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Sun Helps Architect with J2EE™
Technology Standards and
Instill Development Best Practices

By David S. Marshak

*A Patricia Seybold Group Case Study
Prepared for Sun Microsystems, Inc.*





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NETTING IT OUT

In 2000, eBay, the leading online marketplace and possibly the most successful Web-based enterprise in existence, faced a serious challenge. Its business was growing so fast that it threatened to tax its existing two-tier technology architecture in areas of scalability and maintainability. At the same time, eBay was exploring new marketplace models to supplement its traditional auction model and found that its infrastructure was not flexible enough to support its new initiatives and its long-term strategy of becoming a marketplace that supported all models of commerce. Although a number of efforts had been made in 1999 and 2000 to shore up the existing infrastructure and, importantly, users of the site were not yet impacted by the infrastructure limitations, eBay decided in late 2000 that a completely new architecture would be needed to meet future quality-of-service requirements. The key would be to move from a monolithic application architecture to a services- and component-based architecture that would take eBay into the future.

eBay evaluated two architectural platforms: Microsoft's .NET initiative and the industry-standard Java™ 2 Platform, Enterprise Edition (J2EE™) platform. According to Chuck Geiger, Vice President of Architecture and Technology Strategy at eBay, eBay decided that "Java [technology] had finally matured with J2EE [technology] to the point to which large-scale velocity could be considered." (Sun played a key role in assuring eBay, including demonstrations of successful deployments of J2EE technology-based platforms for high-volume destinations such as J.Crew, Ford Credit, and Charles Schwab.) eBay then turned to Sun Services to help with its J2EE technology-based architecture design and implementation. As part of this process, Sun mentored and trained eBay developers in development best practices based on the SunToneSM Architecture Methodology. The Sun team also served as a "watch dog" to help insure that the implementation would remain based on J2EE technology standards rather than become proprietary to any specific vendor.

In June, 2002, eBay completed the second phase of the three-phase roll-out of the new architecture, which it dubbed "V3." Phase One was a production-quality design concept and was successfully completed at the end of 2001. Phase Two moved the bulk of user activity to the new architecture—proving the scalability of the new architecture. And Phase Three—the long-term migration of virtually all eBay functionally to the new architecture—is scheduled for completion mid 2004.

Thus far, the results have been very positive. A number of large and mission-critical functions is now on the new architecture. Currently, over 75 percent of user traffic are on the new architecture, with no negative impact on the experience of more than 62 million registered users. eBay has also seen performance improvements. In addition, eBay is expecting a much improved time to market for the deployment of new initiatives through more than 25 percent reuse of architectural frameworks and design patterns, with measurable gains in productivity and availability. Most importantly, eBay is now on the road to a more viable, flexible, and scalable architecture upon which to build its future.

BACKGROUND ON EBAY

eBay, Inc. is possibly the most successful Web-based enterprise in existence. Its name is universally known and is synonymous with the auction model of Internet selling. eBay was pivotal in helping to facilitate buying and selling between individuals and businesses. The industry leader also created one of the first trusted online commercial communities, whereby the transactional exchange between sellers and buyers is regulated by the evaluations and recommendations of each. Although eBay has spawned many imitators as well as a spate of other Web destinations with auction capabilities, it continues to dominate the auction category and remains on the leading edge in innovation with models such as fixed-price and half-price sales.

Since its inception in September, 1995, eBay has facilitated billions of dollars of transactions. On any given day, there are more than 12 million items listed on eBay across 18,000 categories for sale on eBay, with customized trade enabled for markets around the world.

The eBay community includes over 62 million registered users and, according to Media Metrix, is the most popular shopping site on the Internet when measured by total user minutes. In 2002, eBay members transacted \$14.87 billion in annualized gross merchandise sales. Indeed, Internet users spend more time on eBay than any other online site, making it the most popular shopping destination on the Internet.

Members from all over the world buy and sell on eBay. Currently, eBay has local sites that serve Australia, Austria, Belgium, Canada, France, Germany, Ireland, Italy, Korea, the Netherlands, New Zealand, Singapore, Spain, Sweden, Switzerland, Taiwan, and the United Kingdom. In addition, eBay has a presence in Latin America and China through its investments in MercadoLibre.com and EachNet, respectively.

Today, the company is no longer simply a one-size-fits-all (or, more appropriately, one-model-fits-all) auction site. In addition to its well-known auction services, eBay provides many other services and sale models, including:

- **eBay International.** eBay currently has country-specific sites in Austria, Australia, Canada, France, Germany, Ireland, Italy, Korea, New Zealand, Switzerland, and the United Kingdom.

Indeed, it is not uncommon to hear about eBay members in Korea purchasing items from members in the U.S. or members in Australia buying from others in France.

- **eBay Motors.** eBay Motors is the Internet's largest auction-style marketplace for buying and selling all things automotive. At any given time, eBay Motors has a wide variety of vehicles listed for sale, from cars, to SUVs, to trucks, with virtually all makes and models. The site also features collector cars, motorcycles, as well as auto parts. eBay Motors also provides end-to-end online services such as financing, inspections, escrow, auto insurance, vehicle shipping, title & registration, and a lemon check.
- **eBay Stores.** eBay Stores expand the marketplace for sellers by allowing them to create customized shopping destinations to merchandise their items. For buyers, eBay Stores represent a convenient way to access sellers' goods and services. Buyers who shop at eBay Stores are able to make immediate and multiple-item purchases for fixed-price and auction-style items.
- **Buy It Now.** Buy It Now is an optional enhancement for item listings. It allows buyers to purchase an item at a specified price without waiting for the end of the auction. It gives sellers an easy and convenient method to sell items quickly at a specified price.
- **eBay Professional Services.** Professional Services on eBay serves the fast-growing and fragmented small business marketplace by providing a destination on eBay to find professionals and freelancers for all kinds of business needs such as Web design, accounting, writing, technical support, among others.
- **eBay Local Trading.** eBay has local sites in 60 markets in the U.S. These localized eBay sites allow users to easily find items located near them and browse through items of local interest. eBay's local sites deliver a distinctive regional flavor, while giving users the convenience to shop for more difficult-to-ship items such as automobiles, furniture, or appliances.

- **eBay Live Auctions.** Live Auctions provides live, real-time online bidding on items being sold on the sales floor of the world's leading auction houses. A proprietary technology developed by eBay, Live Auctions empowers traditional auctioneers to extend their sales beyond the auction house floor and reach millions of potential buyers online. Buyers gain easy access to exclusive, high-end property with the convenience and comfort of bidding from their home or office.
- **PayPal.** eBay recently acquired PayPal, a global, real-time payment solution that allows any business or consumer with an email address to securely, conveniently, and cost-effectively send and receive payments online. PayPal has over 20 million registered users, including more than 3 million business accounts.

Unprecedented growth in traffic and transactions, coupled with increased demands for greater functionality, prompted Geiger and his team to investigate architectural enhancements and changes.

BUSINESS DRIVERS AND TECHNOLOGY CHALLENGES

Evolving Requirements

As eBay's business exploded, the company faced two significant forces that would challenge its technology infrastructure and compel it to evolve in new directions.

The first was the sheer scale of the site. Whether measured by visits, minutes on the site, registered users, items for sale, or transactions (either by number or dollar volume), eBay was (and still is) continually redefining what scalability means.

The second is the evolution of services that eBay provides and intends to provide in the future. As demonstrated by the eBay Stores and Buy It Now, eBay has already expanded beyond the auction model of commerce.

Facing the Architectural Challenges

EBAY ARCHITECTURE VERSIONS 1 AND 2—HISTORY AND LIMITATIONS. By the end of 2000, these forces were severely testing the eBay technology architecture, which, according to Geiger, though it was called "Version 2," was "for all intensive purposes the original architecture of the company." (Version 1 was eBay Founder Pierre Omidyar's homegrown desktop for Auction Web.) Geiger explains, "There is a lot of genius behind it, and the fact that it scaled and continued to meet the needs of our trading community is pretty amazing. But it's a fairly flat, two-tier architecture based on a proprietary C++ procedural system—with direct connectivity from the presentation logic to the data logic." Unprecedented growth in traffic and transactions, coupled with increased demands for greater functionality, prompted Geiger and his team to investigate architectural enhancements and changes. The major limitations of the existing architecture were:

- Flexibility
- Scalability
- Manageability

Flexibility. The Version 3 eBay architecture was intended and optimized for supporting the auction model of online commerce. Geiger points out, "One of the issues that we had with the architecture was its relative inflexibility in regard to business rules outside of the boundaries of auctions."

Geiger goes on to emphasize that the earlier architecture was not flexible enough for eBay to expand its commerce models. "As we grow our business and look at business directions in 2003 and even 2005—when we're a \$3-billion company—we will be doing more than just auctions," notes Geiger. "Consequently, transforming our technology architecture into a global trading platform in which users can buy and sell in any number of ways is one of the objectives that we believed would be difficult to accomplish with the earlier architecture."

eBay V3 Solution at a Glance	
Core Functionality	<p>More than 62 million registered eBay users have access to the largest and most successful auction marketplace in the world. In order to maintain its growth and enable more flexible online business models, eBay created a next-generation architecture that would:</p> <ul style="list-style-type: none"> • Enable near seamless changes with significant reuse of frameworks and design • Provide scalability and flexibility to accommodate rapid business growth • Enhance efficiencies of developers and administrators through much easier system maintenance
Application Platform	eBay chose an advanced, open, standards-based, multi-tiered architecture powered by J2EE technology and IBM WebSphere Application Server residing on a heterogeneous platform infrastructure and operating environment.
Solution Approach and Architecture	Sun Services worked with eBay to design a services-driven network architecture and to instill development best practices based on the SunTone Architecture Methodology. The project included skill assessments, training, and certification from Sun Services in Java technology. Sun Services also played a major role in assuring that the implementation would be based on standards and be vendor neutral.
Benefits	<p>With its V3 architecture eBay expects to achieve:</p> <ul style="list-style-type: none"> • New architecture expected to handle growth in transaction volumes and increased number of registered users over the next 5 years and beyond—leading to eBay become a \$3 billion dollar company • More than 25% architectural framework and design reuse helping to significantly speed development cycles • Perceptible improvement in application performance—faster, more efficient page loads and responses

This was at a time when eBay was already adding new models, such as its Buy It Now service. The company found that it needed not only to support multiple purchase models, but multiple search models—such as parametric search by attributes.

Scalability. At the same time, Geiger recollects, “Back in November and December, 2000, we were faced with some severe concerns on scalability. We were reaching a limit based on the way we had our data architecture designed, thus limiting our hardware capacity. We were basically running one instance of Oracle database on one instance of the Solaris™ Operating Environment on a Sun Enterprise™ 10000 server.” Hardware upgrades for added performance was not then an option. “Sun wasn’t ready to deliver a Sun Fire™ 12K at the time,” he quips. “There wasn’t such a thing.”

Between June, 1999, and the first part of 2001, eBay underwent several significant upgrades to address, at least temporarily, these issues. This included migrating from the single database server to a storage area network (SAN) environment based on Sun StorEdge™ technology. Improvements were

also made to the scalability and performance of the eBay search functionality.

Geiger remembers that, by the early part of 2001, the earlier “nervous feeling” he and his team had felt had been assuaged. The architecture still comprised a monolithic design with various space and capacity ceilings, however. Geiger explains, “As an example, we had a 3.3-million line ISAP DLL that had simply grown too large and had become very difficult to debug.”

Manageability. This example points to the third major limitation of the earlier architecture—it was just too difficult to maintain. This, in particular, had impacted the eBay development organization. “We were spending an inordinate amount of time working on system maintenance and fixing bugs rather than on differentiating the product—coming up with the designs and development practices that distinguish eBay as an innovation leader.”

Geiger likens this to a pyramid, “We had an inverted pyramid. Instead of having the senior architects at the top providing thought leadership and the system administrators at the bottom providing the

necessary support to sustain that direction, we had the exact opposite. The senior architects were expending most of their time and capital on understanding how to keep the architecture functioning—connection pooling, memory management, data access, and so forth.”

EBAY ARCHITECTURE FOR THE FUTURE

eBay embarked on the effort to upgrade to a next-generation architecture in November/December, 2001. Facing the issues of flexibility, scalability, and manageability, eBay began to put together a plan for a next-generation architecture—helping to prepare the company to evolve to meet the business drivers for a global trading infrastructure for the 21st century.

From the beginning, it was clear to eBay that—for its next-generation architecture—it needed to completely rethink its design, management, and functionality, an undertaking that would involve hundreds of developers, system administrators, and project owners. And, perhaps, the most daunting challenge, as aptly described by Geiger, “We had to change engines on the plane while in flight.” Based on business drivers, eBay determined that the new architecture would need to comply with specific quality-of-service requirements and guiding principles.

Architectural Objectives and Principles

The architectural objectives included business goals and quality-of-service requirements such as:

- Time to market
- Performance, scalability, and availability
- Business continuance
- Functionality, with the specific need to absorb business changes

- Security, including authorization and authentication protocols and data integrity
- Open-standard components for vendor product interdependence

The corollary guiding principles were:

- Flexibility: the ability to make changes to the architecture in a near seamless fashion with significant re-applicability of frameworks and design

Sun played a key role in assuring eBay, including demonstrations of successful deployments of J2EE technology-based platforms for high-volume destinations such as J.Crew, Ford Motor Credit Company, and Charles Schwab.

- Scalability: keep the application and platform infrastructure ahead of business growth
- “Making life boring”

This last principle is a particularly interesting quote from eBay President Maynard Webb. It derives from his oft-cited quip to move site management from last-minute technology heroics to the desired state of “making life boring” by having an archi-

tecture and operational processes that seamlessly handle the peaks and unexpected events.

Throughout one key aspect of the architectural decision was subtle, yet essential to eBay’s ultimate success. A key principle of the project would be to ensure that the architecture was based on industry standards rather than vendor-specific implementation methods and techniques. Geiger notes, “One of our design principles for V3 was to visualize our architecture and development framework as an airplane—we did not want to rely on just one gyroscope; technology products sometimes break. One of our objectives was to design an architecture that masks these potential deficiencies. The technology selections behind the V3 architecture were made with the intent of helping us to avoid susceptibility in going with a solution from a single vendor—in particular, proprietary technologies.”

ARCHITECTURE, PRODUCT, AND PARTNER DECISIONS

Based on these objectives and principles, eBay focused on three key decisions that would be critical to its success:

- Application platform and development framework
- Messaging infrastructure
- Consulting partner

Platform Evaluation: J2EE vs. .NET

According to Geiger, the application platform decision was based on the needs to “increase productivity by creating a component-based architecture, which would do away with the monolithic code base.” eBay’s evaluation centered on the platform’s ability to meet the high quality-of-service requirements (flexibility, adaptability, manageability, scalability, and security) and the need for the architecture to be comprised of frameworks focused on reuse. The two candidates were Microsoft’s .NET initiative and industry-standard J2EE technology, with the latter initially considered as a long shot. Geiger recalls, “This was not in the initial vision of V3: If you were to ask me back in December [2000] if we would go to Java [technology], I would have said ‘No.’”

eBay’s evaluation of Microsoft’s .NET initiative concluded that, at the time, it was not ready to meet its needs. As Geiger puts it, “We were not going to adopt a brand new technology.” This was somewhat surprising since eBay’s existing “architectural foundation was firmly rooted in C++ [technology]. But, as we dug into the different issues, we reached the realization that we needed a more open architecture accompanied with overarching process changes. This paradigm was integral to our decision to go with Java technology.”

eBay still needed to be convinced that J2EE technology would address its quality-of-service requirements. Sun played a key role in assuring eBay, including demonstrations of successful deployments of J2EE technology-based platforms for high-volume destinations such as J.Crew, Ford Motor Credit Company, and Charles Schwab. At this point,

Geiger was convinced. “We felt that Java [technology] had finally matured with J2EE [technology] to the point to which large-scale velocity could be considered.”

With this critical decision in place, eBay then focused on selecting its J2EE application server. After considerable analysis, eBay narrowed the field to BEA WebLogic Server and IBM WebSphere Application Server, with the latter eventually being selected.

Messaging Infrastructure Evaluation

A key aspect of the overall architectural decision was to move from a static two-tier architecture to a more flexible multi-tier, services-driven network architecture in which presentation, application, and data logic are separated. Geiger elucidates, “There was a very tight coupling between applications and where data physically lives. If we wanted to change that from an option perspective or maintenance perspective, we had to modify the application. We wanted to be able to have complete control over data without needing to affect the application itself.” The J2EE technology-based architecture enables this separation and communication via Java Database Connectivity (JDBC™) technology and connection pooling. To this, eBay decided to add a messaging layer that would eventually be integrated into the J2EE technology-based architecture. After looking at IBM MQSeries (now IBM WebSphere MQ), eBay selected a messaging solution based on TIBCO ActiveEnterprise.

Selection of a Consulting “Partner”

When it came time for the design and implementation of the new J2EE technology-based architecture and, moreover, the instillation of development best practices to its approximately 100 developers, eBay turned to its long-term technology provider Sun Microsystems, Inc. Specifically, Sun Services was selected over the consulting arms of other technology providers.

THE ROLE OF SUN SERVICES' CONSULTING

The Need for Java Expertise

Perhaps the foremost challenge that eBay faced in its decision to embrace J2EE technology as the core of its application architecture was the fact that its development team had little experience in working with Java technology. Geiger recalls, "Our development team had only a small amount of experience working in Java [technology-based] environments. With over 100 developers, largely with a background in C++ development, we recognized the need for assistance in architecture design as well as development practices."

eBay ultimately determined that Sun Services had the breadth of experience as well as the methodological approach that would help ensure its success in moving from a C++-based application environment to one based on J2EE technology. Its long-term relationship with Sun was an important factor in its final decision. In particular, Sun's interest in providing initial direction by supplying eBay with some of its most senior consultants gave eBay the assurance that Sun was committed to helping it make the application platform transition a success. In addition, even though eBay opted for IBM WebSphere Application Server over Sun ONE Application Server, Sun remained resolute in providing eBay with the architectural and development direction it was seeking. The fact that Sun consultants possessed extensive experience designing application architectures around any number of J2EE standard-based application servers, including a proven track record working with IBM WebSphere Application Server, was also an important consideration. Sun consultants provided eBay with direction in the following areas:

- Helping to keep the architecture design based on J2EE technology standards
- Providing a development methodology, including best practices around framework replicability
- Guidance in addressing security requirements on a J2EE technology platform

- Mentoring (knowledge transfer) in application development using Java technology

Staying to the J2EE Standard

Designing and building to the J2EE technology standard was a guiding objective for eBay. "One of our architectural design principles was the need to architect and write to industry-standard J2EE specifications," notes Geiger. "We wanted to make sure that we would have the flexibility of vendor independence, something that we felt the Sun consultants would help ensure." Sun served in what Geiger describes as a "watch-dog role," helping to ensure that development coincided with J2EE technology standards—not drifting into vendor-specific, proprietary architectural components. As part of the endeavor to do this, eBay engaged Sun consultants to help design an application architecture that it would run on both IBM WebSphere Application Server and Sun ONE Application Server. "With an already established, long-term relationship in place, we looked to Sun for assistance in helping us to conform to industry standards," says Geiger. "Sun wrote the standards behind Java technology, and we were confident that the 'inventor' of such would give us the best guidance. We thus engaged Sun consultants to help us learn how to write code, how to do architecture design, how to document, how to follow development best practices—essentially everything across the spectrum. With the help of Sun, we are in a solid position with compliance with the J2EE technology standard as well as processes and documentation to help ensure that we stick to it."

SunToneSM Architecture Methodology

Sun consultants drew on significant components of the SunTone Architecture Methodology for architecture design and instillation of development best practices in working with the eBay development team. In particular, the SunTone Architecture Methodology embodies: architecture design (services-driven network architecture consisting of separation of services), project management (based on the Prince2 methodology and best practices from the Project Management Institute), and development best practices (architecture frameworks, design patterns, use cases, iterative/sequential development, etc.). The mentoring Sun distilled to the eBay devel-

opers encompassed all of these different areas. In many ways, Sun consultants served as the architecture team for eBay and led the design of the multi-tier, services-driven network architecture. In addition to helping design and configure the different services' tiers in the architecture, the Sun team helped in the development of business rules and policy frameworks, configuration subsystems, and logging of frameworks. Sun consultants also worked with eBay on the application management and underlying security architecture.

Learning and Embracing Java Technology

There initially was some ambivalence on the part of eBay developers in regard to the decision to embrace Java technology for the next-generation application infrastructure. Geiger reports that Sun consultants were able to win over the eBay developers because of their own extensive expertise and experience. "We had one of the architects who developed the concept of *Core J2EE Patterns*,"¹ says Geiger. "We were able to formulate important architectural decisions based on his insight as well as that of other Sun consultants. Such was a good thing; our initial thoughts were not quite on target, and we were able to redirect and avoid some dead-end streets in our architecture design and subsequent development efforts."

Geiger continues, "The team from Sun was exceptional. We felt as if we had a 'brain trust' that was quite unique, with the expertise of the consultants ranging from security, to internationalization, to framework design and reuse." Geiger notes this did not happen instantly. "It took us some time before we had achieved success. We have some unique challenges, and Sun demonstrated the flexibility and

¹ See "Core J2EE Patterns: Best Practices and Design Strategies," Prentice Hall, 2001, by Deepak Alur, Dan Malks, and John Crupi. Deepak Alur was the lead architect on the Sun team that worked with eBay.

willingness to supplement and even change the consultants to fit our requirements. The consultants ultimately hit the mark perfectly."

A key objective as eBay embarked on the project, with the assistance of Sun, was to enable eBay to take over the architectural planning and implementation. Today, eBay is doing almost all of the architecture design and application development. Geiger explains, "We ramped down the activity with the Sun consultants, as we didn't want to keep the 'training wheels' on too long. We wanted Sun to help teach us how to fish, not just fish for us. So, while currently self-sustaining in application and architectural issues, we anticipate milestones in the

future where we'll need to re-engage Sun consultants for direction. Sun's focus on making development engagements short-term efforts with a premium on transferring knowledge to the customer gives Sun a strategic advantage and demonstrates Sun's commitment to the ultimate success of the customer."

Geiger summarizes the work between Sun Services and his team: "Sun helped lay a solid architectural foundation. We broke new 'snow' together and,

though we uncovered some issues, we were able to maintain 'the light at the end of the tunnel' in purview throughout."

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EBAY V3 ROLLOUT STATUS

Three-Phase Roll Out

From the beginning, the V3 architecture roll-out was planned to occur in three distinct phases:

- **Phase One: Design Concepts.** A broad set of eBay constituents, Sun consultants, and other technology vendors agreed on concepts and produced top-level design specifications. These specifications were used to convert a small part of the site to prove the viability of the architectural strategy.

EBAY'S SERVICES-DRIVEN NETWORK ARCHITECTURE

Sun Services helped eBay design a services-driven network architecture for V3, as shown in Illustrations 1 and 2, that provides a powerful, extensible platform for building eBay's current and future applications using J2EE technology. eBay's V3 architecture is based on four fundamental principles that address quality-of-service requirements, including scalability, security, flexibility, and performance:

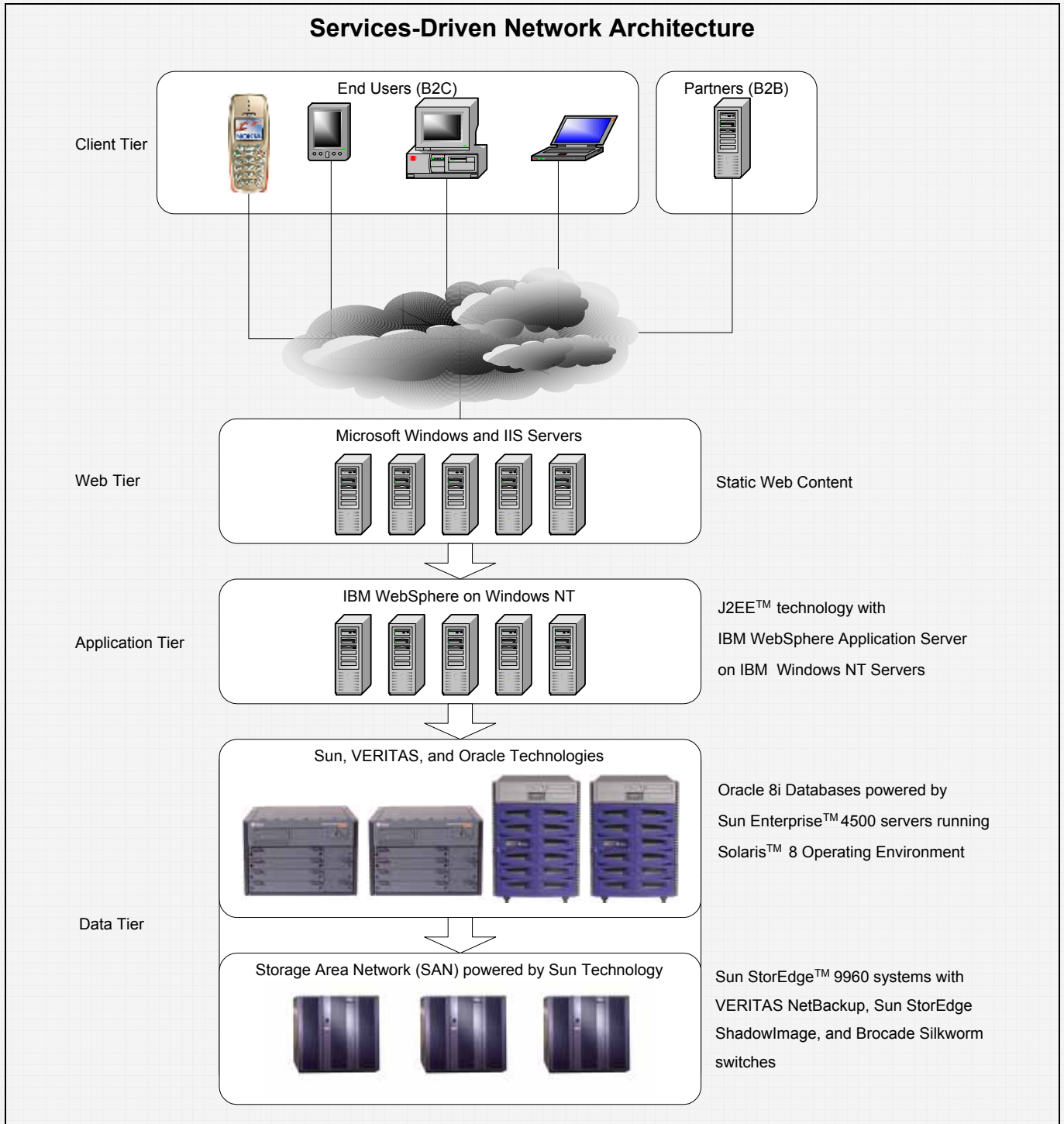


Illustration 1. The eBay V3 architecture includes client, Web, application, and data tiers.

- N-tier, services-driven network architecture
- Componentized code
- Data partitioning
- Read/write partitioning

Illustration 1 highlights how the architecture facilitates good partitioning based on functional decomposition, enables loosely-coupled tiers, and offers great flexibility and scalability. The tiers are partitioned into client, Web, application, and data tiers.

The client tier caters to end-user applications, browser and device-based clients, and external applications that integrate and interact with the eBay V3 application. The Web tier caters to the static content and acts as the initial boundary between the client and the J2EE application tier. The application tier (Illustration 2), key to the service-driven network architecture, caters to the needs of presentation services, business-logic services, and data-access services using various Java and J2EE technologies, including Java servlets, Enterprise JavaBean™ (EJB™) technology, JDBC technology, Java Naming and Directory Interface (JNDI™) technology, Java Management Extensions (JMX), and Java XML technologies. The data tier represents the infrastructure needed to host and provide the data services using Sun, VERITAS, and Oracle technologies.

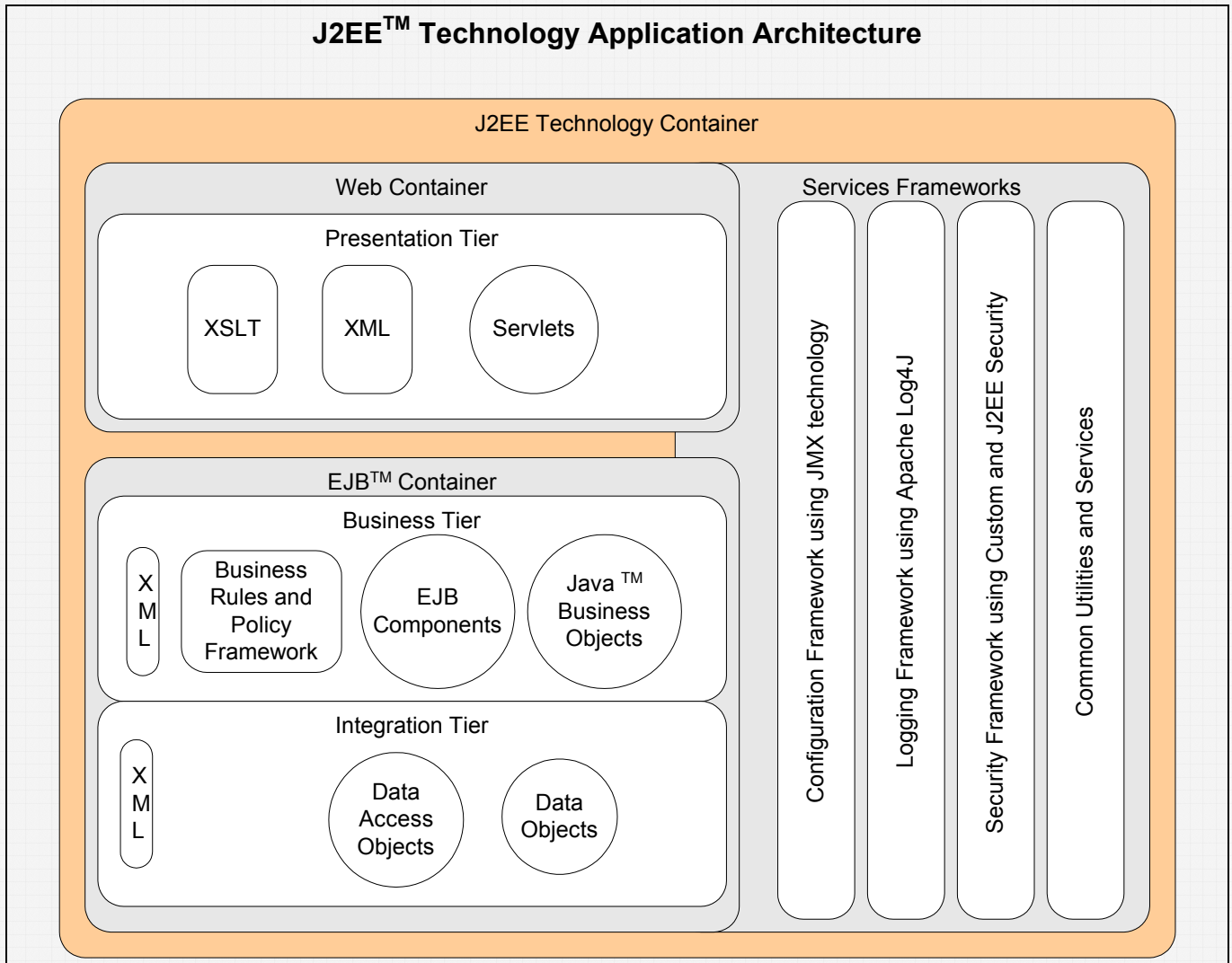


Illustration 2. eBay's V3 J2EE application architecture.

Illustration 2 zooms in on the application tier and shows the high-level J2EE application architecture for V3, whereby various Java and J2EE technologies are used to realize a scalable, extensible, and flexible architecture. The application tier is further partitioned into different logical tiers: presentation, business, and integration tiers. The presentation tier is responsible for interacting with the client tier and providing the required service to various types of clients. This layer consists of a Java servlet-based framework and uses Java XML and eXtensible Standard Language (XSL) technologies for highly flexible presentation services. The application tier is composed of a component framework to facilitate business-logic and business-rule execution. The application tier is based on EJB technology and uses custom Java business rule and policy framework, business objects framework, and XML technology. Integration services within the application tier provide a data-access-layer framework, which facilitates interaction between the application components and the data sources via extensive usage of JDBC technology. This implements eBay's sophisticated requirements for data access and object-relational mapping.

In addition to these three framework tiers, there are other frameworks that provide for a complete end-to-end J2EE application architecture. The configuration framework is implemented using Java Management Extension (JMX) technology and provides for an event-driven configuration service across all layers and tiers of the application services platform. The generic logging framework is implemented to abstract the underlying logging API implementations and uses Apache's Log4J implementation to facilitate a powerful logging service. The security framework is implemented using standard J2EE technology security features to protect the J2EE application components; it also implements certain custom security components based on specific eBay requirements. The common utilities and services provide various reusable utilities and services that are common across all the layers and tiers in the application architecture.

- **Phase Two: Proof of Concepts and Initial Deployments.** Working with Sun consultants, eBay teams refined concepts and made final decisions through prototyping and the actual development of initial V3 components. This included converting the most heavily trafficked part of the site to confirm that the architecture could deliver on the quality-of-service requirements that had been identified.
- **Phase Three: Wide-Scale Migration.** Based on priority and, moreover, ease of integration, eBay will migrate all of its services and applications to the V3 architecture.

Phase One—Design Concepts

Starting in December, 2000, Phase One demonstrated the viability of the proposed architecture design, ranging from the need for individual services' tiers, to security requirements, to proposed development frameworks. According to Geiger, "The approach was to select a small piece of the site's infrastructure for migration to the V3 architecture, with the ability to quickly revert to the V2 version in case of any problems. The plan was to learn from design patterns—those that worked—for development effi-

ciency. The development plan was designed in mind all of the way down to those managing the operations, with the goal of sorting through all of the issues at one time, thereby allowing us to resolve potential issues before other applications were brought into production."

Phase One release of the J2EE technology-based architecture was completed in December, 2001.

Phase Two—Proof of Concepts and Initial Deployments

Phase Two, with Phase One complete and the architecture solidified, was intended, as Geiger explains, "to prove scalability by selecting one of the most heavily trafficked areas of the site." That section is what eBay defines as the "View Item" area, which accounts for about 65 percent of all site traffic. Although the functionality itself is fairly simple, the high traffic and transaction volume of the area was chosen to demonstrate that the new architecture would scale. Complete migration of "View Item" to the new architecture was achieved in June, 2002.

With this migration, close to 75 percent of the eBay traffic is now being handled by the new architecture—which translates to over 400-million transactions per day.

Phase Three—Wide-Scale Migration

The final phase, Phase Three, which was initiated in July, 2002, will be to migrate eBay's entire infrastructure to the new architecture. Geiger explains, "Phase Three is effectively bringing the J2EE [technology-based] architecture to the masses, the general development population."

In addition to moving its existing infrastructure to the new architecture, all new business requests will be built on the V3 architecture. "Working with Sun Services' training specialists, we developed a sequential, targeted training and development program," says Geiger. That development plan includes certification in Java technology. "With our development team now adequately trained in Java [technology] and development best practices in place, we can begin designing and implementing new business requests within this new architectural framework." Geiger acknowledges that the completion of this change will take time. "Now that we have proven it, we plan to have most areas of our application infrastructure for all of the site migrated to the new architecture by middle of 2004."

RESULTS

While still a work-in-progress, eBay's V3 architecture clearly has already begun to deliver results. Geiger notes, "The first positive result is that it works great." This was not always a foregone conclusion, however. Geiger continues, "You know, back when we were looking down the road to converting an application to Java [technology], it was a daunting task. Being the largest, in terms of scale,

velocity, and users, made us all nervous. The fact that we've effectively been able to keep our response time from an end-user perspective the same if not better while driving various quality-of-service requirements is an important benchmark."

Geiger notes the key result is the proof that the new architecture will work, both in scalability and in developer productivity. "We're successfully demonstrating that we can horizontally scale—in a virtually infinite manner—this new architecture," notes Geiger. "The changes that are taking place in the realm of development productivity are also a major accomplishment." Indeed, Geiger estimates that his development team will realize over 25 percent in architecture design and patterns reuse, equating to significantly shorter development cycles.

The efficiencies to the development team extend down to the rewriting of code. "We have a four-year-old application and 3.3-million lines of code, something we want to examine both strategically and tactically. What we'll likely find is that we can rewrite it in a more efficient manner. Such will contribute to better CPU utilization and user response times." Accordingly, the V3 architecture is already showing demonstrable improvements in performance—such as faster, more efficient page loads and responses—over the V2 architecture.

In terms of scalability, eBay projects the V3 architecture to be able handle the rapid, continuous, non-linear growth that it expects to continue for the next five years and beyond.

Ultimately, the benefit of moving to its leading-edge architecture has been to put eBay on the road to a more viable, flexible, and scalable architecture upon which to build its future.

