Enhancing systems integration by incorporating business continuity drivers

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Abstract

Purpose – The purpose of this paper is to present a framework for developing an integrated operating environment (IOE) within an enterprise information system by incorporating business continuity drivers. These drivers enable a business to continue with its operations even if some sort of failure or disaster occurs.

Design/methodology/approach – Development and implementation of the framework are based on holistic and top-down approach. An IOE on server's side of contemporary business computing is investigated in depth.

Findings – Key disconnection points are identified, where systems integration technologies can be used to integrate platforms, protocols, data and application formats, etc. Downtime points are also identified and explained. A thorough list of main business continuity drivers (continuous computing (CC) technologies) for enhancing business continuity is identified and presented. The framework can be utilized in developing an integrated server operating environment for enhancing business continuity.

Originality/value – This paper presents a comprehensive framework including exhaustive handling of enabling drivers as well as disconnection points toward CC and business continuity.

Keywords Integration, Systems analysis, Business continuity, Computer hardware

Paper type Conceptual paper

1. Introduction

The term, "business continuity" (business continuance, business resilience) refers to the ability of a business to continue with its operations even if some sort of failure or disaster occurs. Several factors affect the level of BC such as:

- data availability;
- application availability;
- networking reliability;
- operating system's reliability, availability and scalability; and
- server hardware reliability, etc.

To be truly competitive in today's information era, the business should be able to operate continuously, maintain data available all the time, and be agile in accessing available data.

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With recent advances in information technology (IT) including the internet and e-business technologies, the need for achieving business continuity based on continuous computing (CC) technologies became even more critical. Therefore, business continuity management (BCM) should be an essential part of any contemporary organization's information management. BCM involves several measures and activities that have to be planned in order to have higher availability ratios of an information system. Most of these measures and activities are inter-dependent, hence an integrated solution is needed.

A framework for developing an integrated operating environment (IOE) for business continuity was developed and is presented in this paper. The primary goal of such integration is to enhance the levels of enterprise information systems' availability, reliability and scalability, thus, to achieve CC as a main prerequisite toward business continuity. Important components of the framework are a set of CC drivers (enablers) and the features of contemporary servers and server operating systems (SOS) that need to be integrated.

The paper is organized as follows. Section 2 presents a summary of current research on systems integration, system development and business continuity and a brief literature review. Section 3 identifies and discusses main issues in systems integration including main disconnection problems and downtime points. Section 4 presents a framework for integrating business continuity drivers for enterprise information system architecture. The paper concludes with Section 5.

2. Systems integration and business continuity

2.1 Systems integration and system development

The term, "systems integration" is relatively new in IT discipline as it emerged some 15 years ago (Henderson, 1994; Hodge, 1989; Varney, 1996; Wyse and Higgins, 1993). In its narrow sense, the systems integration is concerned primarily with technical integration problems that may occur within and between several information resources such as:

- mono-functional systems and devices;
- operating systems;
- communication-networking protocols;
- applications; and
- data.

These problems are mainly solved by developing specific hardware and software solutions that integrate different platforms. Other frequently used solutions are multi-functional systems and devices, integrated desktop applications, and integrated enterprise-wide systems such as enterprise resource planning (ERP), supply chain management (SCM), customer relationship management (CRM), business intelligence, integration protocols, middleware products and integrated systems management products.

Published research articles on general aspects of systems integration tend to focus on both or one of data integration and application integration. Sage and Lynch (2004) provide an overview of principles, practices, and perspectives of systems integration and systems architecting. Irani *et al.* (2003) propose a framework for implementing enterprise application integration (EAI) techniques in order to bridge weaknesses of traditional life cycle as one of the most frequently used IS design methodology. Rousset and Reynaud (2004) focus on the use of knowledge representation techniques for building mediators for information integration. Wainwright and Waring (2004) define four domains of integration: technical, systems, strategic, organizational. The first three domains are mainly considered in the systems integration literature. Therefore, they put forward strategic model for implementing integrated IS which incorporates an organizational domain. Erasala *et al.* (2003) define EAI drivers as main factors driving the use of EAI in organizations: e-commerce, mergers and consolidations, ERP packages. Peak *et al.* (2005) present a case study in IT alignment planning. Robb (2005) discusses several aspects of the integration projects and emphasizes the fact that integration is an ongoing process as software is updated and business processes change. Phusavat and Jaiwong (2008) used the balanced scorecard method for linking and integrating of time lag effects and the development of a strategy map. Chen and Dwivedi (2007) proposed a novel conceptual model on integration technologies adoption between SMEs and large companies.

Gunasekaran and Ngai (2004) develop a framework for studying information systems in supply chain integration and management. Coughlan *et al.* (2005) discuss the business-IT relationship. Oglesby (2005) define the six pillars of IT alignment namely: strategy, organization, applications, infrastructure, projects, and governance. Versteeg and Bouwman (2006) define the main elements of a business architecture as business domains within the new paradigm of relations between business strategy and ITs. Gulledge (2008) proposes a holistic approach in the field of enterprise integration called architecture-driven enterprise integration by focusing on business process management as the key element in achieving total enterprise integration.

The ultimate systems integration needs to address organizational problems that occur between IT subsystem and the rest of organization. For example, implementing an ERP system is a widely accepted solution to achieve an integrated enterprise information system. The ERP implementation requires many technical undertakings such as client-server setting, networking protocols, construction of master data, configuration of an ERP software, etc. However, an equally important aspect of this kind of systems integration is the re-engineering part of the organization. Moon (2007) provides a comprehensive literature survey on ERP systems and their issues. Chakraborty and Sharma (2007) presented an integrated strategic framework for identifying parameters in achieving successful ERP implementations. Aerts *et al.* (2004) discuss several models of ICT platform architectures and their role in IS development while Budgen and Thomson (2003) present some empirical experiences related to computer aided software engineering tool evaluation.

Several authors considered the ways of integrating information system (IS) development and business process reengineering/total quality management projects (Attaran, 2004; Fok *et al.*, 2001). Specific aspects of IS modeling within the context of ERP projects are given by Somers and Nelson (2004) and Soffer *et al.* (2003). Ranganathan and Brown (2006) consider two kinds of organizational integration that are associated with information systems in general and ERP systems in particular: technical integration and business integration. Jonkerr *et al.* (2006) underscore the fact that in current business practice, an integrated approach to business and IT is indispensable. They define an enterprise architecture as “structure with a vision”. Such an architecture provides an integrated view of the system being designed or studied.

Goethals *et al.* (2006) argue that enterprises are living things, they constantly need to be re-architected in order to achieve the necessary agility, alignment and integration. Gulledge (2006) provided a comprehensive explanation of the question "what is integration?" by introducing and exploring two types of integration: one called "Big I" and the other "Little i" in "integration" as a term. Other aspects of the system integration are addressed by various researchers. For example, issues with the selection and deployment of different IS design methodologies are explored by Huisman and Livari (2006) and Li and Chen (2001). IT-Business alignment issues are also addressed in more details by Bergeron *et al.* (2004), Marble (2003), Peak *et al.* (2005), Burn and Szetob (2000) and Wu *et al.* (2004a, b).

2.2 System downtime, economics of downtime, business continuity

According to a recent survey made by AT&T/Economist Intelligence Unit (Ernest-Jones, 2005) the principal risks of a breakdown in business continuity are given below:

- loss of revenue;
- loss of data;
- deterioration of brand;
- defection of customers;
- loss of shareholder value; and
- higher insurance costs.

Recent IDC Report (2006) indicates that priorities and spending intentions are aligned around the central theme of improving application availability and recovery from different failure types on increasing numbers of applications and services. According to this report it is not uncommon for availability and business continuity requirements to be published in a company's corporate goals. An emphasis is given also on a continued user productivity and connectivity, a platform in which the users remain seamlessly connected to critical applications and services.

However, not every business needs to have high-availability ratios such as 99.999 percent or even 99.99 percent for its mission-critical applications. It depends on the type of business. Therefore, an appropriate cost-benefits or return-on-investment analysis should be used before making decisions on increasing the levels of availability just because of the fact that the applications are mission-critical. Hill (2006) suggests not to equate high availability with high value when mission-critical applications are considered. Infonetics Research Report (2005) has revealed results of their study of five large organizations in North America in different vertical markets: finance, transportation and logistics, healthcare, manufacturing and retail. They proposed a metrics for revenues loss calculation and productivity loss calculation.

According to a survey done by the security services practice of Deloitte & Touche/TPM Report (2006), the number of companies that have developed formal BCM programs within the last six years has nearly tripled. According to this report, whereas just 30 percent of organizations had corporate business continuity plans in place six years ago, more than 83 percent of 273 survey respondents representing a cross section of industries say they now have formal business continuity plans.

2.3 Business continuity management

Business Continuity Institute (www.thebci.org) defined BCM as a holistic management process that identifies potential impacts that threaten an organization and provides a framework for building resilience with the capability for an effective response that safeguards the interests of its key stakeholders, reputation and value creating activities. Its primary objective is to allow the executive to continue to manage their business under adverse conditions, by the introduction of appropriate resilience strategies, recovery objectives, business continuity and crisis management plans in collaboration with, or as a key component of, an integrated risk management initiative.

Research papers on BCM focus either on frameworks or separate technologies that are used in order to improve the availability levels. Botha and von Solms (2004) proposed a cyclic approach to business continuity planning. Gibb and Buchanan (2006) defined a framework for the design, implementation and monitoring of a BCM program within the context of an information strategy. Pitt and Goyal (2004) see BCM as a tool for facilities management. Walker (2006) considers outsourcing options for business continuity. King (2003) introduced a term of "business continuity culture" and underscored the fact that "If you fail to plan, you will be planning to fail." Bertrand (2005) researches the relationships between business continuity and mission-critical applications. In their article, Herbane *et al.* (2004) examined the organizational antecedents of BCM and developed a conceptual approach to posit that BCM, in actively ensuring operational continuity, has a role in preserving competitive advantage. Butler and Gray (2006) underscore the question on how system reliability translates into reliable organizational performance. They identify the paradox of "relying on complex systems composed of unreliable components for reliable outcomes." Umar (2005) explored the role of several business servers in designing an IT infrastructure for "next generation enterprises." Williamson (2007) found that in business continuity planning, financial organizations are ahead of other types of businesses. Hepenstal and Campbell (2007) provide some insights on transforming Intel's worldwide materials organization from crisis management and response to a more mature BC approach. According to these authors, the BC-oriented approach improved Intel's ability to quickly recover from a supply chain outage and restoring supply to manufacturing and other operations. Craighead *et al.* (2007), considered business continuity issues within the supply chain mitigation capabilities and supply chain disruption severity. They proposed a multiple-source empirical research method and presented six propositions that relate the severity of supply chain disruptions. Stanton (2007) underscores the following saying "Fail to Plan, Plan to Fail". Bielski (2008) states that some think of business continuity as doing what is necessary to set up a "shadow" organization that will take you from incident response through various phases of recovery.

3. Issues in systems integration

3.1 Main disconnection problems

Two main groups of disconnection (alienation) problems on enterprise-wide level are:

(1) the organizational problems; and

(2) the technical problems.

The organizational problems refer to those that occur between IT (IS) subsystem and the rest of organization. In the past, information has become an organizational resource that has to be managed in an efficient and effective way just like any other resource. However, many organizations still keep these two managerial activities independently. They do not realize that neither financial nor marketing nor human resources management cannot be efficient and effective if there is no organization-wide information management. This is in particular important for contemporary business that requires CC platform that is in turn "conditio-sine-qua-non" for business continuance. Therefore, in modern business there is a need of integrating BCM into organizational management.

Four main disconnection points that causes the organizational problems are shown in Figure 1:

(1) Disconnection between organizational system and its IS. In general, there is a need for coordination between IS (IT) and the rest of organization. Sabherwal and Chan (2001) address the alignment between business and IS strategies as a widely believed approach to improve business performance. Ba *et al.* (2001) introduced the notion of "incentive alignment" as the third dimension in information systems design.

(2) With respect to organizational management, there is a need for integrating several aspects of information management into organizational management.

(3) Disconnection between IT (IS)-professionals and managers. Usually, they speak "different language" and most frequently "do not understand" each other (Wixom and Todd, 2005).

(4) Disconnection between managers and computers – "a fear" of computers. Computer-alienated managers resist IT adoption by refraining from using computers. Manager's IT knowledge (both computer and information literacy) and IT training level are closely associated with alienated beliefs and attitudes toward IT.

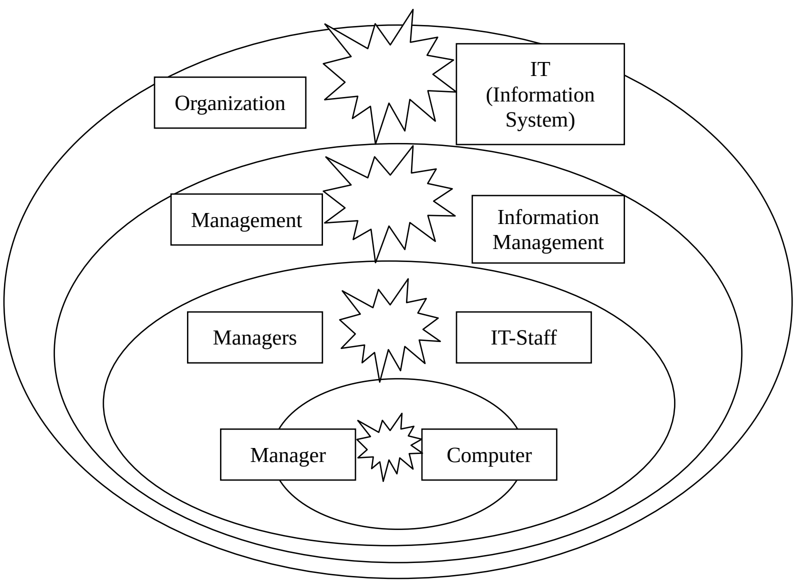

Figure 1.
Organization-IT gaps: major disconnection points

The technical problems are the ones that are related to hardware and software dimensions of integrating several systems and managing them (components, devices, hardware and software protocols, data formats, program libraries, applications, languages, operating systems, networks, etc.). Disconnection problems can be identified on several points within today's dominantly used client-server platforms, both on server side and client-desktop side (Figures 2 and 3).

3.2 Identifying downtime points

Both server and desktop (client) side within today's dominant client-server architecture contain several disconnection points where some sort of integration, connectivity or interoperability is needed. On the server side which is run by SOS, the following areas are most frequently identified as major disconnection and "must-have-integration" points: SOS and server hardware components, SOS and application protocols, SOS and data communications protocols, SOS and application development tools, SOS and desktop operating system (DOS), SOS and server-based application suites, SOS and portable devices, client-server applications and legacy applications, SOS and storage hardware/software. On the desktop (client) side, the integration is needed between DOS and the following components: DOS and desktop's hardware components, DOS and application protocols, DOS and data communications protocols, DOS and application

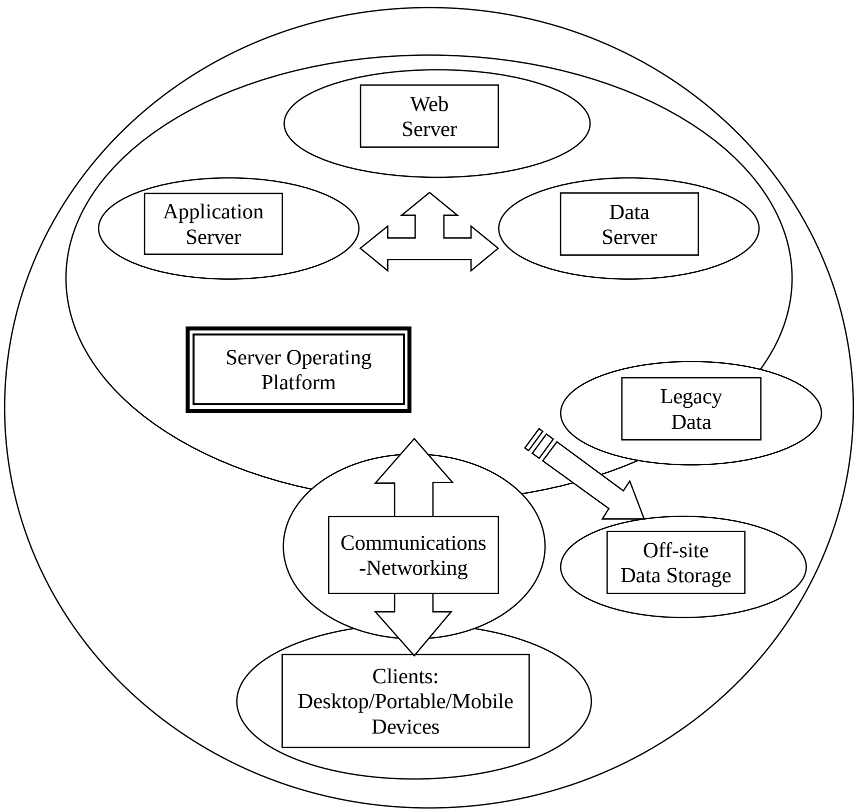

Figure 2.
Disconnection points within C/S platform

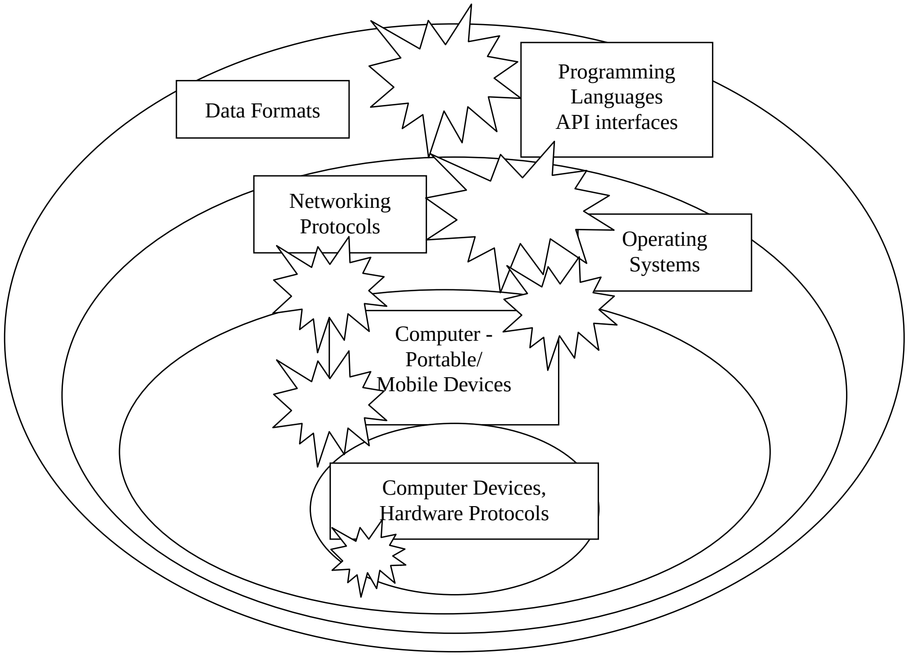

Figure 3.
Major disconnection points – hardware/software level

development tools, DOS and SOS, desktop and portable devices, desktop and legacy applications, and so on.

No matter which c/s model is implemented, some most commonly used layers of the c/s architecture can be identified as follows (Figure 4):

- *Client layer*. Client application (can be "thick" or "thin", depending on the type of client-server architecture that is implemented).
- *Networking layer*. A layer that includes a number of different data communication devices, media, communication protocols and network software.
- *Server operating platform layer*. A layer that is consisted of one or more servers (data, application, web, messaging, firewall, etc.) accompanied with SOS and integrated serverware solutions.
- *Data storage layer*. A layer that contains several data storage, data backup and recovery solutions intended to be used for primary and secondary data storage.

When one of these servers running mission-critical applications is not reachable, for any reason, this can be considered as system downtime. In addition, whenever end-users have no access to the application, again for any reason, it can also be considered as some sort of downtime.

Having in mind such a kind of infrastructure, a number of critical points at which a downtime may occur can be identified with regard to possible downtime problems (Figure 5):

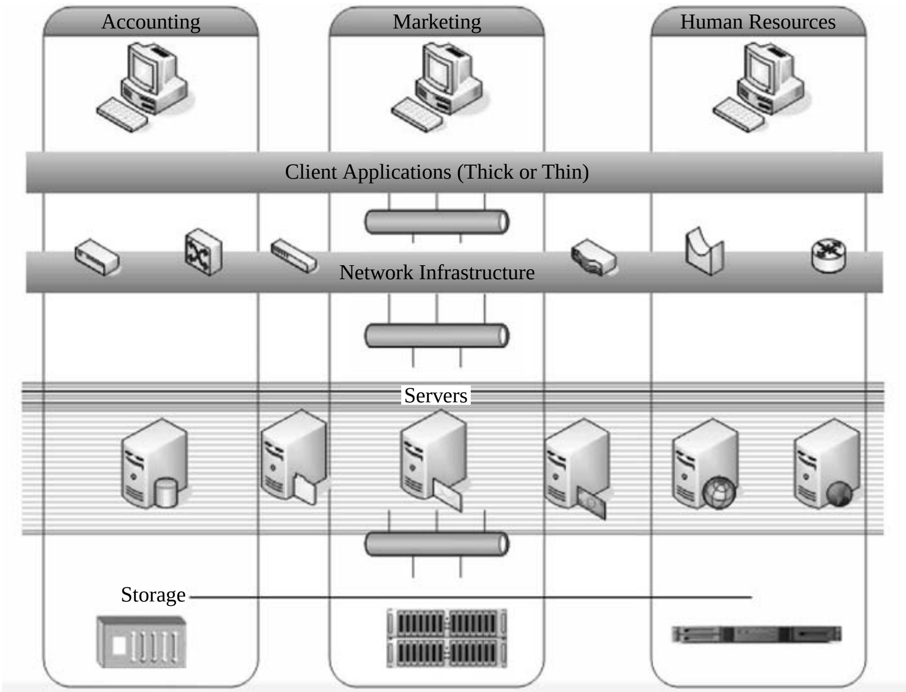

Figure 4.
Client-server infrastructure layers and components

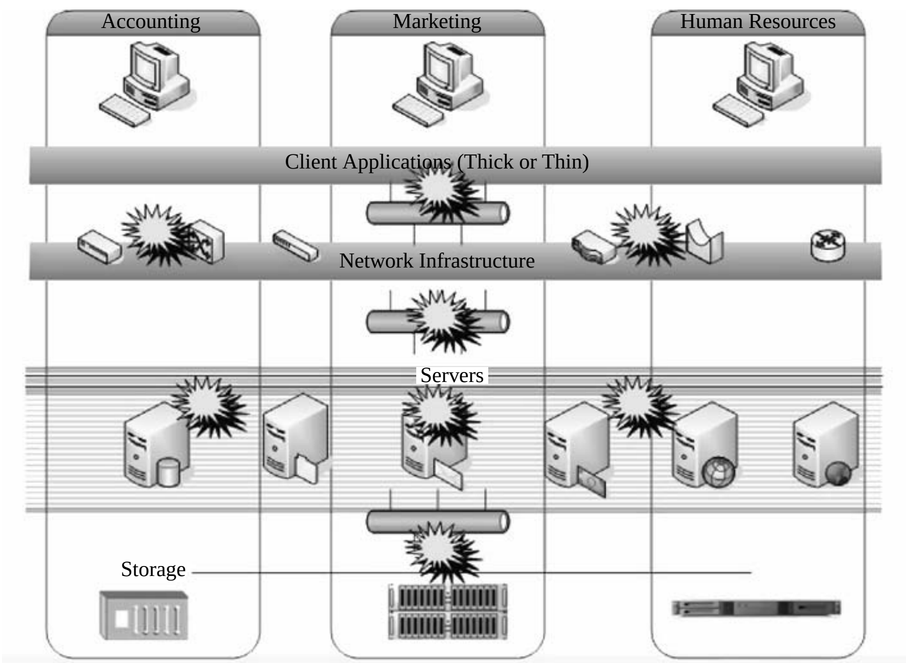

Figure 5.
Client-server infrastructure components and possible downtime points

- hardware conflict or glitch on a client PC;
- problems with DOS;
- problems with client application;
- LAN/WAN/internet-related problem which causes disconnection from servers and other resources;
- server operating platform-related problems (dump on core operating system, application protocol, library, networking protocol, security intrusion, etc.); and
- data storage (hard disk crash, file or file system corruption, magnetic tape broken, etc.).

These downtime points are considered as critical points in creating CC solutions for enhancing business continuity.

4. Integrating business continuity into server operating environment

4.1 Framework for integration

Critical factors required for achieving the business continuity in information age are high levels of application/data availability, reliability and scalability. The availability is a term that describes the ability of a system (operating system, application, or network) to continue with its operation despite of hardware/software failures, sometimes due to natural disasters. The reliability is the ability of a system to adapt to outages by hardware components such as CPUs, memory, storage, and I/O adapters. Also, the reliability includes the system's resiliency functions that help in operating system crashes such as kernel dump facilities, dump analysis tools, automated hang detection, etc. The scalability is the ability of an OS platform to support the following features: 64-bit capabilities, SMP capabilities – the ability to take advantage of multiple processors, storage scalability, and clustering capabilities.

Business continuity which is enabled by CC solutions is a way of doing business in information age and is characterized by:

- continuous data processing with high-availability ratios;
- availability of continuous, reliable and secure data to internal members of an enterprise (for example, ERP systems);
- easy, continuous, reliable, secure, and company-wide data access from end-users' computing devices (decision makers, other knowledge workers, clerical staff);
- continuous, reliable, and secure data access from customers and/or suppliers within CRM/SCM application platforms;
- multi-platform data access, including support for all commonly used computing devices (desktops, portable computing devices, mobile phones); and
- better decisions through better access to business-critical information wherever and whenever required.

A conceptual model to illustrate the concepts of business continuity, CC and enabling technologies is shown in Figure 6. It is based on Churchman's (1968) systems approach philosophy. This model is then re-shaped into "the onion model" of high availability information architecture (Figure 7).

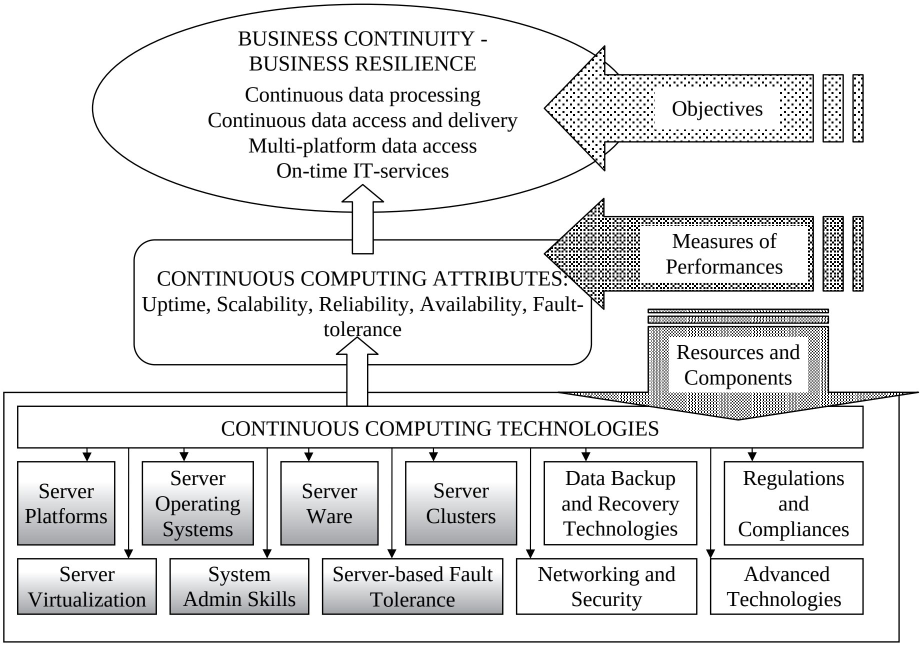

Figure 6.
A systemic model of business continuity, CC and continuous computing technologies

CC technologies as identified in the previous figures are considered as business continuity drivers having in mind their role in assuring a CC as a main prerequisite for business continuity. This set of ITs include several IT-based solutions that can be implemented in enhancing CC ratios such as availability, reliability, scalability, etc.

4.2 Integrated operating platform – server operating platforms

Server platforms consisting of servers, SOS and extended SOS capabilities are crucial components in business continuity. Such platforms are of special interest for businesses that rely on "always-on" computing environments such as banks and other financial institutions, airline reservation systems, point-of-sale systems, dispatching systems, online shops, etc. The server platforms in such computing environments must be reliable, available and scalable so that server-based applications run with high reliability, availability, and scalability ratios. Ideally they should achieve zero-downtime/100-percent uptime. In addition, they are expected to provide other types of services such as internet-web technology services, directory services, security services, and remote access capabilities including support for mobile computing.

Today's business computing is mainly based on client/server architecture and its several modifications (thin/thick, two-tier/three-tier). Server's side of such architecture in its broader sense is called server operating environment. It consists of standard server-based and CC technologies that are used to enhance key server platform characteristics (e.g. high levels of data/application servers' reliability, availability, and scalability). In the context of commercial hardware/OS platform, the availability of a SOS is expressed in terms of "nines" which determine the system's uptime.

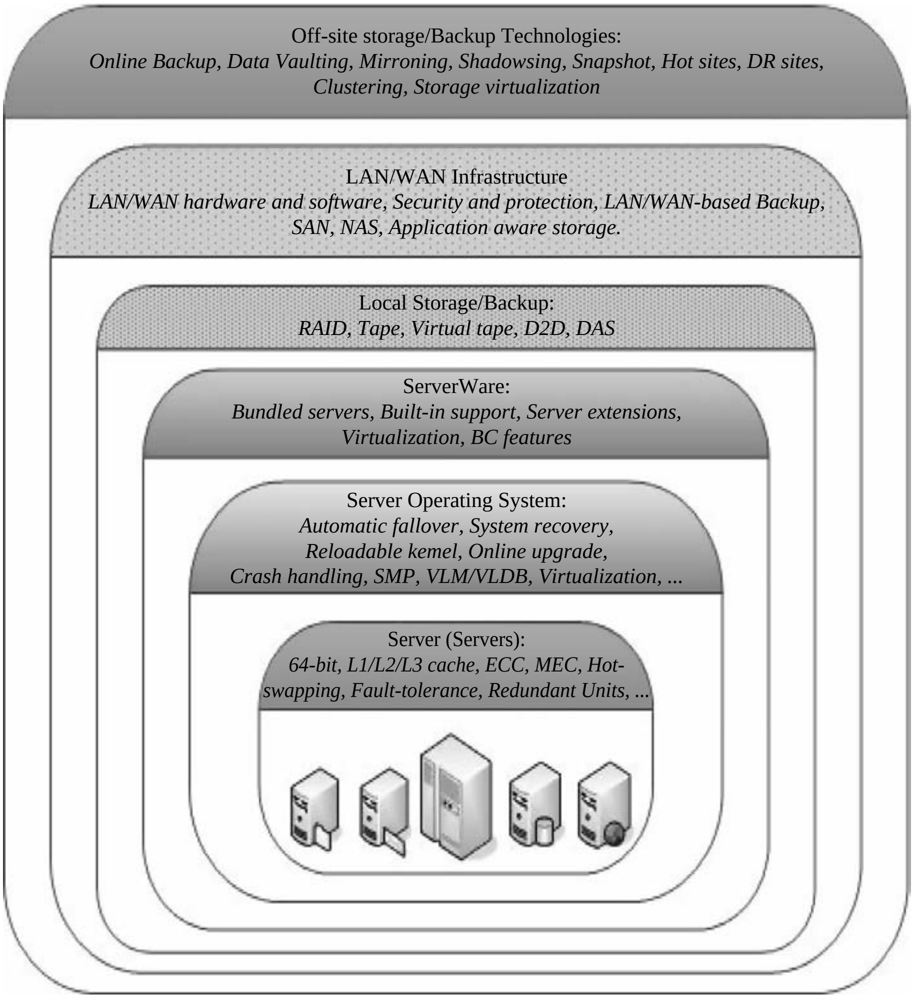

Figure 7.
The "onion" model of an information architecture for business continuity

In this approach, the "five nines" is referred to a system with 99.999 percent uptime – the availability ratio that is regarded as the highest number achievable today.

Modern servers and SOS are expected to provide a set of features and functions that are crucial in achieving business continuance. These features and functions usually come bundled (pre-installed) together with core operating system. This "built-in support" includes the following major functions/drivers (Figures 8 and 9):

4.2.1 Choosing a server for business continuance. The selection of a server or server configuration is an activity which has to provide answers to a number of questions. These questions are listed below having in mind server's business continuity perspective (availability, reliability and scalability):

- What is the planned application portfolio?
- What is the number of users; how many users, both named and concurrent users?

- Which SOS will be used?
- How fast data processing do we need?
- How many servers do we need?
- What are the input/output considerations?
- What kind of backup technology will be used?

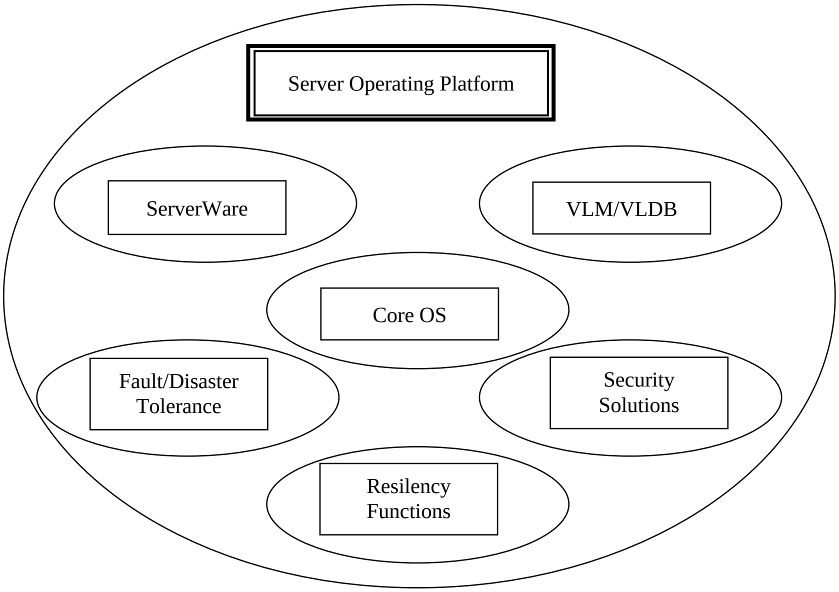

Figure 8.
Server operating platform: built-in functions

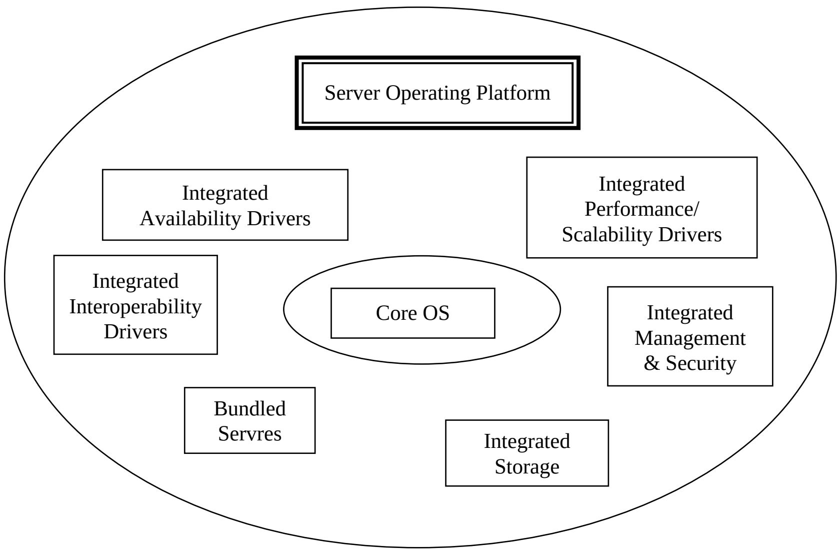

Figure 9.
Server operating platform – continuous computing drivers

- What kind of networking do we need?
- What kind of system administration and system management?
- What is industry support for operating systems? What is the viability of OS vendors?

In case of planning and purchasing a server for mission-critical applications, the selected server should have most of high-availability oriented features such as:

- multi-core processor technology;
- dedicated L1 and L2 cache per core;
- large L3 cache shares among cores;
- reduced memory latency time;
- recovering from data bus error;
- ability to turn off unused parts of processor;
- error correcting code memory (ECC);
- cache ECC coverage;
- cache reliability;
- lockstep support;
- better scaling of memory bandwidth;
- bad data containment;
- memory error correct;
- double-bit error detect;
- memory spares;
- hot swappable components; and
- hardware partitioning.

Questions such as: how many users will be on server; how many employees are in the company; how many clients must be supported simultaneously; how many users we can expect from outside (customers, suppliers); what are expectations with regard to the growth over time; how to address potential scalability problems;, etc. refer to scalability issues of an operating platform. A typical scalability problem occurred recently (in October 2007) when the Beijing 2008 Olympic Committee decided to start the process of online ticket reservation. The server (servers) went down immediately after activating online reservations and sales. Owing to a huge number of requests, much more than predicted and designed, the system could not handle as many as eight times bigger number of requests.

The decision on which SOS will be used on server platform depends on several factors and should be considered together with decision on which server platform will be selected. Several options and decision points exist: proprietary system – the system that works on a specific processor platform (e.g. z/OS, OpenVMS), commercial UNIX version from a variety of UNIX versions (IBM's AIX, HP's HP-UX, HP's Tru64UNIX, Sun's Solaris, Silicon Graphics' IRIX), free-open source UNIX such as FreeBSD UNIX, several Linux versions (RedHat, SuSE, Debian), Windows Server, Novell NetWare, etc.

Small business can run all its applications on a single server that hosts several server-based applications such as: database management system, messaging server, web server, e-commerce server, etc. Mid-size businesses and large companies employ several dozens, hundreds and even thousands of servers. Server consolidation and server sprawling are two issues that might occur while configuring multiple servers. Another alternative is server virtualization, a solution that can place several server operating environments on a single hardware platform.

With regard to viability of OS vendors, it is well known that commercial operating system costs more that an open source operating system in terms of initial-license and servicing costs. However, other dimensions should be considered as well, such as support and viability of OS vendors. The following dilemmas are present when this question is considered:

- Linux versus commercial UNIX.
- If Linux, which Linux?
- Windows Server versus Linux.
- Free-open source UNIX (e.g. FreeBSD) versus commercial UNIX.
- Free-open source UNIX versus Linux.

What follows is a list of the most important dimensions of contemporary SOS from CC perspective. This list represents a set of requirements or preferred features that a SOS should have in order to be selected as a platform for mission critical applications:

- the lowest level of total cost of ownership;
- multiplatform support – support for different processor platforms;
- multiprocessing support – support for multicore, multiprocessor, multinode systems;
- support for 64-bit processors and 64-bit applications;
- support for very large memory (VLM) and very large data base (VLDB);
- support for fault-tolerance and disaster tolerance;
- support for virtualization;
- system management features;
- patch management;
- applications availability and integratibility;
- application development tools (integrated suites) availability;
- support of major DBMS vendors, both commercial (Oracle, SQL Server, DB2, INGRESS, INFORMIX, etc.) and open source (MySQL);
- availability of ERP suites (SAP, Oracle, Navision, etc.) for a specific SOS platform;
- availability of system integration tools (middleware support);
- support for file/print services;
- support for internet, communication, networking, security protocols;
- support for application-programming protocols;

- availability of serverware products (messaging servers, web servers, etc.);
- PC-client and mobile/portable support (PC-X, CIFS and PC-NFS, WAP support);
- availability of specialists (system administrators) for a specific platform;
- GUI and web-based interface; and
- viability of OS vendor.

The rapid advances in internet technologies have resulted with changes in traditional SOS structures. Therefore, in addition to core SOS capabilities that are necessary to run a typical server configuration, an increasing number of both application and networking-oriented features, so-called "Serverware" applications, are required on server systems to fully support contemporary internet-based computing. Some of these applications come in the form of pre-installed or pre-integrated software "bundles" while some others are operating system – independent but very closed to that specific SOS platform. These features, so-called "Serverware applications" represent additional set of CC drivers, hence, critical success factors needed in implementing an efficient business continuity platform. They are presented here as business continuity drivers.

4.2.2 Serverware solutions for business continuity.

4.2.2.1 Integrated availability, reliability, scalability and high-performance drivers. Integrating availability, reliability and scalability drivers comprises including several technologies such as: resiliency drivers, solutions that minimize planned downtime such as online CPU and memory reconfiguration, online I/O reconfiguration, alternate root installation, dynamic kernel patching, crash-handling techniques (kernel dump facilities, dump analysis tools, dynamic core file generation, multimode boots, automatic hang detection, etc.), workload management solutions and high-availability clustering features.

Creating a highly available and resilient system represents a major effort when trying to improve the levels of availability and reliability of server operating platforms. Resiliency of the systems means their ability to return to their original state sooner or later after encountering some sort of problem which causes system shutdown. In that sense, a highly resilient system is a system which returns back to its function as soon as possible, if possible in a matter of seconds. Making a system resilient requires a lot of planning activities having in mind numerous possibilities that may occur and cause system shutdown (hardware and software crashes, cutting power for several hours, exhausting UPSs, etc.).

Reliability, availability, and scalability basically include the following drivers:

- Resiliency drivers – technologies that allow SOS to adapt to outages by hardware components (online failure recovery functions).
- Solutions that minimize planned downtime such as online CPU and memory reconfiguration, online I/O reconfiguration, alternate root installation, dynamic kernel patching.
- Crash-handling techniques (kernel dump facilities, dump analysis tools, dynamic core file generation, multimode boots, automatic hang detection, etc.).
- Workload management solutions such as: partition fault isolation, dynamic partition reconfiguration, etc.

- High-availability clustering features including: fault tolerance, failover capabilities, disaster recovery/disaster tolerance, cluster file system, work with partitions, TCP connection failover, high-availability storage support.
- Support for storage scalability, including support for RAID systems and scalability clustering options.
- Symmetric multiprocessing (SMP) support for higher levels of availability and scalability.

This set of built-in drivers includes the following features as well: support for memory and processor-scaling, dynamic memory page sizing, support for large file and file systems, support for VLM and VLDB, support for high-availability clustering, support for 64-bit computing which means support of several "large" options such as: large files, large file systems, large-VLM, large-VLDB, etc. VLM concept gives the ability to address large amounts of RAM on the order of several dozens gigabytes, while VLDB represents the possibility of addressing multi-gigabyte databases stored in RAM.

For instance, SAP AG recommends migrating to 64-bit platforms for running SAP enterprise suites (Fritz, 2006). According to SAP, 64-bit servers are currently prerequisite for running SAP on HP-UX, AIX, Solaris, IBM OS/400 and z/Linux operating platforms. In addition, starting from 2007 on, new releases of SAP NetWeaver and applications based on this platform will no longer be supported on servers running 32-bit Windows and Linux operating systems.

4.2.2.2 Bundled servers. SOS usually come preinstalled and accompanied with a set of server-based applications that is aimed at enhancing its core capabilities. Mail server and web server are just two examples of such server software. Among other server-based applications that may come bundled (integrated) with a SOS, the most important are the following ones: proxy servers and/or firewalls, e-commerce servers, chat server, news server, list server, etc. Moreover, most SOS vendors include parts or even the whole application servers to their OS platforms. For instance, Sun's decision to bundle Java 2 Enterprise Edition application server and Sun ONE directory server with its Solaris 9 SOS transformed the operating system environment into a fully integrated platform for implementing web services and Java-based applications.

4.2.2.3 Integrated compatibility, connectivity and interoperability drivers. This set of drivers consists of several protocols, extensions, bundles and supports that are intended to be used for resolving compatibility, connectivity and interoperability problems. The IOE has to provide availability, reliability, compatibility, manageability, and interoperability required to control today's distributed, heterogeneous IT environments. In addition, it must be based on an infrastructure that enables systems integrators to manage every IT resource, from desktops to mainframes and UNIX machines, from LANs to WANs, from standard data to knowledge, from databases to applications. To achieve true integration, it must contain integrated functions, built upon common objects and services that are open and available to all applications.

4.2.2.4 Integrated management and security drivers. The solutions that belong to this set of drivers include the following features:

- centralized, online and GUI-based systems administration;
- online and GUI-based dynamic kernel configuration;

- reloadable kernel;
- online upgrade;
- crash-handling techniques;
- memory mirroring;
- centralized management of remote computers;
- automatic OS-related and application software updates;
- partitioning and virtualization;
- workload management;
- centralized cluster management;
- TCP/IP failover support;
- Integrated authentication services, active directory, NIS, PKI, IPsec;
- host intrusion detection system;
- built-in encryption-decryption;
- secure socket layers;
- transaction prioritization; and
- encryption acceleration.

Integrated support for online reconfiguration, online upgrade and reloadable kernel. Features that allow making changes (reconfiguration, updates, upgrades) on hardware components, kernel and the whole operating system while keeping the system on. These technologies include functions such as: online CPU and memory reconfiguration, online I/O reconfiguration, alternate root installation, dynamic loadable kernel, dynamic kernel patching and dynamic partitioning. These features reduce both planned and unplanned downtime.

Support for system virtualization and system partitioning. The technologies such as Sun's "N1 Grid Container" allow creating up to 8,000 software partitions (containers) per single instance of the SOS. Each instance has its own IP address, memory space, hostname, root password, etc.

Support for TCP/IP extensions and/or protocols. These are such as: mobile/wireless TCP/IP, IPv6, IntServ, DiffServ, SLP, BGP and RIP, including support for TCP connection failover.

Support for HTML/XML development tools and web services. This kind of bundled software enhances capabilities of the server in order to support web-based applications (cgi-bin, Perl and PHP support, FrontPage extensions, e-mail services such as listing, filtering, support for different e-mail formats: MIME, uuencode and Bin/Hex, Active Server Pages support, software for stabilizing web server performances under heavy loads, bots or intelligent agents, e.g. data mining bots, shopping bots, e-mail bots, search bots, news bots, etc.).

Extensions for application development tools and DBMS. These extensions include support for Windows, UNIX and Linux APIs, object-oriented middleware solutions such as CORBA, COM/DCOM, Java/JavaBeans, support for Java Runtime environment, J2EE, server database extensions (Oracle, MS SQL Server, MySQL), indexing and search engines, ODBC support, Web-to-DBMS features, etc. Support for these application development tools, DBMS extensions, data exchange and integration, web-to-host solutions, make the process of application development easier and improves both efficiency and effectiveness of application platforms.

Support for web-based presentations. MStreaming media (ASX, ASF, MPEG, Real Audio, Real Video), Net-based road shows (using online PowerPoint, streaming media, chat), RealAudio/Video support are some examples of such a software.

Support for Windows/UNIX integration. In today's dominant information architecture – client/server computing, unlike desktop systems which are in most cases WIntel-based, enterprise servers run on different processor types and vendor-specific OS platforms, hence there is a need for an efficient integration capabilities. Dominantly multi-platform e-commerce infrastructures, models such as B2B, B2C, usually employ several types of server configurations. Therefore, solutions such as SMB/common internet file system (CIFS) which is a middleware for UNIX-to-Windows integration), PC-NFS and WebNFS are extremely important from data integration point of view.

Enhancements for e-commerce. Solutions that support and enhance e-commerce applications such as:

- *Dynamic page caching* – utility which allows the system to dynamically cache frequently accessed pages in memory.
- *Bandwidth allocation* – allows I/O bandwidth to be reserved or prioritized according to the type of internet protocol, or location of the page.
- *Transaction prioritization* – a feature which gives priority to transactions or high volume customers.
- *Encryption accelerator support* – aimed at improving performance and scalability of e-commerce sites.

Other web page supplements. These are such as: web statistics, site performance, data traffic reports, guest books, online polls and counters, auto-responders, aliasing and forwarding.

To give an example on the SOS level, for instance, HP offers a range of server operating features and bundled solutions for its UNIX-based SOS – HP-UX 11i (www.hp.com):

- *HP-UX 11i foundation operating environment* – HP-UX core – UNIX – foundation.
- *HP-UX 11i enterprise operating environment* – for enterprise-class performance and stability, with the added value of resource management, monitoring, scalability, and online data management.
- *HP-UX 11i mission critical operating environment* – for top levels of availability, workload management, and security.
- *HP virtual server environment suite for HP-UX 11i* – providing very broad mission-critical virtualization capabilities coupled with high availability.
- *HP serviceguard storage management suite for HP-UX 11i* – enabling improved manageability and performance for Oracle and Oracle RAC databases.

4.2.2.5 Integrated DBMS-based serverware features. Data base management system is a typical server operating environment that provides a powerful platform for efficient data management and application development. Examples of this software and the most frequently used DBMS environments include Oracle data base management system, IBM DB2 data base management system, Microsoft SQL Server data base management system. All these DBMS suites are commercial products and have to be purchased on a specific license scheme in order to be used. An alternative that appeared couple of years ago is an opensource product called MySQL, a data base management system that can be installed on several server platforms: Windows Server, Sun Solaris, HP's HP-UX, IBM AIX, Red Hat Linux, Novell SuSE Linux, Debian Linux, Apple MacOS X Server.

Here, are some examples of business continuity-oriented serverware solutions based on DBMS level:

- Microsoft SQL Server's component called "SQL Server 2005 always on technologies" provides a full range of options to minimize system downtime and maintain appropriate levels of application availability.
- Oracle's maximum availability architecture is a feature of the Oracle DBMS for achieving a highly available database management system.
- IBM DB2 universal database has a high-availability disaster-recovery product called with the primary aim of recovering from physical disasters.
- MySQL data base management system environment provides several solutions in order to achieve a highly available database operating environments. Some of them are: MySQL Master/Slave Replication, MySQL Distributed Block Device, MySQL Cluster, etc.

5. Conclusions

It is common that the application of IT in modern organizations lacks true integration. The question is how to manage and how to integrate several types of technologies, how to integrate today's distributed, heterogeneous IT environments, how to remove numerous disconnection points and, in general, how to align IT with business. Information management must be based on an infrastructure that enables IT-staff to control every IT resource, from desktops to mainframes and UNIX machines, from LANs to WANs, from standard data to knowledge, from databases to applications. At the same time, it should effectively incorporate BCM in order to achieve business continuance.

In this work some aspects of systems integration in its broader sense are considered. One of the factors – the server operating environment – is described in more detail by defining a set of systems integration drivers in the form of server-based CC technologies from business continuity perspective.

The presented framework can be used to assess current or future information systems as well as accompanying supporting components in a company. Using the framework, the company can avoid the potential problem of developing an integrated information system only for local business continuity. The framework presents a comprehensive set of checkpoints in terms of discontinuity points and necessary tools to address these.

The following are some future research directions for practitioners and researchers interested in this field:

- High-availability performance measurement of specific IOEs such as proprietary systems, UNIX platforms, Linux versions, Windows Server-based environments, etc.
- Models for implementation of IOEs for SMEs, large companies, different industries, etc.
- Benchmarking with regard to IOEs for several types of enterprise information systems (ERP, CRM, SCM, business intelligence).

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