and their supporting artifacts.
- Provide the means to apply governance policies to BI assets, and to systematize reuse of those assets.
- Include the tools and metrics necessary to measure and communicate both compliance with governance policies and the ROI of the SOA transformation effort.

5.1 Service Registry

An efficient, UDDI-compliant service registry provides an organization with a checkpoint to ensure service alignment and compliance with corporate and IT policies and standards. The service registry must do the following:

- Integrate with the BI enterprise repository to bridge the entire SOA life cycle, providing a comprehensive life cycle management solution.
- Dynamically bind governance policies with BI services to allow discovery and enforcement by the service bus, management framework, or other enforcement participants.
- Catalog data about deployed services, and provide a standards-based mechanism for the discovery of existing deployed services by applications in production.

5.3 Effective SOA Management and Enforcement

Effective SOA life cycle governance requires proper SOA management and enforcement to ensure that constituent BI components operate as intended, within design parameters. This is critical for visibility into policy compliance and QoS metrics. This visibility, in turn, allows the continued evolution and maturity of the SOA.

SOA management and enforcement must do the following:

- Ensure that defined governance policies are properly enforced in production.
- Track compliance with those policies.
- Monitor BI service adequacy, performance and behavior.

5.4 Real-Time Data Acquisition & Warehousing

While the majority of enterprise data warehouses continue to move towards real-time data acquisition, there are numerous organizations that are seeing the benefits of real-time data warehousing today.

These organizations continue to push the envelope with active data warehousing and are achieving measurable gains in their customer satisfaction levels and ultimately gains to their bottom line. Perhaps a significant investment into taking the enterprise data operational or active may not be justifiable for all businesses today – however as businesses becomes increasingly real-time, the enterprise analytics and data warehousing infrastructures should be built and ready to support faster business decisions.

6 Advantages of SOA for Business Intelligence Solutions Developers

The core value of Web services is that it enables an SOA-style application development paradigm which offers the business intelligence solution developer two key advantages:

1. *Web services are commonly built for standardized interoperability and application program interface (API) evolution* – Web services work on every operating system. Their design objective is to deliver APIs that are very simple to use and which evolve over time in such a way as *not* to break existing applications [18]. This holds the promise of less overall time spent in application development, maintenance, support and upgrade, allowing developers to spend more time on new solutions instead of maintaining old ones.
2. *Web services are built on ubiquitous Internet protocols (i.e., loosely coupled, firewall-immune APIs).* Web services are specifically designed around the challenges of remote system functional access over the Internet. They can be deployed using current staff skill sets [19]. Web services-based BI solutions can be deployed across corporate firewalls. They can be used where a Business Intelligence resource is only occasionally available, and they can be consumed everywhere, by desktop client applications, server applications and mobile devices.

The concept of usage of business intelligence solutions outside the firm's walls as Web services is shown in Fig. 3.

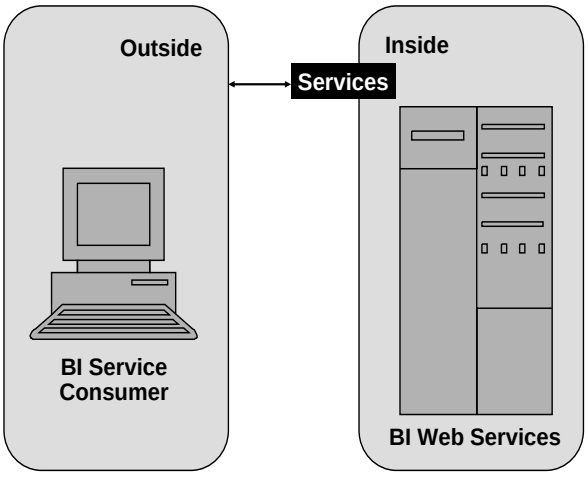

Fig. 3: Using Business Intelligence solutions from outside the enterprise

Together these two features give Web services-based solutions a new level of solution agility, adaptability and reuse. This is a reason why Web services technology intrigues and attracts as many people coming from different fields as it does.

6 Web Services & SOA: A Business Case for Business Intelligence

6.1 Web Services Benefits and Challenges

Web services provide several technological and business benefits, a few of which include:

- Application and data integration
- Versatility
- Code re-use
- Cost savings

The inherent interoperability that comes with using vendor, platform, and language independent XML technologies and the ubiquitous HTTP as a transport mean that any application can communicate with any other application using Web services. The client only requires the WSDL definition to effectively exchange data with the service – and neither part needs to know how the other is implemented or in what format its underlying data is stored. These benefits allow organizations to integrate disparate applications and data formats with relative ease.

Web services are also versatile by design. They can be accessed by humans via a Web-based client interface, or they can be accessed by other applications and other Web services. A client can even combine data from multiple Web services to, for instance, present a user with an application to update sales, shipping, and ERP systems from one unified interface – even if the systems themselves are incompatible. Because the systems exchange information via Web services, a change to the sales database, for example, will not affect the service itself.

Code re-use is another positive side-effect of Web services' interoperability and flexibility. One service might be utilized by several clients, all of which employ the operations provided to fulfill different business objectives. Instead of having to create a custom service for each unique requirement, portions of a service are simply re-used as necessary.

All these benefits add up to significant cost savings. Easy interoperability means the need to create highly customized applications for integrating data, which can be expensive, is removed. Existing investments in systems development and infrastructure can be utilized easily and combined to add additional value. Since Web services are based on open standards their cost is low and the associated learning curve is smaller than that of many proprietary solutions.

Finally, Web services take advantage of ubiquitous protocols and the Web infrastructure that already exists in every organization, so they require little if any additional technology investment.

With the numerous advantages of Web services

come a few challenges. Most significantly, though Web services themselves are designed to be simple, actually developing and implementing them can be complex. WSDL syntax becomes complicated quickly, especially when building a service with multiple operations in a text-based editor. Even looking at the completed code, it's difficult to follow the chain of connections from a service name, to the binding, to the port type, and so on, never mind writing the code correctly by hand.

There are tools that will auto-generate WSDL code based on an existing application that a developer wants to expose as a Web service. However, best practices dictate that designing the WSDL be the first step in architecting Web services. The contract-first approach to Web services development has many advantages. Designing the interface first results in better overall planning prior to implementing the service and helps ensure the service will be effective in multiple client scenarios.

In addition, because WSDL is standards-based, designing the WSDL first, then building the Web service based on this definition prevents developers from including language-specific types and constructs in their Web service. This ensures that any Web services client can interact with the service without interoperability issues. Though the WSDL contract-first approach may seem more rigorous at first, the resulting benefits make the service more effective by ensuring interoperability – which, after all, is the rationale behind using Web services in the first place. Lack of tool support is often cited as the biggest obstacle to the contract-first approach to Web services design.

Another challenge arises after the WSDL is defined, when the developer must actually write the code to connect the required data sources and implement the service on a server. Given that even the simplest of Web services may require thousands of lines of code, this process is often timeconsuming and error prone.

Despite the challenges mentioned, if managed in an appropriate manner, Web services can be considered to be a promising business case for Business Intelligence.

6.2 A Business Case for Business Intelligence

The following are some key use cases for which Web services technology is almost ideal when considered from the BI perspective:

- *Becoming a Business Intelligence service provider.* Converting BI application solutions into a BI service provider allows the departmental staff to customize their BI content, while insulating central staff from the headaches normally associated with such customizations. Long-term support and maintenance costs decrease because technical support is isolated to Web service calls and invocation. One example of this is a legal firm which has deployed a single BI service provider that feeds content into two very different departmental applications: a legal portal which presents necessary contract information and a finance application which presents the financial data (Fig. 4).

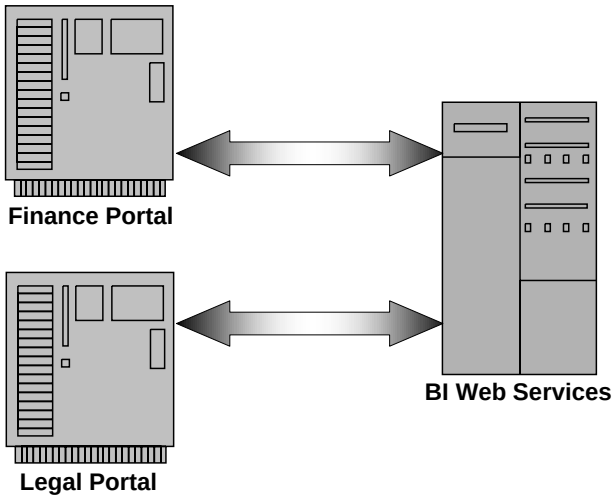

Fig. 4: Multiple use of BI Web services

- *Integrating disparate application data into a corporate data warehouse.* This is the reverse of the first use case, Web services makes it very easy to integrate BI content from several departmental, partner or vendor BI solutions into a corporate data warehouse without impacting the individual deployments, whether they reside inside or outside the company's firewall.
- *Deploying rich clients.* Large vendors are creating client tools and platforms to consume and extend Web services for a variety of end-user solutions. Microsoft's vision of "smart clients" offers a rich client user experience and is built on the functional capabilities of remote Web services. One leading provider of healthcare information technology has built a proof of concept of exactly this kind of solution [20]. The company wants to use this approach to provide highly customizable, feature-rich solutions to its clients while simplifying its application development tasks.
- *Partner Functional Extensions.* Web services allow your partners or vendors to seamlessly integrate BI content, with a light software footprint, into their value added offerings for specialized functionality. An example of this is third parties providing specialized visualization solutions such as call center dashboards or power management efficiency grids.

7 Conclusion

Business intelligence has become a key component of companies' IT frameworks. It is a component that enables business users to report on, analyze and optimize business processes and operations to reduce costs and increase revenues.

As competitive pressures are forcing companies to react faster to changing business conditions and customer requirements, there is now a need to use business intelligence to help drive and optimize business processes and operations very quickly. This type of BI is usually called operational business intelligence.

The objective of operational BI is to make more timely business decisions, and, therefore, if has a close relationship to the subjects of real-time and near real-time BI processing needed for the business to be agile.

On the other side, Web services technology and concept of Service-oriented Architecture are becoming widely accepted. They provide a new means of all kinds of application interoperability including business intelligence applications. Our opinion is that Web services will help enterprises revolutionize BI by enabling the conversion of specific BI application deployments into flexible BI service providers that can easily integrate into Web, server and desktop solutions. This will shift the focus of BI solutions from applications to complete networks which provide targeted BI to everyone both inside and outside the organization.

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