Building a Better e-Business Infrastructure

N-tier Architecture Improves Scalability, Availability and Ease of Integration

Analysts at META Group* are advising IT organizations to increase their proficiency in designing and deploying N-tier architecture. The N-tier architecture, in conjunction with appropriate middleware and Intel®-based servers, can give businesses a real edge in meeting the unique challenges of the e-Business economy.

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Executive Summary

High-volume e-Business transactions are putting new pressures on the corporate computing environment. Functionality and stability are no longer sufficient to provide a competitive advantage. Businesses must be able to deploy and adapt applications quickly to address rising workloads and changing business requirements. Data and applications must be integrated across the enterprise to improve efficiency, and the highest levels of performance and availability must be maintained to support business-critical processes.

Infrastructure analysts at the META Group* have outlined a strategy that can help IT organizations meet these demands. The strategy is built around the N-tier architecture, which partitions systems and software to enable a more flexible, building block approach to infrastructure design and growth. By taking advantage of off-the-shelf middleware and the N-tier architecture, businesses can design, deploy and integrate e-Business applications more quickly and cost-effectively.

As noted by the META Group, a key advantage to this approach is that it enables businesses to deliver the highest levels of performance and availability using Intel®-based servers and components, rather than relying on far more expensive RISC-based systems. Faster integration, incremental scalability, and affordable availability help IT organizations create the kind of infrastructure that can truly deliver on the e-Business promise.

This paper discusses the advantages of the N-tier architecture, and offers a variety of useful tips for creating a more scalable and cost-effective e-Business infrastructure. It should prove useful to anyone involved in planning and managing an e-Business strategy.

The Challenge of e-Business Computing

Leading companies are accelerating their business cycles by establishing e-Business connections across their entire chain of customers and suppliers. The advantages are compelling. Information sharing, collaboration and transaction processing are more efficient. Costs are reduced, and each connected business can respond more quickly to new opportunities and market shifts. The growing maturity of applications for e-Commerce, supply-chain management and customer resource management is fueling this evolution by simplifying deployment and providing a faster and more substantial return on investment.

With these advantages come new IT challenges. Workloads escalate when customers and suppliers access applications that are linked to core business systems. Security must be tightened, and 24x7 availability is essential. At the same time, the performance of e-Business applications often has a direct and immediate impact on revenue and corporate credibility. Up-to-date application functionality is important, but business value is equally dependent on the flexibility, scalability and availability of e-Business services (Figure 1).

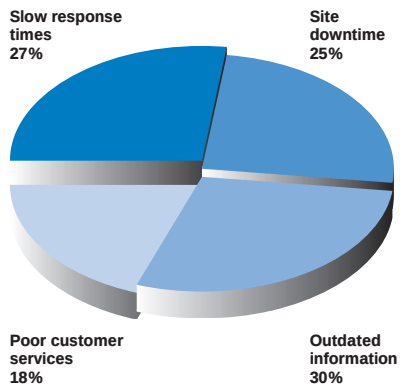

Figure 1. *Leading application functionality is not sufficient to maintain customer loyalty in an e-Business environment.*

Meeting the Challenge with an N-tier Architecture

According to META Group analysts, the infrastructure demands of e-Business require that IT organizations become proficient at designing and implementing the N-tier architecture (Figure 2). This architecture makes a significant departure from the more traditional 2-tier pattern, in which core applications and data are typically hosted on a monolithic system (mainframe), which is accessed by a variety of "thick" clients.

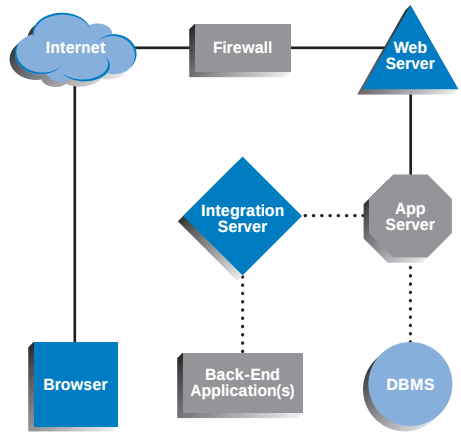

Figure 2. *The N-tier pattern partitions functionality to simplify upgrades and integration at all layers.*

LIMITATIONS OF THE TRADITIONAL 2-TIER ARCHITECTURE

The traditional 2-tier architecture places substantial loads on the network due to the heavy interaction between clients and the server. Though manageable within the high-bandwidth environment of a corporate LAN, latencies and bandwidth usage can become prohibitive when applications are accessed over the Internet. In addition, the 2-tier model doesn't scale incrementally. When usage exceeds capacity, it is commonly necessary to replace the entire system.

The software structure of the 2-tier architecture is equally unsuited to the volatility of the e-Business environments. Business logic is fundamentally intertwined with presentation logic and with database access protocols. This works well for stable, isolated applications, but lacks the flexibility required for e-Business agility. Developers typically have to re-create the business logic if they want to take the application to the Web, adapt it to new user interfaces or integrate it with other applications.

GREATER FLEXIBILITY WITH N-TIER SOLUTIONS

An N-tier design partitions application functionality into three independent layers, enabling easier integration with core business systems and other e-Business applications:

- **Layer 1: Presentation Logic—**Typically hosted on front-end Web servers
- **Layer 2: Business Logic—**Hosted on mid-tier application or general-purpose servers
- **Layer 3: Database Management—**Hosted on back-end database servers

In effect, an independent application layer is added to the traditional 2-tier architecture. This additional layer has the effect of decoupling business logic from presentation and database functions, both physically and in the software architecture. The ramifications for software development and maintenance are particularly compelling. Customized code can be replaced with standardized APIs to interface business logic with presentation code and database access protocols. When properly implemented, the hardware and software for each of the three layers can be scaled and upgraded independently.

This partitioning also makes it easier to integrate new applications into the environment. Application code no longer has to be re-created when a new user interface is added, or when a transaction is linked with another application in the e-Business matrix.

SHARED SERVICES SIMPLIFY DEVELOPMENT

Businesses can extend the benefits of the N-tier architecture even further by establishing standardized hardware and software designs at each tier. If properly implemented, this process leads toward the creation of a menu of shared services that IT can use in planning, designing and deploying new applications. The reuse of core components accelerates application development and integration, and reduces maintenance and support costs by simplifying the computing environment.

Businesses don't have to create these standards from the ground up. The selection and deployment of an appropriate middlware stack can provide a robust platform for both off-the-shelf and customized e-Business applications, and contribute significantly toward a more standardized and agile infrastructure.

Taking Advantage of the Middleware Stack

Application server software (middleware) is currently available from a variety of vendors within the Intel® e-Business Network. A good middleware stack provides essential infrastructure services for deploying robust, scalable and secure transactional applications at the middle layer of the N-tier architecture. In fact, middleware now offers much of the functionality traditionally associated with high-end UNIX* implementations. This can be a major cost advantage, enabling businesses to create standard, high-availability solutions using Intel-based servers instead of far more expensive RISC-based systems.

Appropriate middleware can also reduce application development costs. Instead of writing custom code for infrastructure services, programmers can configure the middleware to handle essential tasks such as load balancing, resource management, security and transactional integrity. Middleware also insulates programmers from many of the intricacies of operating systems and database applications. Instead, they can focus on creating better business logic, and capitalize on middlware functionality to integrate their application both vertically and horizontally within the e-Business environment.

"Focus on the application server to enable ordinary programmers to build extraordinary applications."
—META Group Inc. 2000*

Affordable Scalability and Availability

When an N-tier architecture is used in conjunction with appropriate middleware, it does more than improve e-Business agility. It also enables businesses to deliver very high levels of performance and availability using Redundant Arrays of Inexpensive Servers (RAIS) at the front-end and middle tiers. This process is known as scaling out, and it lets businesses increase performance and availability incrementally and inexpensively, using standard Intel-based servers and components.

SCALING OUT AT THE FRONT-END

The scale out approach is ideal for front-end Web server implementations (Figure 3). Service requests are handled by a pool of similarly configured servers, each providing identical services to all clients. A router or load-balancing appliance distributes incoming requests across the server farm. Redundant ISP connections and a hot-standby load-balancing appliance ensure that there is no single point of failure.

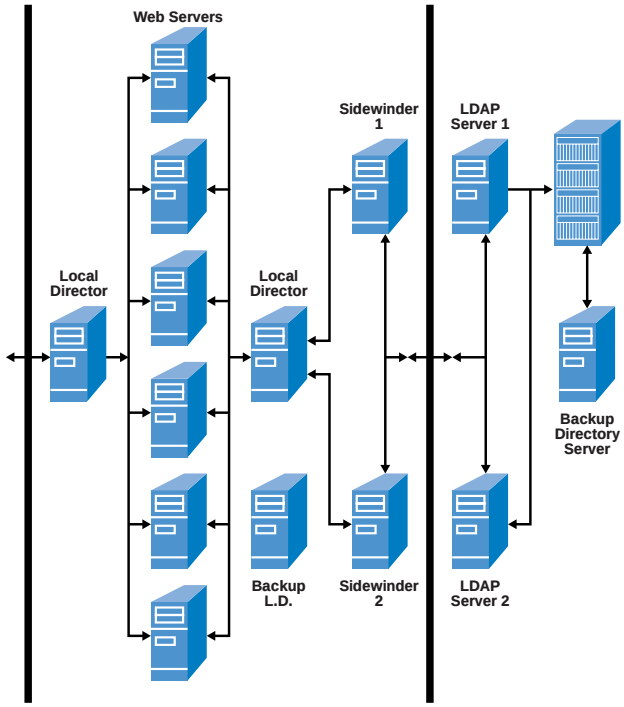

Figure 3. *In a scale-out configuration, traffic is balanced across multiple inexpensive servers, delivering high levels of performance and availability at affordable costs.*

To increase performance and availability, another inexpensive server is simply added to the farm. The larger the pool, the less the impact of a failed server. If a failure does occur, the load is automatically distributed across the remaining systems, and a backup server is brought online to restore peak performance.

Availability increases rapidly with the size of the server pool (Figure 4). For small server pools, it may still be advisable to configure individual servers for high availability. A variety of advanced options for single-system fault tolerance are available on Intel® architecture from virtually all major server vendors. For larger server pools, it is generally simpler and more economical to keep configurations simple, and rely on multiple server redundancy to meet availability requirements.

Though scaling out is typically accomplished using 2-way or even single-processor servers, some businesses prefer to contain the size of the server pool by using larger, 4-way Intel-based servers. The advantages of a smaller pool of more powerful, fault-tolerant systems must be balanced against deployment costs, availability needs and the capabilities of available management tools.

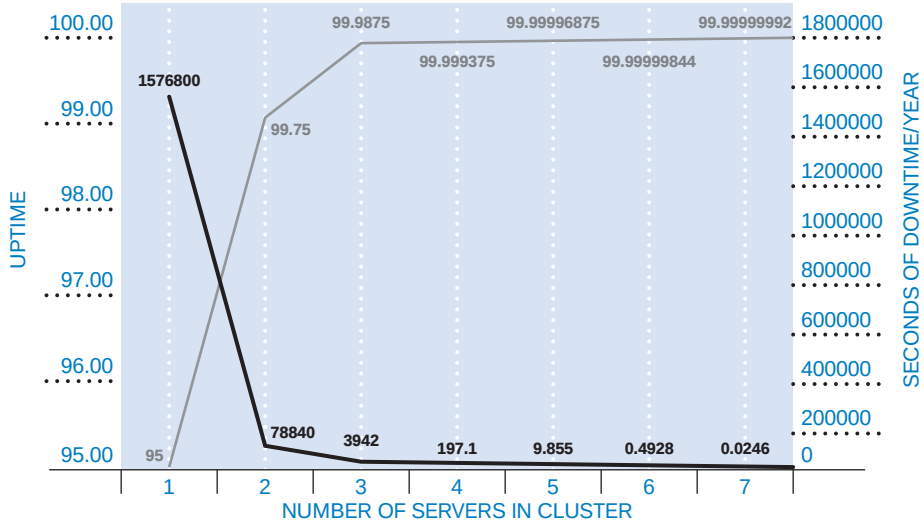

***Figure 4**. In a scale-out configuration, availability climbs rapidly with the size of the server pool, (Graph assumes each individual server to have 95 percent uptime if treated as stand alone).*

In many scale-out scenarios, a network-attached storage solution is advisable. With captive storage (resident hard drives in each server), storage limitations could eventually require the simultaneous replacement of all the servers in the pool. A networked storage utility eliminates that possibility, and allows processing power and storage capacity to be scaled independently. This solution also favors the use of thin, rack-mounted servers to conserve valuable data center real estate.

SCALING OUT IN THE MIDDLE TIER—THE KEY TO E-BUSINESS SCALABILITY

The sophistication of current middleware applications has extended the value and practicality of scaling out into the middle layer of the N-tier architecture. As in the front end, this enables businesses to add computing power incrementally, using pools of affordable Intel-based servers. Instead of continually outgrowing and replacing single-server solutions, companies can add servers as needed to accommodate growing workloads.

In the recent past, scaling out at the middle tier required the creation of custom code, a resource-intensive task. Stronger OS support in Microsoft* Windows* 2000 Data Center has helped close the gap for many businesses. The compatibility of Intel architecture with UNIX, Linux* and other leading operating systems offers strong solutions in other computing environments. However, any good middleware application offers even more robust tools, delivering high levels of performance and availability with less effort.

Scaling out in the middle tier is similar to front-end implementations, but typically involves the use of 4-way or 8-way servers to accommodate the larger software footprint and processing demands of middle tier applications. Scaling out at this level can range from a two-server cluster to a large server pool.

In most cases, the features of the middleware can be used to simplify deployment and ensure efficient failover and transaction integrity. For example, because of the greater complexity of transactions at the middle tier, it is usually not practical to mirror each transaction across the entire server pool. Instead, middleware tools can be used to configure mirrored pairs within the pool. This provides more than sufficient levels of transaction integrity, and overall service availability is still supported by the entire pool of servers.

State management also becomes an issue at the application layer. In general, it is best to push state management back into the database tier whenever possible, to simplify scaling at the application layer. However, if a transaction lives across multiple interactions with a Web or application server, middleware tools can be used to configure “sticky ports,” which return successive interactions to the same server. Such an approach can be used, for example, to maintain a user’s shopping cart during an online visit, without pushing every state change back into the database.

SCALING OUT IN THE EXTREME THE SUCCESS OF THE GOOGLE* SEARCH ENGINE

One highly successful example of scaling out is being used to run one of the Web's fastest and most popular search engines (www.google.com*). In fact, Google* takes scaling out to its logical extreme, hosting both its search engine and its 1–2 terabyte database on over 3,500 inexpensive, uniprocessor, Intel®-based servers—each configured with two resident disk drives.

To streamline operations in such a massively distributed environment, Google developed its own applications for functions such as load balancing, remote management and new server builds. Using affordable servers and components, they have created the ultimate modular computing environment.

Of course, the computing needs of most businesses aren't so narrowly focused, and the challenges of end-to-end scaling out would be prohibitive in many environments. Nevertheless, Google's success clearly highlights the potential benefits of scaling out to meet the Internet's insatiable demand for speed, availability and scalability.

SCALING UP IN THE BACK-END

E-Business is increasing the volume and complexity of corporate data. As applications are integrated throughout the enterprise and user volumes grow, data integrity must be controlled across larger data stores. Though clustering is common at the back-end or database layer of the N-tier architecture, the use of redundant arrays of inexpensive servers is not practical at this time. Instead, the more traditional "scale-up" approach will continue to be the primary method of scaling database applications into the near future.

A scale up approach relies on the deployment of larger individual servers, alone or in small clusters, to meet growing performance and availability requirements. As the solution evolves, the individual servers are configured with more processors, more memory, and with greater I/O and networking capacity. Businesses can deploy servers with extra headroom to improve short-term platform scalability. However, when scalability limits are reached, new and larger servers must be deployed. This is typically a resource-intensive and potentially disruptive undertaking. For the time being, there's no way to duplicate the virtually limitless incremental scalability of the scale out approach when scaling up at the back end.

Improving Performance While Driving Down Costs

RAIS, middleware and the N-tier architecture provide IT organizations with a new, building block approach to infrastructure growth. Farms of affordable Intel-based servers and standardized software components reduce the need for expensive RISC-based systems and customized code. Development times are therefore reduced and integration is simplified.

The use of Intel-based servers offers dramatic benefits, since they typically deliver twice the performance of comparably priced RISC-based systems. They are available in a wide variety of configurations, including standard 2-way, 4-way and 8-way configurations, plus 16- and 32-way systems from several major server manufacturers. Since all these systems are based on Intel architecture, they are compatible with all major operating systems, and with the enormous range of applications, third-party components and services that are offered by the global Intel e-Business Network.

The price/performance and compatibility advantages of Intel-based servers offer a compelling value proposition across all three layers of the N-tier architecture (Figure 5). Businesses can scale out on 2-way, 4-way, and 8-way servers, and scale up on 8-way and higher systems. Intel architecture not only provides industry-leading performance and price/performance, it also incorporates advanced availability technologies at both the processor and platform levels. In fact, most major server vendors now offer 99.9+ percent service availability contracts for selected applications and configurations.

Best Practice Recommendations

- **Become proficient at designing and deploying N-tier architecture.** Partitioning presentation logic, business logic, and data management functionality will simplify upgrades and integration. During application development, push session management back to the database layer, to improve scalability at the front-end and middle tier.

- **Deploy High-Quality Application Server Software (middleware).** Proper implementation will reduce application development costs and help to standardize your e-Business environment.
- **Scale Out at the Front-end.** Redundant arrays of inexpensive servers (RAIS) can be scaled incrementally and affordably, and provide virtually unlimited levels of performance and availability. Take advantage of affordable Intel® Pentium® III processor-based servers for basic front-end services; and consider systems based on the Intel® Xeon™ processor family when higher levels of performance, availability and manageability are required.
- **Scale Out at the Middle Tier.** With appropriate middleware, the advantages of scaling out can also be realized at the application layer. For best results, use middleware tools rather than the operating system to configure failover and clustering solutions. The advanced features of 4-way and 8-way Intel® Pentium® III Xeon™ processor-based servers are recommended to meet the heavier transaction demands of most middle tier applications.
- **Scale Up in the Back-end.** Intel Pentium III Xeon processor-based servers configured with 8, 16, and 32 processors lead the industry in absolute performance, price/performance and compatibility for back-end applications. Larger configurations are available from specialized vendors. Servers based on the new 64-bit Intel® Itanium™ processor will soon extend Intel architecture solutions even further, to accommodate the most demanding of back-end applications—and to meet the extraordinary demands of next-generation e-Business.

Conclusion

The N-tier architecture, along with appropriate middleware, offers today's best solution to the unique pressures e-Business places on corporate computing infrastructures. By partitioning systems and applications into front-end, middle tier and back-end layers, the N-tier architecture supports a more standardized, building block approach to application design. Hardware and software for presentation, application and database functions can be scaled independently, and integrated more easily into complex e-Business environments.

Middleware adds the advantages of standardized, off-the-shelf infrastructure components that help programmers focus on business logic, and create more flexible and adaptable solutions. Middleware also extends the advantages of scaling out into the application layer of the N-tier architecture. With this approach, businesses can significantly reduce their infrastructure costs by using redundant arrays of affordable Intel-based servers to meet their most challenging performance and availability requirements. By scaling out at the front-end and middle tier, and scaling up with 8-way and higher Intel-based servers in the back-end, businesses can keep their costs down and their performance and availability high.

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