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IBM i on Power Systems Meets the Diverse Needs of Midsize Businesses

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Market Situation

Midsize organizations are growing by incorporating the latest IT innovations to meet the diverse needs of their customers, employees, and executives. Their users need mobile access, their developers require open source and web-smart coding environments, and their CIOs expect high performance, security, reliability, and scalability from flexible, cost-effective platforms. While midsize businesses are discovering that IT modernization is a way to compete more effectively, they must also develop a strategy that will minimize disruptions and balance the adoption of innovative new technologies with the strengths of existing assets. Adopting a proven platform that can be easily integrated with cloud, open source, and cognitive computing technologies will enable midsize companies to access new business insights without sacrificing security or availability.

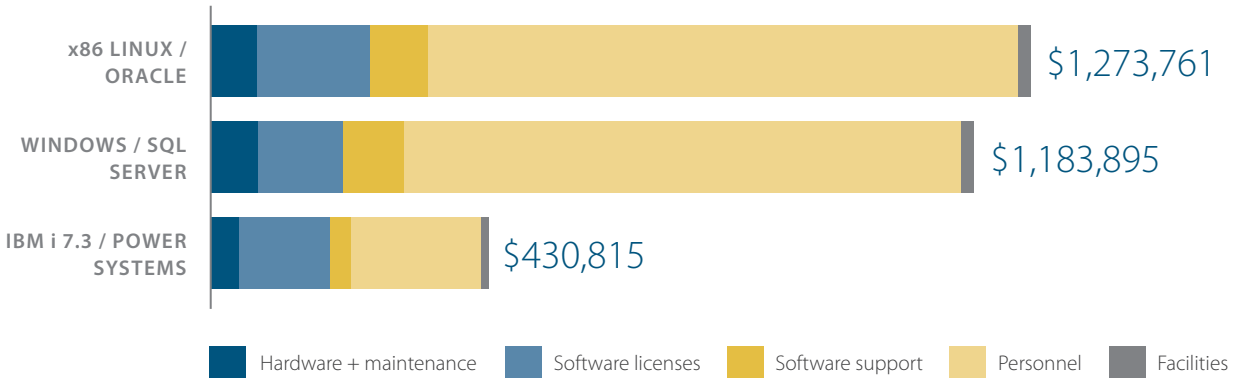
This paper compares the use of three core business information technology (IT) platforms for midsize businesses: IBM i operating system with Db2 on IBM Power Systems; Microsoft Windows Server with SQL Server on Intel x86 servers; and Linux with Oracle Database on Intel x86 servers. For these server platforms, the three year costs of ownership has been quantified using latest generation software and hardware as well as industry standard pricing. Additionally, the average cost of downtime has been estimated for each platform to assess the financial impacts planned and unplanned downtime have on midsize organizations.

IBM i's continued evolution through adoption of highly sought after open source tools, development languages, data application environments, and web content management standards is attracting the attention of a growing number of midsize IT leaders. IBM i with Db2 on Power Systems provides a highly integrated, easy-to-deploy, and secure platform that leads in system reliability, availability, and serviceability (RAS) when evaluated alongside x86 systems running SQL Server on Windows Server or Oracle Database on Linux.

These platforms were evaluated based on the value they provide in the following categories: security, modernization, and hardware advancements. IBM i's integrated design and compatibility with open-source technologies provides a flexible environment that allows users to select tools and applications with ease. Its object-based architecture is a secure foundation upon which to build core business applications. The robust RAS and security features supported by IBM i on Power Systems, industry-leading scalability and flexibility, and the steady increase in availability of open-source tools and technologies result in average lower costs of ownership for organizations that deploy IBM i.

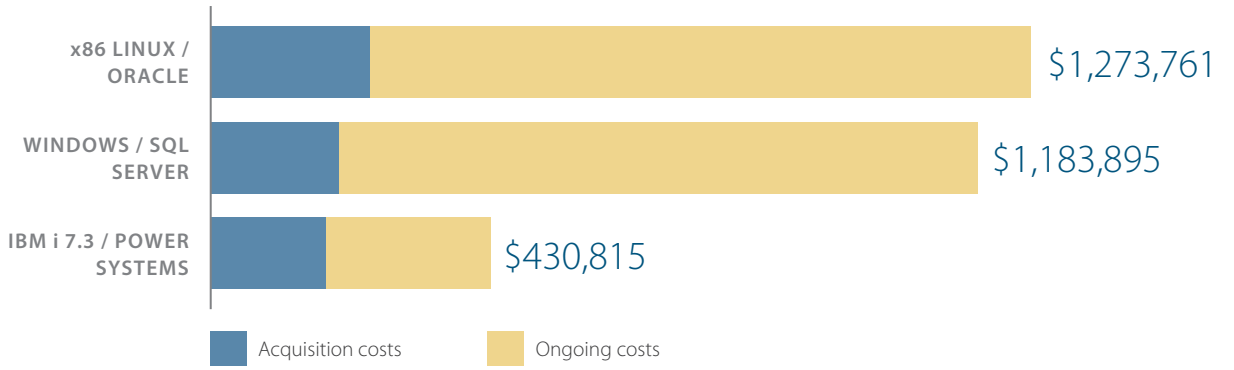
Estimated three-year costs of ownership for the three platforms were calculated based on the costs of hardware acquisition and maintenance; license and support for operating systems, databases, and other systems software; personnel for system and database administration; and facilities (primarily energy). Hardware, maintenance, and software license and support costs are based on discounted prices reported by users.

FIGURE 1: Three-year Costs by Platform—Averages for All Installations



SOURCE: Quark + Lepton (August 2017)

FIGURE 2: Three-year Acquisition and Ongoing Costs by Platform—Averages for All Installations



SOURCE: Quark + Lepton (August 2017)

Operating system and database comparisons are between IBM i 7.3 with Db2 for i on Power Systems; Windows Server 2016 with SQL Server 2016 on Intel x86 servers; and Linux with Oracle 12c on Intel x86 servers.

Server hardware comparisons are between IBM Power S814 and S824 models equipped with POWER8 technology, and two- and four-socket x86 servers equipped with Intel Xeon E5 and E7 processors. IBM PowerVM (virtual machine) technology, Microsoft Hyper-V, and a comparable x86 Linux hypervisor are employed for virtualization.

Average costs for installations on each platform are shown in Figure 1.

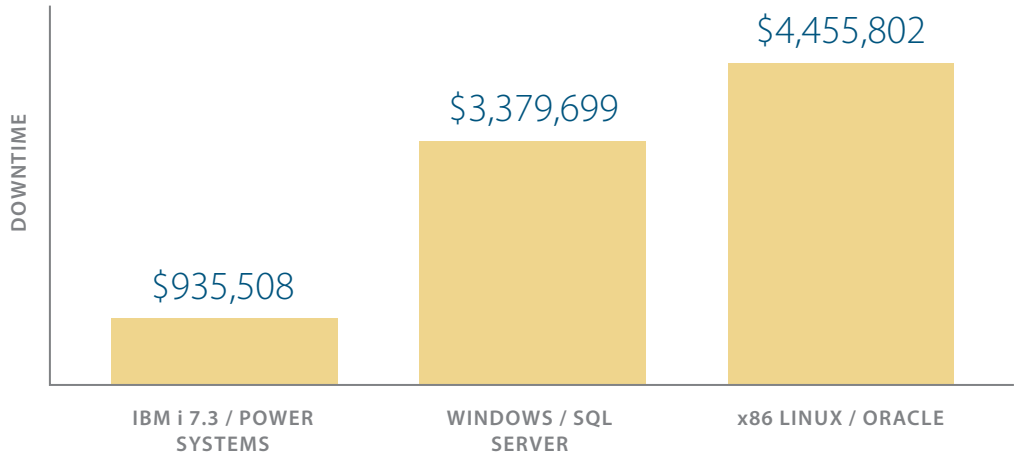
Costs for use of IBM i on Power Systems are lower across the board. For example, initial acquisition costs for hardware and software licenses average 8 percent less than for x86 systems with SQL Server on Windows, and 24 percent less than for x86 systems with Oracle on Linux. Ongoing costs average 75 percent and 76 percent less, respectively. Figure 2 summarizes these results.

A number of fundamental core capability differences contribute to cost disparities. More granular partitioning and real-time workload management mean that greater workload density may be achieved with IBM i on Power Systems. Additionally, IBM assumes the responsibility for developing, testing, and preloading middleware components and applications, so customers don't have to.

Downtime costs were calculated using a two-phase process. First, average costs per hour of downtime were calculated for all companies using appropriate industry- and organization-specific values. These values were then extrapolated based on user estimated expected downtime for each platform, based on user input, to obtain three-year costs of downtime due to core business system outages.

Cost of downtime estimates presented in this paper not only reflect user experiences, but they are also impacted by the technology differentiators discussed in the paper. IBM i on Power Systems averaged 72 percent less than use of SQL Server on Windows, and 79 percent less than use of Oracle on Linux in costs of downtime. Figure 3 illustrates these disparities.

FIGURE 3: Three-Year Costs of Downtime—Averages for All Installations



SOURCE: Quark + Lepton (August 2017)

Midsize Business Trends

Rapid transformations brought on by the Information Age have changed the way businesses operate. New tools provide access to vast amounts of knowledge and insights that were once only accessible by large enterprises. Cloud, analytics, mobile, and social media platforms have enabled organizations to collect and analyze an unprecedented amount of actionable information. Adopting such technologies will position small and midsize businesses to more effectively compete with larger organizations.

Cloud services have become an important equalizer for small and midsize organizations that cannot fund the on-premises data center resources large enterprises can. Cloud solutions can serve as simple, unified platforms, or they can be integrated with existing on-premises IT infrastructure to provide customizable approaches to meeting an organization's unique needs.

Analytics and in-memory technologies have increasingly been deployed to provide near real-time insights for decision makers, enabling companies to create value from data faster than ever before. However, as departments and organizations become ever more dependent on the information delivered by these systems, the costs of downtime, whether planned or unplanned, will grow as well.

Mobile applications have become a popular channel, not only to communicate with customers, but also to facilitate transactions and provide services. Mobile users in 2017 are projected to account for over half of digital commerce generated in the world's mature economies. A growing number of industries are participating in, and contributing to, mobile ecosystems. For example, users are becoming reliant upon certain mobile software, such as banking applications, for everyday needs. In addition, many physicians are taking advantage of mobile medical applications that allow them to conduct medical consultations and prescribe medication for their patients.

Social media outlets have emerged as an essential marketing tool, allowing companies to reach a wide audience, while curating content for a targeted following. Social media users tend to be savvy and informed customers, often relying on Internet research and online reviews before selecting products or services from competing vendors. They have, and often exercise, the power to influence others in their immediate and virtual circles, which can positively or negatively impact businesses. Due to their selective and self-promoting interests, companies that provide satisfactory experiences for online customers can benefit from repeat business as well as word-of-mouth marketing through low-cost social media services.

Artificial intelligence (AI) and cognitive computing have increasingly been adopted by businesses and consumers to harness the benefits of cognitive science from technologies such as IBM Watson. IBM Watson services are available as open APIs and/or as licensed software-as-a-service (SaaS). Watson's machine learning and AI capabilities can help businesses gain competitive advantage by parsing unprecedented amounts of data to retrieve new business insights. Watson can assist businesses of all sizes with various tiers of services, while IBM's world class security and encryption capabilities ensure that all customer data is protected. As more and more businesses begin to rely on the knowledge and intelligence from cognitive computing via the cloud, use of a proven, stable and secure platform to access to these innovative technologies is more important than ever.

The **Internet of Things (IoT)**, often hailed as the new Industrial Revolution, is a connected network of devices and sensors that provides unprecedented automation and access to information. From smart home assistants to traffic optimization sensors, the availability of IoT data, for example, can increase the efficiency of a single-home or a metropolitan area-based monitoring and automation system.

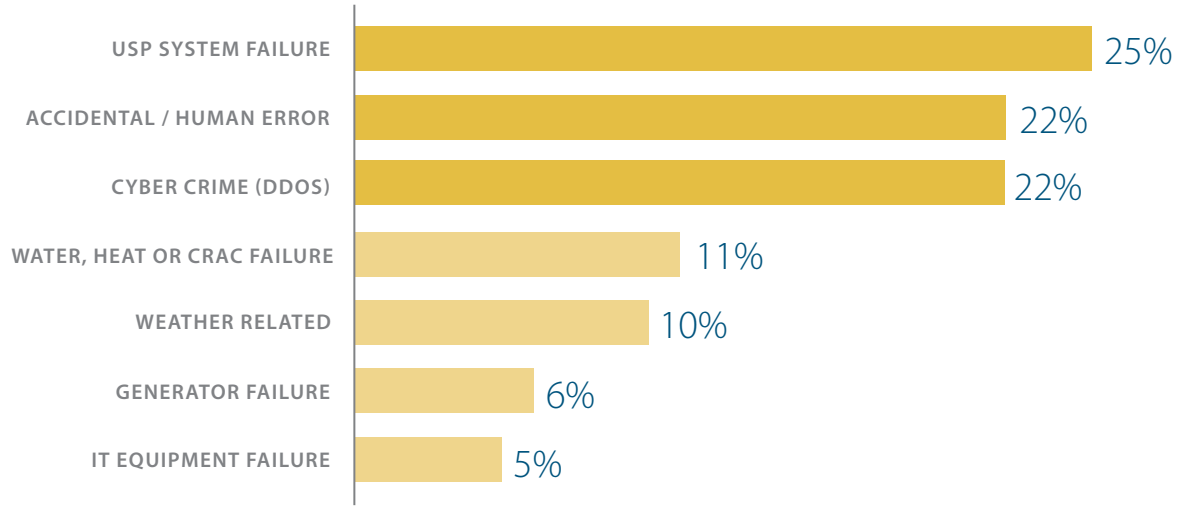
Midsize companies looking to leverage innovative solutions must do so with vigilance. Opening up business-critical infrastructure to new technologies poses certain risks, and compromising the stability of core infrastructure can result in long-term negative impacts. The secure architecture of IBM i and recent enhancements in modernization provide a secure foundation on which midsize organizations can build innovative solutions such as cloud, analytics, mobile, and social media applications.

IBM investment in the IBM i platform is evident in the strong legacy of IBM support and feedback from a passionate community of users. IBM i 7.3, available with the latest Power Systems and integrated with the Db2 for i database, can support both mission-critical business applications and web serving. Recent enhancements to the platform enable users to integrate a variety of tools and open source software, without sacrificing the robust security features natively offered by IBM i. The platform also offers extensive scalability and flexibility, allowing clients to grow their infrastructure as they see fit.

SECURITY

Security and data breaches remain ubiquitous threats for organizations of all sizes, and result in far-reaching consequences affecting both businesses and customers. It is increasingly important for organizations to implement robust infrastructure with security policies that minimize the risks of intrusion. An examination of downtime risks suggests cybercrime is one of the leading causes of IT outages (Figure 4), thus emphasizing the importance of effective security measures in minimizing downtime.

FIGURE 4: Root Causes of Unplanned IT Outages—Percentage of Organizations Reporting



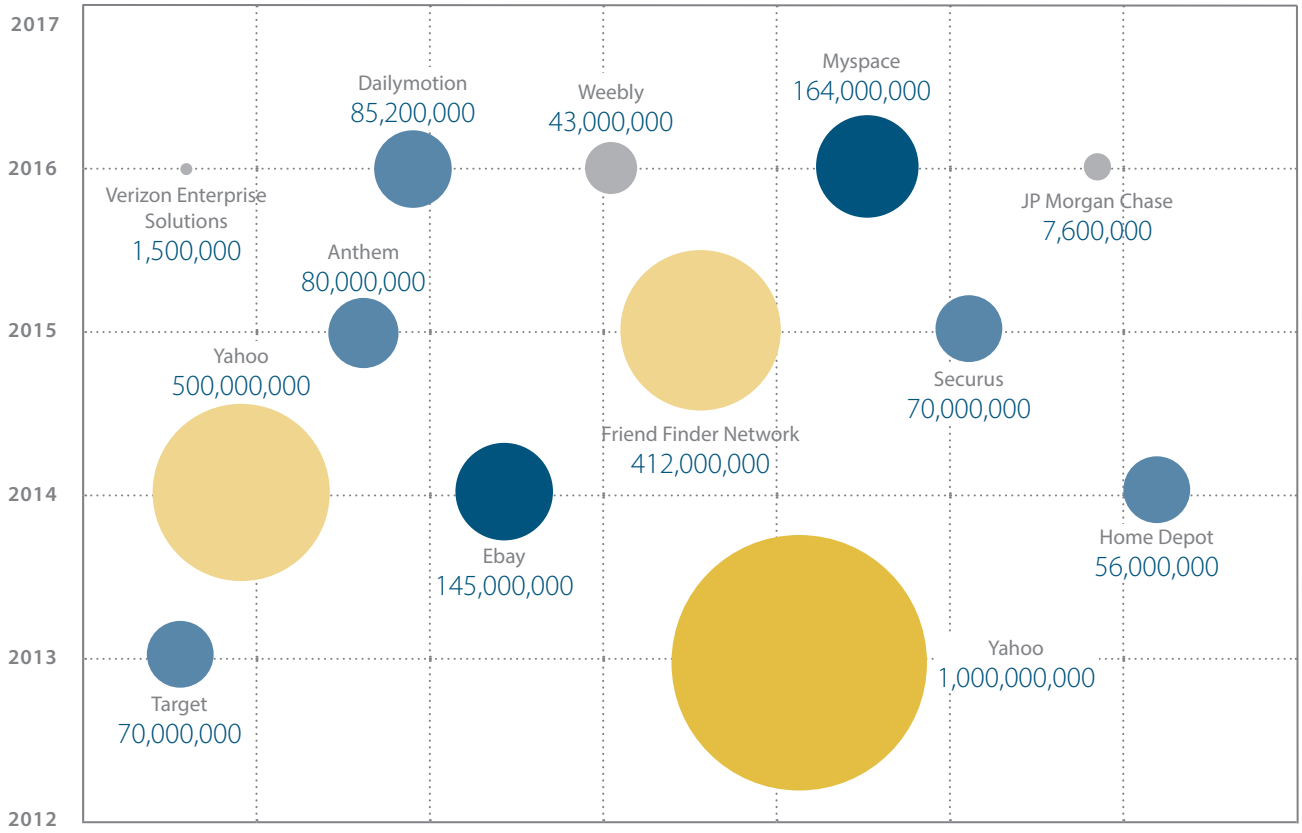
SOURCE: Quark + Lepton (August 2017), Ponemon Institute, Cost of Data Center Outages, January 2016 (Data reported by 63 data centers)

In 2016, the Identity Theft Resource Center (ITRC) recorded 1,093 data breaches, which compromised over 36 million records. Some of the largest breaches in terms of records compromised occurred in financial institutions, government agencies, and healthcare companies. Notable breaches in 2016 affected Verizon Enterprise Solutions, Dailymotion, Weebly, Myspace, and JP Morgan Chase (Figure 5). In many cases, customers' personal information was exposed and/or stolen. Even in cases where customer data is not compromised, other types of sensitive information may be stolen, and malicious damage to systems and software may occur.

The financial services industry is one of the most susceptible to security breaches. For financial services, sophisticated risk management processes and systems help in early detection of such breaches, but other businesses may be less nimble. For many organizations, breaches may not be discovered until days, even years, have passed, long after most damage has been done.

In September 2016, for example, Yahoo disclosed a 2014 intrusion that compromised the details of 500 million user accounts. Shortly after, in December 2016, the company disclosed another breach that occurred in 2013 compromising one billion accounts. This breach was only discovered when law enforcement became involved. The Securities and Exchange Commission (SEC) is currently investigating whether Yahoo disclosed these breaches to shareholders in a timely manner. Yahoo can face significant

FIGURE 5: Number of Records Compromised in Recent Data Breaches



SOURCE: Quark + Lepton (August 2017)

fines if the SEC findings are unfavorable. These breach disclosures not only led to falling stock prices and customer dissatisfaction, but also continue to haunt Yahoo. For example, Verizon, set to acquire Yahoo's core business prior to the revelation of the two data breaches, delayed its plans for the acquisition and negotiated a lower price for the deal. In addition, Yahoo is facing numerous lawsuits as a result of these breaches.

Despite the newsworthy attacks that affect large enterprises such as Yahoo, the majority of cyberattacks actually target small to midsize businesses. Most midsize organizations lack the sophisticated resources large organizations employ to ward off cyberattacks, which are on the rise across the board. Once the subject of a cyberattack, midsize organizations are also less equipped to recover from it.

Additionally, successful attacks on midsize companies can also affect large enterprises, as many midsize companies are contractors or suppliers with access to larger companies' systems. Due to the interconnectedness of modern IT infrastructure, it can take significant time to discover all the details of an attack, prolonging business interruption. Even the SEC advocates for the need to focus on cybersecurity challenges facing small and midsize businesses due to cybercriminals viewing them as gateways to larger enterprises. Thus, the best strategy for minimizing costs for all organizations is prevention through investment in systems designed and proven to be secure.

IBM i on Power Systems has built a reputation as a highly integrated and secure system. Malware infection and security incidents are rare for IBM i users, due to object-based architecture and sophisticated tools for monitoring and logging. Organizations that configure systems for maximum security and follow best practices as recommended by IBM, enjoy high levels of protection.

IBM i's unique object-based architecture provides isolation and malware resistance for business-critical systems. Objects, such as data and code, are encapsulated in a container that dictates what it can do, and who can access it. This architecture resists malware by scrutinizing containers to ensure the objects inside are not disguised as something else. This is done constantly and automatically, providing real-time protection against viruses masquerading as files. By placing strict controls on data as well as system code, using containers makes it extremely difficult for unauthorized instructions to execute. Intrusion detection compliments the object-based architecture by gathering information on unauthorized access attempts made over TCP/IP.

The security features offered by IBM i on Power Systems enable the platform to be highly securable, as demonstrated by the statistics collected by the National Institute of Standards and Technology (NIST) National Vulnerability Database (NVD). Table 1 summarizes vulnerability data reported for IBM i, Red Hat Enterprise Linux (RHEL), SUSE Linux Enterprise Server (SLES), Oracle Linux (OL), and the Windows Server operating systems.

IBM i MODERNIZATION

The IBM i operating system has been refined over many years from its earliest days driving AS/400 servers as a fully integrated, business application data processing environment. Its design is built around an object-based kernel, which manages all resources and processes using elemental object

definitions and permission sets. Because its kernel is coded to automate access, organization, and administration of all storage resources through its unique single-level storage design, manual database and application data administration requirements are minimal (Figure 6). In addition, high levels of configuration flexibility are easily achieved, and scaling out is accommodated without significantly impacting operations.

This ability to manage objects across physically dispersed storage devices—enabling parallel I/O actions to increase system performance, for example—automatically supports IBM i's integrated Db2 database actions, other application operations, as well as partitioned Linux and/or AIX co-hosted environments and applications.

Another core element responsible for IBM i's hardware independence, and perhaps the most essential design characteristic enabling industry-leading performance and security standards over the years, is the *Technology Independent Machine Interface* (TIMI). Regardless of how disruptive underlying hardware innovations have been, TIMI acts as a virtual instruction set with which applications interact. TIMI is independent of the underlying CPU instruction set, and allows users to update underlying hardware platforms without recompiling application software. There are no Windows or Linux equivalents to IBM i's single-level storage or TIMI architectural layers.

Inherent Security and Malware Protections

IBM i's object-based design reinforces the efficiency of integrated security functions within compiler, directory server, and object-based file system structures. Achieving comparable security results within Windows- and Linux-based environments calls for separate software tools and subsystems. The implementation and administrative management of security alternatives in these environments adds coding and processing layers as well as manual maintenance and monitoring routines.

IBM i also contains a full IP security suite, including support for the principal industry security standards and encryption techniques, and employs extensive access control and audit facilities. Single sign-on is

TABLE 1: Comparative Operating System Vulnerability Data—January 2008 through March 2017

CVSS SEVERITY LEVEL	Windows Server			Red Hat Enterprise Linux Server (RHEL)		SUSE Linux Enterprise Server (SLES)		Oracle Linux (OL)		IBM i			
Version *Release date*	*2008* *Feb '08*	*2012* *Oct '12*	*2016* *Oct '16*	*6* *Nov '10*	*7* *Apr '14*	*11* *Mar '09*	*12* *Oct '14*	*6* *Feb '11*	*7* *Jul '14*	*6.1* *Apr '08*	*7.1* *Apr '10*	*7.2* *May '14*	*7.3* *Apr '16*
Critical	2	4	1	11	9	1	2	12	10	0	0	0	0
High	725	296	66	76	50	10	34	51	65	1	1	0	0
Medium	257	117	28	53	58	24	39	26	58	0	0	0	0
Low	47	59	3	4	18	2	6	1	13	0	0	0	0
TOTAL VULNERABILITIES	1,031	476	98	144	135	37	81	90	146	1	1	0	0

SOURCE: Quark + Lepton (August 2017), NIST Computer Security Division, National Vulnerability Database, CVSS Metrics Versions 2 & 3

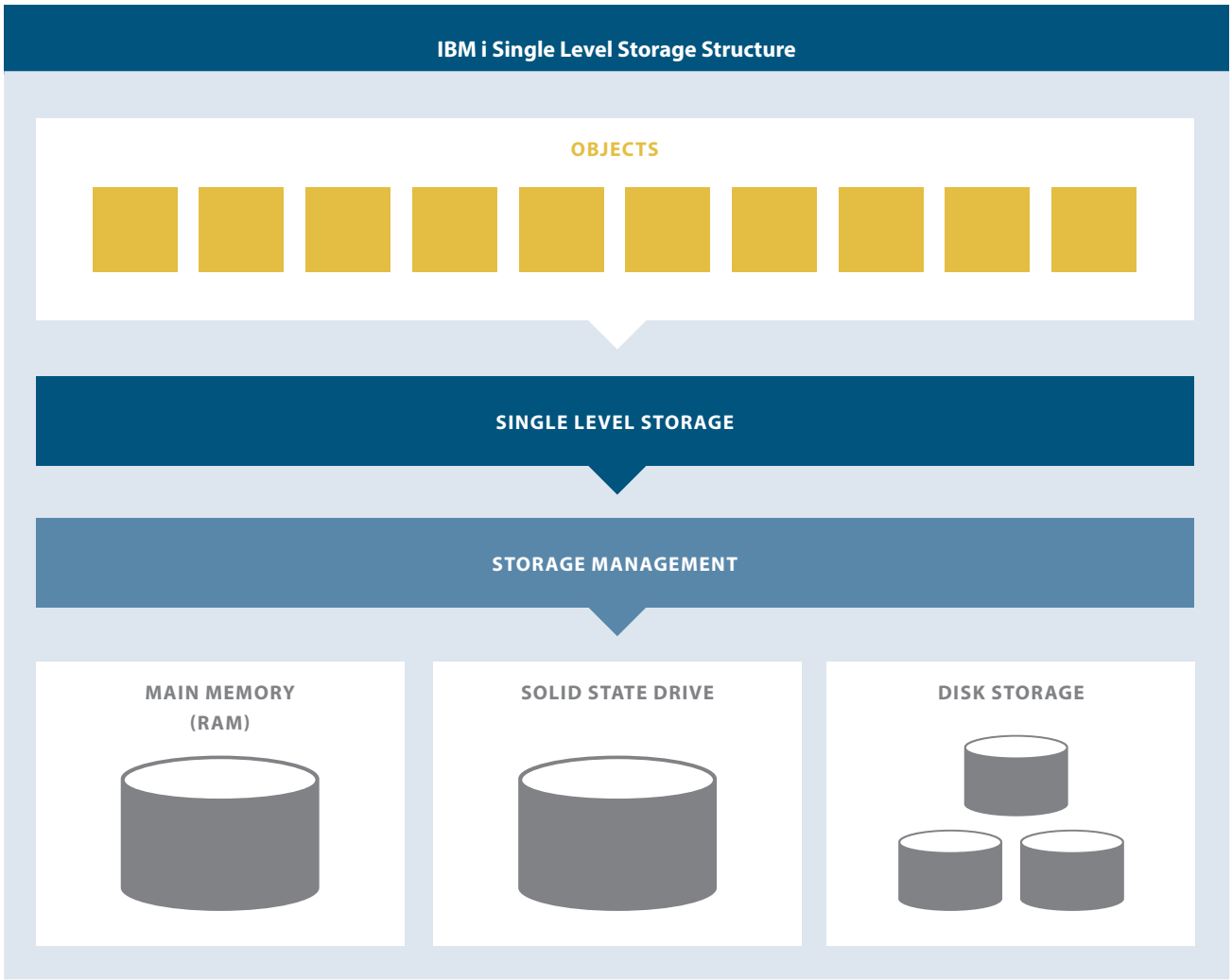
enabled using IBM Enterprise Identity Mapping (EIM), which maps user IDs across all middleware and application components.

Additionally, IBM i 7.3 is protected by a major enhancement known as the Authority Collection, which tracks object usage by applications and users, enabling administrators to optimize security and prevent intrusions by removing excess authority. This feature provides another layer of protection at a time when IBM i systems are increasingly supportive of Internet, social activity, and mobile connections.

Across all of its integrated storage, processing, and security automation structures, the most acknowledged benefit for business users is that system administration and DBA costs and planned downtimes for IBM i environments are lower than for either Windows or Linux mission-critical business application environments.

Three integrated system features further minimize risks of data loss in the event of an IBM i unplanned outage. These include 1) kernel-based independent auxiliary storage pools (IASPs)—a collection of

FIGURE 6: IBM i Single Level Storage Structure



SOURCE: Quark + Lepton (August 2017)

storage units that can be brought online or taken offline and kept independent of the rest of the data on a storage system that is connected to IBM i; 2) Remote Journaling—file and system changes that may be automatically copied to a second server; and 3) Save While Active—backups that may be performed without taking systems offline.

Open Source and Development Ready

IBM i incorporates the full function SQL-compliant Db2 database, along with full suites compliant with the latest Internet and mobile standards. A wide range of development languages are supported for new or RPG-asset leveraging software projects, including C/C++, Java (JTOpenLite for mobile devices), PHP, XML, IBM Rational Enterprise Generation Language (EGL), and others.

Numerous open source products—including Node.js, Git, Orion, Python, Apache Web Server, Apache Spark, Apache Kafka, Zend, MySQL and SugarCRM—are available on IBM i in response to user demand. IBM continues to invest heavily in the RPG, COBOL and CL languages in addition to the wide range of application modernization tools are offered by IBM and ISV Partners.

IBM policy on IBM i technology upgrades is distinctive. As a general principle, IBM introduces new IBM i releases every two to three years and Technology Refreshes (TRs)—which may be applied in a simple and non-disruptive manner—twice each year. This approach, which was widely requested by customers, avoids the disruptions caused by frequent version migrations. The IBM policy also contributes to higher availability levels. Unplanned downtimes, as well as an increased risk of severe outages, are more frequent following operating system, database, or hardware migrations within less well integrated environments.

Cognitive Computing and High Performance Analytics

IBM's Watson platform has garnered attention in recent years for its AI and cutting-edge machine learning capabilities. Available through IBM's Bluemix cloud platform for IBM i users, Watson products such as Discovery, Conversation, Knowledge Studio, and Virtual Agent help transform businesses through identification of insights in unstructured data as well as deployment of intelligent virtual agents.

Watson's innovative search and analytics functionality can merge traditional data with other data sources, such as data from social media, to extract insights previously not discoverable by standard search features used by small and midsize organizations.

For example, a prominent IBM i customer, in the online travel booking industry, is benefiting from Watson's natural language processing capabilities by offering users more intuitive ways to carry out searches.

Another IBM i organization, a consumer products distributor, has reported success integrating and leveraging Watson's services through Bluemix. Using Db2 Web Query for i and data migration tools, the customer was able to retrieve and integrate data from various other databases, including SQL and Oracle. Through Db2 Web Query and Bluemix, Watson's features were then used to perform high-performance predictive analytics on the consolidated data.

Watson's predictive analytics capabilities can help many industries streamline operations by using data such as historic sales, demographics, weather, and other public information to make the most informed decisions.

HARDWARE ADVANCEMENTS

Power Systems, since their introduction in 2008, have been designed to handle enterprise-class workloads requiring high levels of performance and scalability. The latest IBM POWER8 processor-based systems deliver significant advances over previous generations. Processor performance is accelerated, up to eight threads per core are supported (compared to four on POWER7+-based systems and two on Intel x86 servers), and memory and I/O features are upgraded to support faster throughput. The latest POWER8-based servers can be easily added to clusters of earlier Power Systems to deliver highly granular, real-time virtualization even under demanding, high-volume production conditions.

IBM offers a variety of pricing options for IBM i on Power Systems. Solution Editions, which are customized for several dozen industry-specific and cross-industry ISV offerings, bundle hardware, software, and services into packages that reduce overall costs of included solutions significantly. Pre-configuration and testing conducted by IBM to meet individual customer requirements also enables more rapid and cost-effective deployment.

Performance Optimization

The industry-leading performance of Power Systems is a function, not only of POWER processors, but also of close optimization at all levels of design and implementation. Key capabilities include highly effective compiler acceleration; chip symmetric multithreading (SMT); low levels of symmetric multiprocessing (SMP) overhead; and on-chip memory acceleration and compression technologies.

Along with a POWER8 processor increase in the number of cores to eight, a hardware-based transactional memory feature accelerates high-volume parallel applications, and a Coherent Accelerator Processor Interface (CAPI) enables higher-bandwidth CPU access from specialized co-processors. On-chip accelerators also provide high-speed encryption and compression capabilities to speed operations that would otherwise utilize CPU resources.

Mixed Workload Management

Features such as intelligent threading and intelligent cache adjust numbers of threads and cache configurations respectively to more efficiently execute workloads. Parameters may be set automatically or by system administrators.

The combination of the IBM i fully-integrated, data processing operating system running on IBM Power Systems server hardware pairs generations of interconnected hardware, firmware, and software system and subsystem designs. Inter-relational mechanisms that control how processors, cores, threads, cache, main memory and I/O, multiple types of partitions, multiple threads, and dedicated or pooled processors work together to execute different types of computational workloads is sometimes referred to as intelligent automation or autonomic computing. By designing with this end in mind, IBM i running

on Power Systems leverages this wide range of processing variables with higher levels of granularity and flexibility than competitive platforms.

PowerVM Virtualization

PowerVM, by delivering highly granular combinations of hardware- and software-based partitioning, is one of the industry's most sophisticated virtualization architectures. Hardware-based LPARs (logical partitions) isolate workloads more effectively than software-based partitioning techniques, and provide additional security functions. Native (bare-metal) hypervisor technology delivered in firmware like PowerVM is not supported on Windows or x86 Linux servers.

PowerVM also allows AIX and Linux to run in partitions on the same physical system as IBM i. Linux support has allowed IBM i users to deploy Internet and intranet infrastructures, along with open source applications, on Power Systems that host core business systems running on IBM i.

PowerVM also provides memory and I/O virtualization features. The Active Memory Sharing (AMS) feature of PowerVM enables dynamic sharing of memory resources amongst VMs on the same server. PowerVM's Virtual I/O Server (VIOS) is a unique VM that virtualizes I/O resources to allows other VMs to share physical adapters, eliminating the need for dedicated I/O adapters. VIOS also allows VMs to share a pool of virtualized storage. VMware, Hyper-V, and other x86-based hypervisors either do not provide these capabilities, or only provide limited support.

Partitioning creates the potential for high levels of capacity utilization. However, the extent to which this occurs in practice depends on mechanisms that allocate, monitor, and control workload execution processes and system resources across partitions. If these mechanisms are not effectively configured, a high proportion of system capacity may be idle over time.

To avoid the risk of bottlenecks, administrators may tend to operate partitioning systems at well below capacity. These factors explain why, in many organizations, use of x86 hypervisors falls short of their architectural potential. Power Systems enable higher workload densities.

In addition, firmware- and hardware-managed reliability, availability, and serviceability (RAS) features in Power Systems are among the most sophisticated in the industry today. Comparable features may be found in x86 servers in some cases. However, the microelectronics technology in Power Systems is more advanced, and has set Power Systems apart with a longer track record of stable and effective operation.

Detailed Data

The cost comparisons presented in this paper are based on the installations, server configurations, and FTE staffing levels summarized in Table 2. Detailed costs are summarized in Table 3.

Estimated costs were based on industry standard metrics and industry specific factors of consideration:

- **Health products distributor.** Costs of downtime include lost sales due to inventory shortages; inability to process customer queries and orders and related effects; supply chain disruption costs; underutilization of labor and capacity; product rejection and lost revenue due to equipment error;

and noncompliance penalties. Due to the time sensitive nature of certain health and pharmaceutical products in relation to patient demand and product shelf life, downtime experienced by manufacturers and distributors can cause significant harm to customers as well as the brand.

Costs may also include remedial actions such as product recalls and marketing costs.

- **Industrial distributor.** Costs of downtime include lost sales due to inventory shortages; inability to process customer queries and orders and related effects; and supply chain disruption costs, including the same components as for the automotive parts manufacturer and retail chain.

  Costs of downtime for customer and partner clouds were divided between both categories, and comparable costs for mobile sales applications were included in lost sales.

TABLE 2: Installations and Scenarios Summary

HEALTH PRODUCTS DISTRIBUTOR	INDUSTRIAL DISTRIBUTOR	SPECIALTY RETAILER
Business Profile		
Health & cosmetic products distributor $500 million sales 500 employees 3 distribution centers	Specialty industrial distributor $300 million sales 650 employees 10 distribution centers	$300 million sales 1,500 employees 250 stores 2 distribution centers
Applications		
ERP/CRM, query & reporting *Data warehouse: product performance, customer relationship, sales & supplier analysis; sales & operations planning, revenue planning, promotions management* *Mobile sales & customer service* *Social media merchandising & marketing*	CRM, order management, finance, HR, supply chain, & e-commerce *Distribution analytics system* *Sales & talent management clouds* *Mobile sales* *Social media marketing*	Core retail / merchandising, supply chain, finance, HR, Web & wireless *Retail analytics, workforce management & supplier clouds* *Mobile point of sale* *Social media customer engagement, merchandising & marketing, online product / inventory data & sales*
Number of Users		
300	350	400
PLATFORM SCENARIOS		
IBM i 7.3 / Power Systems		
Power S814 8-core 3.6 GHz IBM i 7.3, PowerVM *0.3 FTE*	Power S814 8-core 3.6 GHz IBM i 7.3, PowerVM *0.3 FTE*	2 x Power S814 6-core 3 GHz IBM i 7.3, IASPs, PowerVM *0.45 FTE*
Windows / SQL Server		
4 x 2/8 x 2 GHz Windows Server 2016 with Hyper-V, SQL Server 2016 AlwaysOn *0.5 FTE*	2 x 2/8 x 2.5 GHz; 2 x 2/8 x 2 GHz Windows Server 2016 with Hyper-V, SQL Server 2016 AlwaysOn *0.55 FTE*	4 x 2/8 x 2.5 GHz; 2 x 2/16 x 2.6 GHz Windows Server 2016 with Hyper-V, SQL Server 2016 AlwaysOn *0.95 FTE*
x86 Linux / Oracle		
4 x 2/8 x 2 GHz Linux, Oracle Database 12c R2 *0.55 FTE*	2 x 2/8 x 2.5 GHz; 2 x 2/8 x 2 GHz Linux, Oracle Database 12c R2 *0.6 FTE*	4 x 2/8 x 2.5 GHz; 2 x 2/16 x 2.6 GHz Linux, Oracle Database 12c R2 *1.05 FTEs*

Continued on next page

Values were based on user input as well as published material such as financial reports and presentations.

- **Specialty retailer.** Costs included lost sales; supply chain disruption (including the same components as for the automotive parts manufacturer); and selling, general and administrative (SG&A) costs including reordering, restocking, and (in storefront outlets) display changes.

TABLE 2 (CONTINUED): Installations and Scenarios Summary

DISCRETE MANUFACTURER	PROCESS MANUFACTURER	AGRIBUSINESS
Business Profile		
Industrial machinery & components manufacturer $600 million sales 2,500 employees 5 manufacturing & distribution centers	Food & beverage manufacturer $1 billion sales 2,000 employees 6 manufacturing plants	$1.65 billion sales 5,000 employees 10 production & distribution centers
Applications		
ERP, supply chain, e-commerce *Analytics: demand forecasting & planning; customer, sales, inventory, procurement, cost & productivity analysis, quality management* *Sales & CRM cloud* *Mobile sales* *Social media marketing*	ERP, CRM, supply chain, e-commerce, departmental *Analytics: demand forecasting, revenue planning; customer, product sales & merchandising analysis; financial analysis; traceability & other applications* *Marketing, sales & other collaborative applications (IBM Connections network* *Mobile/online consumer engagement, promotions and coupons* *Social media marketing & research*	ERP, procurement, e-commerce, EDI *Analytics: 30+ business & compliance applications* *CRM, procurement, talent management & warehouse management clouds* *Mobile e-commerce extensions*
Number of Users		
600	500	1,200
PLATFORM SCENARIOS		
IBM i 7.3 / Power Systems		
2 x Power S814 8-core 3.6 GHz IBM i 7.3, IASPs, PowerVM *0.65 FTE*	2 x Power S824 8-core 4.1 GHz IBM i 7.3, IASPs, PowerVM *0.6 FTE*	4 x Power S824 8-core 4.1 GHz IBM i 7.3, IASPs, PowerVM *1.0 FTE*
Windows / SQL Server		
6 x 2/12 x 2.6 GHz; 3 x 2/16 x 2.3 GHz Windows Server 2016 with Hyper-V, SQL Server 2016 AlwaysOn *1.25 FTEs*	6 x 2/12 x 2.6 GHz; 2 x 2/16 x 3.3 GHz Windows Server 2016 with Hyper-V, SQL Server 2016 AlwaysOn *1.2 FTEs*	2 x 4/40 x 2.2 GHz; 8 x 2/16 x 2.3 GHz; 2 x 2/12 x 2.6 GHz Windows Server 2016 with Hyper-V, SQL Server 2016 AlwaysOn *2.5 FTEs*
x86 Linux / Oracle		
6 x 2/12 x 2.6 GHz; 3 x 2/16 x 2.3 GHz Linux, Oracle Database 12c R2 *1.2 FTE*	6 x 2/12 x 2.6 GHz; 2 x 2/16 x 3.3 GHz Linux, Oracle Database 12c R2 *1.3 FTE*	2 x 4/40 x 2.2 GHz; 8 x 2/16 x 2.3 GHz; 2 x 2/12 x 2.6 GHz Linux, Oracle Database 12c R2 *2.0 FTEs*

SOURCE: Quark + Lepton (August 2017)

Costs of downtime for mobile sales and social media marketing applications were included in lost sales.

- **Discrete and process manufacturer.** Costs included lost sales; idle and underutilized capacity; handling of delivery delays; additional inventory carrying; procurement, production, and logistics process changes; customer billing and payments delays; late delivery and imperfect order penalties; and remedial actions such as rebates and discounts required to win back customer business.

  Costs were divided between inbound supply chain and production disruption, consisting of costs incurred between supplier queries and factory release; and outbound supply chain disruption, consisting of costs incurred between factory release and customer delivery.

TABLE 3: Three-year IT Costs Breakdown

COMPANY	CONSUMER PRODUCTS DISTRIBUTOR	INDUSTRIAL DISTRIBUTOR	SPECIALTY RETAILER	DISCRETE MANUFACTURER	PROCESS MANUFACTURER	AGRIBUSINESS
IBM i 7.3 / POWER SYSTEMS						
Hardware	20,556	20,556	41,112	41,112	69,045	82,610
Software	73,568	73,568	110,352	147,136	147,136	294,272
Software support	16,185	16,185	24,277	32,370	32,370	64,740
Personnel	111,224	111,224	166,836	240,985	222,448	370,746
Facilities	4,263	4,263	9,932	9,932	11,532	13,121
TOTAL ($)	225,796	225,796	352,509	471,535	482,530	825,489
WINDOWS / SQL SERVER						
Hardware + maintenance	29,292	35,691	60,696	86,931	83,873	132,738
Microsoft software	47,617	45,633	102,683	138,320	169,044	289,575
Microsoft software support	35,713	34,225	77,012	103,740	126,783	217,181
Personnel	371,313	408,444	705,495	928,282	891,151	1,856,564
Facilities	7,860	9,746	10,845	22,893	30,493	43,536
TOTAL ($)	491,795	533,739	956,730	1,280,166	1,301,344	2,539,595
X86LINUX / ORACLE						
Hardware + maintenance	29,292	35,691	60,696	86,931	83,873	132,738
Oracle software	67,898	76,385	101,846	152,770	127,308	305,539
Oracle software support	44,812	50,414	67,219	100,828	84,023	201,656
Linux OS subscription	19,176	19,176	28,764	43,146	38,352	67,116
Personnel	450,798	491,780	860,615	983,560	1,065,523	1,639,266
Facilities	7,860	9,746	10,845	22,893	30,493	43,536
TOTAL ($)	619,836	683,191	1,129,985	1,390,127	1,429,573	2,389,852

SOURCE: Quark + Lepton (August 2017)

Categories correspond to the Source, Make, and Deliver segments of the Supply Chain Operations Reference (SCOR) model developed by the Supply Chain Council. Inbound supply chain and production disruption calculations include costs of scheduling, setup, and other production changes. Costs of downtime for the company's EDI cloud were included in inbound supply chain costs.

- **Agribusiness.** Costs included lost sales; delivery delays; inventory mismanagement; inaccurate production planning; mistiming of crops, leading to higher risk of failure and/or lower yields; waste of perishable materials and products; and inefficient usage of resources.

  Costs also include of remedial actions required to win back customer business as well as penalties incurred by noncompliance caused by system downtime.

  Downtime costs also take into account data center/IT infrastructure and personnel costs. Hardware and software costs were calculated based on use of latest generation technology. Facilities and personnel costs were based on national and industry averages.

- **Server costs** include hardware and software licenses, along with three-year maintenance and software support coverage. Maintenance and support costs are for 24/7 coverage. Calculations were based on vendor list prices discounted to reflect prevailing street prices.

  Power Systems were POWER8-based models with IBM i 7.3 and PowerVM Standard or Enterprise Edition. Branded x86 servers were equipped with current-generation Intel Xeon E5 or E7 processors.

  Windows servers were configured with Windows Server 2016 and SQL Server 2016 Enterprise Edition with AlwaysOn. Intel x86 Linux servers were configured with a major commercial Linux distribution including hypervisor and HA components, along with Oracle Database 12c Release 2 Enterprise Edition. Oracle configurations include Diagnostics and Tuning Packs providing functionality equivalent to that incorporated in IBM i 7.3, and Microsoft SQL Server 2016 at no additional charge.

- **Personnel costs** were calculated based on annual average salaries of $86,000 for IBM i 7.3 and Power Systems administrators handling database as well as system administration tasks; $71,564 and $86,843 for Windows and x86 Linux system administrators respectively; and $100,699 and $103,283 for SQL Server and Oracle DBAs respectively.

  Salaries were increased by 47.3 percent to allow for benefits, bonuses, training, and other personnel-related items. Overall costs were calculated for a three-year period.

- **Facilities costs** include data center occupancy and energy consumption by servers as well as by power, cooling, and other data center infrastructure equipment supporting these. Energy costs were calculated using a conservative assumption for average price per kilowatt/hour (kWh) to determine three-year costs.

Conclusions

IBM i is designed to provide a simple, reliable, secure, and easy-to-administer platform for core business systems. User experiences confirm that it has these characteristics, and IBM i enjoys the highest customer loyalty of any major platform.

At a time when the IT industry trends toward ever-greater complexity, IBM i on Power Systems offers a simple, cost-effective platform upon which to anchor a diverse organizational IT infrastructure. IBM i's ten-year support roadmap complements the RAS features of Power Systems to create a secure, resilient platform with a loyal user base. Simple yet robust system and software architectures contribute to ongoing cost savings and return on investment (ROI), while automated maintenance and security features allow companies to focus on improving business. In addition, updates through Technology Refreshes satisfy customers' wants and requirements, and maintain IBM's dedication to user support.

The value and impact of IBM i strengths increase as midsize organizations move to adopt and integrate next-generation technologies. All channels through which businesses interact with customers and business partners, and all mechanisms through which companies make decisions or apply and compete operational processes, typically require 24/7 availability, credible security, and high levels of cost-effectiveness. IBM i on Power Systems demonstrates an integrated and intelligent approach to satisfying the evolving IT requirements of midsize businesses.

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Ponemon Institute's 2016 Cost of Data Center Outages found at datacenterfrontier.com/white-paper/cost-data-center-outages/

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