Reengineering business information systems to support business continuity

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Abstract: The paper aims at presenting an implementation framework for reengineering traditional business information systems (ISs) into ISs that support business continuity (BC) or ‘always-on’ ISs. The framework has been developed by using a methodology framework based on a literature review and Churchman’s (1971) systemic model, particularly his definition of ‘system designer’. Four reengineering drivers are identified: downtime costs, IT-oriented business models, business continuity and IS-systemic perspective. Technology enablers for implementation of such systems are presented as well. Presented framework brings some additional dimensions with regard to modern ISs particularly those related to human aspects (Churchman’s client, designer and decision maker). It explores critical aspects of modern ISs such as high availability (HA) ratios, continuous data access, always-on computing, continuous computing technologies, as well as managerial aspects with regard to the roles of CIOs, system admins and business continuity managers. As such, the presented framework can be used in the projects of transforming traditional business ISs into always-on ISs.

Keywords: systems approach; information system; business continuity; always-on business; always-on information systems.

Reference to this paper should be made as follows: Bajgoric, N. (2018) ‘Reengineering business information systems to support business continuity’, Int. J. Business Continuity and Risk Management, Vol. 8, No. 1, pp.11–35.

1 Introduction

Most businesses in today’s e-business era are expected to follow a new ‘always-on’ business paradigm and provide products and services on a 24 × 7 × 365 basis. System downtime issues on e-business application servers are considered business-critical since even a few minutes of downtime may result in thousands or even millions in lost revenues. In the age of digital products and services customers never wait and switching to another vendor is simply ‘a mouse click away’. Messages such as ‘Our system is down, please try later’, ‘service unavailable’ or delays in application servers’ response time can result in customers’ switch to another site/vendor.

Newly created business requirements with regard to instant, continuous, and mobile data access have brought up again the question of information system (IS) availability and the ways of reaching ‘continuous availability’ or ‘zero downtime’. In more realistic terms, these expectations are translated into ‘high availability’ (HA) or ‘near-zero downtime’. Not only availability but also reliability and scalability issues have become ‘mission-critical’ for most businesses operating in the internet age. Leitch (2016) argued that downtime has reached an estimated cost of $700 billion per year to US businesses in 2016. Ponemon Institute and Emerson Network Power (Ponemon Institute Report, 2016) reported that the average cost of a data centre outage has steadily increased from $505,502 in 2010 to $740,357 today (or a 38% net change). Forrester Report (2013) highlighted that there is less and less tolerance for any kind of downtime. Actually, a similar requirement was identified even some 50 years ago, in the era of IBM-390 mainframes and DEC-VAX minicomputers, when first transaction processing systems were implemented. Clement and Giloth (2012) provided an example of the AT&T ESS system from the early ‘60s (1965) which achieved HA of 3 min per year downtime. Major causes of downtime were identified as hardware failures (1/3), procedural failures (1/3), software 25% and other causes 5%. However, as IDC Report (2016)

“Business cannot tolerate the same levels of planned and unplanned downtime that they could before they started on their digital transformation journey. While transactional systems once represented the business-critical aspects of an organization, in the modern digital era, systems of engagement are equally important, and employees need to be able to access their productivity tools (email, file shares and analytics), transactional systems and communication channels with customers and partners to create value and support success. The mean cost of one hour of downtime for an organisation with between 1,000 and 4,999 employees is approximately $225,000.”

Niemimaa (2015) noted that leading IS-journals provide little contributions on this perspective and identified the IS-BC relationship as a timely question. The paper aims at developing an implementation framework for reengineering (transforming) traditional business/enterprise ISs into always-on ISs. ‘Always-on’ IS is identified as a business computing model for ‘always-on’ business in the e-business age. The framework has been developed by using a methodology framework based on an extensive literature review and Churchman’s (1971) systemic dimensions.
2 Literature review

Turban and Volonino (2010) presented a model of business pressures related to the modern business environment, namely; market pressures, technology pressures and societal pressures. They argue that businesses employ information technologies in order to provide responses to business pressures and business risks.

However, today’s e-business environment requires additional requirement to be identified, the one that relates to business continuity/business continuance, which is characterised by continuous data access/data availability. In other words, this can be translated to available data, always-on application platform and consequently always-on IS (Figure 1). In addition to availability, both scalability and reliability of e-business application platforms are business-critical as well as modern e-businesses are expected to be always-on, with zero or ‘near-zero’ downtime. Such businesses aim at providing products and services on a continuous basis as each hour, even a minute of downtime, can be easily expressed as financial losses.

Figure 1 Business continuity (always-on business): an internet era’s requirement and business pressure (see online version for colours)

As shown in Figure 1, always-on business relies on continuous computing technologies that should be implemented in a specific form of an always-on IS or, highly available IS – IS having a near-zero downtime.

Some 30 years ago, Brill (1987) wrote that users want a package that will deliver an uptime result. Datamation (1995) quoted: “According to a survey of 400 large companies conducted by Oracle, downtime costs a company $1,400 per minute, on average. Based on these figures, 43 hours of downtime per year would cost $3.6 million. One hour of downtime per year amounts to $84,000 per year”. According to Harvard Research Group (2001), application downtime requirements can range from almost zero to no more than
60 seconds. This report revealed that Compaq’s OpenVMS and IBM’s z/OS (formerly OS/390) are generally regarded in the industry to be the two world-class operating systems. These are the operating systems to use for really critical business applications. Many of the applications in the banking, securities, healthcare, government, transportation and telecommunications industries require both high scalability and extremely high application uptime. Fost (2002) wrote “For VMS, I think the undisputed record holder is Irish Railways’ signal controller system, being in continuous operation since about 1983 to at least 2000 when I heard about it. Reportedly, it is gotten replaced or rebooted since then”. McNelly (2012) quoted a story of an IBM AIX server which was up 4,675 days. The contingency planning research report (Eagle Rock Alliance, 2001) revealed that average hourly downtime costs range was from $28,000/h to $5.4 million/h, depending on the industry. In a report issued in late 2002, IDC stated that IT Security and business continuity are both number one priorities of business professionals (IDC Report, 2002). According to Aberdeen Report (2014), the average cost of downtime for large companies is $686,250/hour, $215,638/hour for medium companies and $8,581/hour for small companies. Gartner (2014) quoted an average downtime cost as $5,600 p/minute. IDC Report (2015) found that some specific industries can reach even $10 million lost per hour of downtime. For the Fortune 1,000, the average total cost of unplanned application downtime per year is $1.25 billion to $2.5 billion (IDC White Paper, 2014). The Veem Data Availability Report (2017) revealed that $21.8M is an average financial cost of availability and protection gaps for the enterprises. This continues the trend toward rising costs from downtime as seen in 2016 ($16M) and 2015 ($10M).

Turban and Volonino (2010, p.18) stated that business organisations must become adaptive and agile. They identified the following requirements:

- recognise the environmental and organisational changes as quickly as they occur, or even before they occur
- deal with changes properly and correctly
- become a digital and agile enterprise
- does not wait for your competitor to introduce change
- change your ISs quickly.

Several authors addressed issues in transforming or adapting current models of doing business and (re)organising business ISs. Bichler et al. (2016) provided a summary of theoretical approaches in business and IS engineering and presented a theory of conceptual models. Chalupnik et al. (2013) presented a framework for comparing the relationships among reliability, robustness, adaptability and resilience in the context of system design. Bharosa et al. (2010) considered issues in sharing and coordinating information during disasters, within the concept of disaster management. Lee et al. (2015) emphasised the need to restore the idea that the study of design in IS needs to attend to the design of the entire IS artefact, not just the IT artefact. Some aspects of modernisation through ICT are given in Faik and Walsham (2013). A framework for assembling IT-infrastructures and business models is given in Kuk and Janssen (2013), while Ashurst et al. (2012) presented a new paradigm for IT-enabled innovation. Baden-Fuller and Haefliger (2013) compared business models and technological innovations, while Hu (2014) considered the relations between business models and technological innovation performance through organisational learning. Several concepts
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of business models developed over the last three decades have been created under the impact of IT trends. Typical examples of such trends are the concepts such as cloud computing and business continuity. Becker et al. (2015) noted that ISs have been the major contributor to economic growth and productivity over the past decades.

Forrester predicted that the global cloud computing market will grow from $40.7 billion in 2011 to more than $241 billion in 2020 (Dignan, 2011). Some aspects of reengineering modern manufacturing platforms by implementing cloud computing are given in Zhang et al. (2014). Availability analysis of enterprise IS architectures is given in Narman et al. (2014). Brenes et al. (2011) focused on assessing the impact of business continuity-related governance structures on family business performances. Avery Gomez (2011) presented a model for alignment of business continuity and sustainable business processes with regard to ICT usage behaviour and response readiness. Arduini and Morabito (2010) argued that the financial sector sees business continuity not only as a technical or risk management issue but as a driver towards any discussion on mergers and acquisitions. Lump et al. (2008) presented an overview of architectures for continuous availability concepts as HA clustering on distributed platforms and on the mainframe. Craighead et al. (2007) considered business continuity issues within the supply chain mitigation capabilities and supply chain disruption severity. Bhatt et al. (2010) considered IT infrastructure as an enabler of organisational responsiveness and competitive advantage. Speight (2011) defined business continuity as a management process that identifies potential factors that threaten an organisation and provides a framework for building resilience and the capability for an effective response. Jarvelainen (2013) focused on a framework for business continuity management (BCM) and extended it to the context of ISs. Brende and Markov (2013) considered the most important risks inherent to the cloud computing. A method for availability analysis is presented in Narman et al. (2014). Torabi et al. (2014) proposed a framework for conducting the business impact analysis by using MADM techniques. Venkatraman (2013) found that more than a third of respondents viewed human error as the most likely cause of downtime. It takes an average of 30 hours to recover from failures, which can be devastating for a business of any size (Clancy, 2013). Butler (2013) reported that a 49 minutes failure of Amazon’s services on January 31, 2013, resulted close to $5 million in missed revenue. Aktas (2010) presented some principles and experiences in designing and building enterprise ISs from the always-on perspective. Bayram et al. (2010) presented a model of an always-on enterprise IS with service-oriented architecture and load balancing. Delic and Riley (2009) noted that HA and dependability are necessary engineering features for such global, ‘always-on’, always-available systems. Nollau (2009) introduced the term of enterprise business continuity. Franke et al. (2012) presented an expert-based Bayesian framework for IT-infrastructure availability. Speight (2011) defined business continuity as a management process that identifies potential factors that threaten an organisation and provides a framework for building resilience and the capability for an effective response. Jarvelainen (2013) focused on a framework for BCM and extended it to the context of ISs. Saha (2013) noted that enterprises are no longer grappling to have access to the latest technologies; harnessing technology to enable business outcomes is given. An example of how a continuous computing technology can be used on enhancing scalability and reliability is given in Chang et al. (2014). Miller and Engemann (2014) proposed using reliability and simulation models in business continuity planning.
### Table 1 Summary of the literature review

<table>
<thead>
<tr>
<th>Article year</th>
<th>Authors</th>
<th>Focus/contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>Rick</td>
<td>Only 6% of companies suffering from a catastrophic data loss survive, while 43% never reopen.</td>
</tr>
<tr>
<td>2002</td>
<td>Barraza</td>
<td>The global economy runs on information, it runs on available information.</td>
</tr>
<tr>
<td>2003</td>
<td>Lewis and Pickren</td>
<td>Presented a technique that can be used to assess the relative risk for different causes of IT disruptions.</td>
</tr>
<tr>
<td>2003</td>
<td>King</td>
<td>Introduced a term of ‘business continuity culture’.</td>
</tr>
<tr>
<td>2004</td>
<td>Botha and Von Solms</td>
<td>Proposed a BCP methodology that is scalable for small and medium organisations.</td>
</tr>
<tr>
<td>2004</td>
<td>Herbane et al.</td>
<td>Developed a conceptual approach to posit that BCM, in actively ensuring operational continuity, has a role in preserving competitive advantage.</td>
</tr>
<tr>
<td>2004</td>
<td>Finch</td>
<td>Large companies’ exposure to risk increased by inter-organisational networking.</td>
</tr>
<tr>
<td>2004</td>
<td>Cerullo and Cerullo</td>
<td>Guidelines for developing and improving a firm’s BC plan.</td>
</tr>
<tr>
<td>2005</td>
<td>Bertrand</td>
<td>Estimated the relationships between business continuity and mission-critical applications.</td>
</tr>
<tr>
<td>2005</td>
<td>Gerber and Solms</td>
<td>Presented a holistic approach with carefully planned security policy, the use of technology and well-trained staff.</td>
</tr>
<tr>
<td>2006</td>
<td>Walker</td>
<td>Considered outsourcing options for business continuity.</td>
</tr>
<tr>
<td>2006</td>
<td>Bartel and Rutkowski</td>
<td>IT service continuity management is typically part of a larger BCM program, which expands beyond IT to include all business services.</td>
</tr>
<tr>
<td>2006</td>
<td>Butler and Gray</td>
<td>How system reliability translates into reliable organisational performance.</td>
</tr>
<tr>
<td>2006</td>
<td>Gibb and Buchanan</td>
<td>Framework for the design, implementation, and monitoring of a BCM program within an information strategy.</td>
</tr>
<tr>
<td>2007</td>
<td>Williamson</td>
<td>In business continuity planning, financial organisations are ahead of other types of businesses.</td>
</tr>
<tr>
<td>2007</td>
<td>Craighead et al.</td>
<td>Proposed a multiple-source empirical research method and presented six propositions that relate the severity of supply chain disruptions.</td>
</tr>
<tr>
<td>2008</td>
<td>Vatanasombut et al.</td>
<td>The proliferation of internet has not only allowed businesses to offer their products and services but has also undermined their ability to retain customers.</td>
</tr>
<tr>
<td>2008</td>
<td>Bielski</td>
<td>Considered business continuity as doing what is necessary to set up a ‘shadow’ organisation from incident response through various phases of recovery.</td>
</tr>
</tbody>
</table>
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Table 1  Summary of the literature review (continued)

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<tr>
<th>Article year</th>
<th>Authors</th>
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</thead>
<tbody>
<tr>
<td>2008</td>
<td>Turetken</td>
<td>A decision model for locating redundant facilities (IT-backup facility location) within the activities of business continuity planning.</td>
</tr>
<tr>
<td>2008</td>
<td>Lump et al.</td>
<td>Investigated several aspects and relationships among HA, disaster recovery and business continuity solutions.</td>
</tr>
<tr>
<td>2009</td>
<td>Wan</td>
<td>The continuity plan needs to be integrated with IT service continuity management.</td>
</tr>
<tr>
<td>2009</td>
<td>Boehman</td>
<td>Presented a model for evaluating the performance of a BCM System according to BS 25999 standard.</td>
</tr>
<tr>
<td>2009</td>
<td>Nollau</td>
<td>Introduced the term of ‘enterprise business continuity’.</td>
</tr>
<tr>
<td>2010</td>
<td>Herbane</td>
<td>BCM as a discipline has evolved since the 1970s in response to the technical and operational risks.</td>
</tr>
<tr>
<td>2010</td>
<td>Adeshiyan et al.</td>
<td>HA-DR solutions require complex configurations, application specific logic, highly skilled personnel, and a rigorous testing process.</td>
</tr>
<tr>
<td>2010</td>
<td>Ipe et al.</td>
<td>Explored the challenges specific to developing and institutionalising an IT system for emergency preparedness.</td>
</tr>
<tr>
<td>2010</td>
<td>Singhal et al.</td>
<td>A solution for optimal BC based on the IP-SAN storage for enterprise applications.</td>
</tr>
<tr>
<td>2010</td>
<td>Kuhn and Sutton</td>
<td>Architectures for continuous auditing by focusing on the strengths and weaknesses of each architectural form of ERP implementation.</td>
</tr>
<tr>
<td>2010</td>
<td>Tammineedi</td>
<td>Identified three phases of business continuity: Pre-event preparation, event management, and post-event continuity.</td>
</tr>
<tr>
<td>2010</td>
<td>Lindstrom et al.</td>
<td>Proposed a multi-usable business continuity planning methodology based on using a staircase or capability maturity model.</td>
</tr>
<tr>
<td>2010</td>
<td>Kadlec</td>
<td>IT DR planning practices of 154 banks in the USA.</td>
</tr>
<tr>
<td>2010</td>
<td>Arduini and Morabito</td>
<td>Financial sector sees business continuity not only as technical or risk management issue but as a driver towards the discussion on mergers and acquisitions.</td>
</tr>
<tr>
<td>2010</td>
<td>Winkler et al.</td>
<td>A model-driven framework for BCM which integrates business process modelling and IT management.</td>
</tr>
<tr>
<td>2010</td>
<td>Kadam</td>
<td>The concept of personal BCM.</td>
</tr>
<tr>
<td>2011</td>
<td>Tan and Takakuwa</td>
<td>Demonstrated how the computer-based simulation technique could be utilised in order to establish the business continuity plan for a factory.</td>
</tr>
<tr>
<td>2011</td>
<td>Zobel</td>
<td>An approach for representing the relationship between two measures of disaster resilience: the initial impact of and the subsequent time to recovery.</td>
</tr>
<tr>
<td>2011</td>
<td>Omar et al.</td>
<td>A framework for disaster recovery plan based on the Oracle’s data guard solution that includes remote site, data replication, and standby database.</td>
</tr>
</tbody>
</table>
Table 1  Summary of the literature review (continued)

<table>
<thead>
<tr>
<th>Article year</th>
<th>Authors</th>
<th>Focus/contribution</th>
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</thead>
<tbody>
<tr>
<td>2011</td>
<td>Greening and Rutherford</td>
<td>A conceptual framework based on network theories to ensure business continuity in the context of a supply network disruption.</td>
</tr>
<tr>
<td>2011</td>
<td>Brenes et al.</td>
<td>Assessed the impact of business continuity-related governance structures on family business performances.</td>
</tr>
<tr>
<td>2011</td>
<td>Avery Gomez</td>
<td>A model for alignment of business continuity and sustainable business processes with regard to ICT usage behaviour and response readiness.</td>
</tr>
<tr>
<td>2011</td>
<td>Sapateiro et al.</td>
<td>A mobile collaborative tool that helps teams managing critical computing infrastructures in organisations.</td>
</tr>
<tr>
<td>2011</td>
<td>Blackhurst et al.</td>
<td>A framework that can be used to assess the level of resiliency and a supply resiliency matrix.</td>
</tr>
<tr>
<td>2012</td>
<td>Broder and Tucker</td>
<td>Focused on the difference between the meaning of continuity planning and of a continuity plan.</td>
</tr>
<tr>
<td>2012</td>
<td>Lavastre et al.</td>
<td>Business continuity planning within the ‘supply chain continuity planning framework’.</td>
</tr>
<tr>
<td>2012</td>
<td>Kim and Cha</td>
<td>A scenario-based security risk analysis method which can create SRA reports using scenario templates and manage security risk in IS.</td>
</tr>
<tr>
<td>2013</td>
<td>Jarvelainen</td>
<td>A framework for BCM and extended it to the context of ISs.</td>
</tr>
<tr>
<td>2014</td>
<td>Miller and Engemann</td>
<td>Using reliability and simulation models in business continuity planning.</td>
</tr>
<tr>
<td>2015</td>
<td>Neimmiaa</td>
<td>Identified the IS-business continuity relationship as ‘a timely question’.</td>
</tr>
<tr>
<td>2016</td>
<td>Jingye and Takehiro</td>
<td>A concept called ‘smart BCM’ (SBCM).</td>
</tr>
<tr>
<td>2017</td>
<td>Ivanov et al.</td>
<td>A literature review on disruption recovery in the supply chain.</td>
</tr>
<tr>
<td>2017</td>
<td>Folkers</td>
<td>BCM and its role in contemporary financial institutions by focusing on two events that triggered continuity management in banks, hurricane Sandy in New York City and the ‘Blockupy’ demonstrations in Frankfurt.</td>
</tr>
<tr>
<td>2017</td>
<td>Niemimaa</td>
<td>Sought to bring to the foreground the implications of the social for IS continuity by developing conceptual foundations of the social dynamics in the IS continuity process.</td>
</tr>
<tr>
<td>2017</td>
<td>DuHadway et al.</td>
<td>Presented a theory-based framework that provides a new theoretical perspective on supply chain disruptions.</td>
</tr>
<tr>
<td>2017</td>
<td>Maboudian and Rezaie</td>
<td>Focused on business continuity in Iran petrochemical industry by investigating the industry environment with regard to risk factors, experienced disruptions, the effectiveness of conducted countermeasures, and the extent of BC management implementation.</td>
</tr>
<tr>
<td>2017</td>
<td>Lozupone</td>
<td>Presented a case of the Medical Records Company which implemented a disaster recovery solution based on windows server.</td>
</tr>
</tbody>
</table>
Table 1  Summary of the literature review (continued)

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<tr>
<th>Article year</th>
<th>Authors</th>
<th>Focus/contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>Rabbani et al.</td>
<td>Elaborated interrelationships between the organisation’s desirable continuity level in terms of recovery time objective (RTO) and recovery point objective (RPO) indicators, and the chosen approach to response disastrous situations.</td>
</tr>
<tr>
<td>2017</td>
<td>Li et al.</td>
<td>Investigated the impact of three critical dimensions of supply chain resilience, supply chain preparedness, supply chain alertness and supply chain agility, all aimed at increasing a firm’s financial outcomes.</td>
</tr>
<tr>
<td>2017</td>
<td>Fischbacher-Smith</td>
<td>Considered the nature of the BCM process and tried to frame it within the wider literature on the performance of socio-technical systems.</td>
</tr>
</tbody>
</table>

Figure 2 identifies major research streams and topics from the literature review classified with regard to main reengineering drivers identified as downtime costs, business models, a systemic perspective of IS, and business continuity (BC). These four areas are considered the main sources for a BC-oriented model of IS called ‘always-on’ IS.

In addition to several types of IS implementations, IS reengineering activities and projects, application of new IT-enhanced business models, ERP implementations, and BPR/TQM projects, the processes of changing or reengineering IS implicitly involve the changes related to some conceptual dimensions of business ISs as to their main objectives, business strategies and business models as well. For more than three decades, the top-priority objectives of business ISs were identified as efficient data processing, management support, efficient data access, better reporting, and decision support, however, in the e-business age, they are more and more focused to BC. The downtime costs and availability issues have become very important drivers for reengineering ISs towards available, scalable and reliable applications.
3 Framework for reengineering business ISs

Churchman (1971, p.43) defined the term ‘design’ as teleological (goal-seeking) thinking behaviour that conceptually selects among alternative behaviour patterns and tries to identify those that lead to desired outcomes. His extended definition of a system includes nine conditions:

1. S is teleological.
2. S has a measure of performance.
3. There exists a client whose interests (values) are served by S.
4. S has teleological components which coproduce the measure of performance of S.
5. S has an environment which also co-produces the measure of performance of S.
6. There exists a decision maker who via his resources can produce changes in the measures of performance of S’s components and hence changes in the measure of performance of S.
7. There exists a designer, who conceptualises the nature of S in such a manner that the designer’s concepts potentially produce actions in the decision maker, and hence changes in the measures of S’s components, and hence changes in measure of performance of S.
8. The designer’s intention is to change S so as to maximise S’s value to the client.
9. S is ‘stable’ with respect to the designer, in the sense that there is a built-in guarantee that the designer’s intention is ultimately realisable.

A conceptual model of an ‘always-on’ enterprise IS within a framework of BCM was presented in Bajgoric (2014) by using Churchman’s five-dimension model (Churchman, 1968). However, in this article, we provide a framework for reengineering business ISs to become ‘always-on’ by using Churchman’s (1971) nine dimensions systemic model and by focusing on the role of Churchman’s system designer in the context of reengineering ISs.

Churchman (1968, 1971) defined the term of ‘inquiry’ as an activity that produces knowledge and identified the basis for design of computer-based inquiring systems. Checkland (1985) suggested a methodological framework called soft systems methodology (SSM), and underlined that SSM is doubly systemic. He pointed out that, in Churchman’s language, SSM is a ‘Singerian Inquirer’, one which accepts that inquiry is never-ending and is intent, in ‘a heroic mood’, on both attacking and defending the status quo (Checkland, 1983).

Mingers and Walsham (2010) underlined the fact that Churchman (1968) was one of the first to say that in order to properly evaluate designs we have to consider the whole system of which they are a part. Swanson (1994, p.55) noted that “taken together, these nine conditions are in their essence a set of precepts for the systems professional, here the designer”. He interpreted Churchman’s The Design of Inquiring Systems as presenting a theory of a system’s design integrity, which is “in essence a theory of a design’s wholeness, soundness, and virtue. This theory is especially powerful in its professional application, where the role of critical observer or responsible social witness also deserves
special attention” (p.54). Bennet et al. (2000) emphasised several dimensions of Churchman’s designer’s relations with client and decision maker. Mingers (2009) noted that a system thinking is at least implicit in most IS research. Linden et al. (2007) argued that building on inquiring systems can contribute to developing IS as a discipline. Balabko and Wegmann (2006) applied the concepts of system inquiry within the concept of enterprise architecture. Gerber and Solms (2005) emphasised the need for a holistic approach pointing to the risks to information or intangible assets, not only tangible assets. According to Mingers and White (2010), Churchman was one of the founding fathers of both OR and systems thinking and his major work was *The Design of Inquiring Systems* (Churchman, 1971). Buckl and Schweda (2013) developed a systemic view of enterprise architecture management, while Rabaey (2013) proposed complex adaptive systems thinking-based enterprise architecture. Bai and Lindberg (1999) presented a socio cybernetic approach to ISs development. Linden et al. (2007, p.836) stated that Churchman’s inquiring systems can form the basis for the design of knowledge management systems and that the IS research community has hardly tapped the potential of inquiring systems in that regard. Swanson (1994) interpreted Churchman’s book *The Design of Inquiring Systems* as presenting a theory of a system’s design integrity, which is “in essence a theory of a design’s wholeness, soundness, and virtue. This theory is especially powerful in its professional application, where the role of critical observer or responsible social witness also deserves special attention” (p.54). Malmso (2006) suggested a methodology for designing supportive ISs based on the works of Miller and Engemann (2014). Syed and Craig (2010) presented a systemic model on IS’ adoption using critical systems thinking. The study suggests that the proposed model has the capacity to serve as a roadmap for a smooth IS adoption by facilitating organisational learning and change. Coenen and Díaz López (2010) compared systems approaches to innovation and technological change for sustainable and competitive economies. Im and Cho (2013) presented a systematic approach for developing a new business model using morphological analysis and integrated fuzzy approach. Carugati (2008) presented an integrative framework for IS development activities and inquiring systems. Segatto et al. (2013) used the systemic approach in business process management. Raza and Standing (2010) discussed the ways towards a systemic model of IS’ adoption using critical systems thinking. Bednar and Welch (2012) suggested a framework for critical systemic thinking as a foundation for ISs research practice. Sahebjamnia et al. (2015) presented a framework for integrated BC and disaster recovery planning with a mathematical model to determine required resources to cope with disruptive events. Swanson (1994) added a tenth condition on a system’s conception: “there exists an observer who is able to evaluate S in terms of its design integrity so that S may be made closer to ideal. Thus, every designer has a critical observer looking over his or her shoulder. This is both the burden and the blessing of systems design”.

Churchman (1971, p.5) outlined five characteristics of design, the fifth one being the following: “The system designer attempts to identify the whole relevant system and its components, defining the design alternatives in terms of the design and the components and their interrelationships. The designer seeks a system in which the client’s values are best served by the decision maker’s actions”. Winter et al. (1995) considered computer-based ISs as systems which serve purposeful human action, necessarily involves two systems, a serving system (the IS) and a served system of purposeful action. Checkland (2000) underlined the premise that organisations and their subsystem ISs are
open systems that interact with their environment and included the human activity subsystems as part of the modelling process.

The literature review framework presented in Figure 2 identified four reengineering drivers:

a. downtime costs
b. IT-oriented business models
c. business continuity
d. IS-systemic view.

Based on the findings of literature review and the framework of reengineering drivers presented in Figure 2, technology enablers critical for implementation of such systems are presented in Figure 3.

a. continuous computing technologies
b. redefined role of server operating systems by including HA features
c. enhanced system and network administration
d. IS auditing and compliance.

The systemic model of an ‘always-on’ IS with a focus on the role of Churchman’s designer is presented in Figure 4.

Churchman (1971, p.48) identified three individuals: the client, the designer and the decision maker:

- The client is the person to whom the system is intended.
- The designer seeks to find the underlying principle behind the client’s trade-offs by deriving performance measures that will allow the objective evaluation of the system’s various states.
The decision maker controls the resources of the system, thus determining the system’s behaviour and creating the real future.

This triangle (client-designer-decision maker) identifies what can be called a ‘people’ part of the framework. In case of an ‘always-on’ IS, it is interpreted as follows:

As the client is in Churchman’s words “the person to whom the system is intended”, the clients are end-users comprising employees, customers, suppliers, and all kinds of end-users who use such IS. They seek for a continuous (uninterruptible) data access; therefore, higher uptime usually means more satisfied clients.

**Figure 4** Model of ‘always-on’ IS – the role of designer(s)

The role of designer (designers) in the context of IS reengineering efforts that would help in reengineering IS towards an ‘always-on’ IS is shown in Figure 4 by arrows 7 and 8. The designers are several IT professionals working on reengineering IS towards an ‘always-on’ IS such as CIO, BC manager, system administrator, and network administrator.

CIO is responsible for recommending the ‘always-on’ IT-solutions to the CEO, by identifying continuous computing measures of performances, implementing continuous computing technologies, monitoring operations of an ‘always-on’ IS, and maximising IS’s value to the client(s). This is in line with Churchman’s condition no. 7 (“There exists...
a designer, who conceptualises the nature of S in such a manner that the designer’s concepts potentially produce actions in the decision maker, and hence changes in the measures of S’s components, and hence changes in measure of performance of S.), and condition no. 8 (The designer’s intention is to change S so as to maximise S’s value to the client”.

With regard to other IT-professionals who are involved in reengineering ISs towards achieving ‘always-on’ attribute, we can identify some of them such as BC analysts, disaster recovery specialists, business impact analysts, risk managers, and IT/IS security specialists.

The Decision maker is the CEO who, in Churchman’s words “controls the resources of the system, thus determining the system’s behaviour and creating the real future”.

The human resources dimension of an ‘always-on’ IS, in addition to CIO and BC managers, includes the system and network administrators who work to reduce system/network downtime and increase the availability ratios. System and network administration includes numerous operations performed by sys admins on servers, server operating systems, data communications and networking layers that are aimed at enhancing application availability and ensuring BC. System administration skills are crucial in enhancing availability ratios of application servers and ISs as experienced system administrators can fix quickly numerous problems that occur on the server, server operating system and network, and therefore minimise downtime. The system administrator has a critical role in keeping server operating system up by performing administrative and troubleshooting operations when the system goes down. A skilled and experienced system administrator can resolve quickly most of the problems that occur on the server or server operating system level when server shuts down or server operating systems crashes and hence reduce significantly the time of system recovery in terms of RTO and RPO. However, system administrator’s privileges (data access rights) should be implemented by following the compliance regulations such as FDCC, Sarbanes-Oxley, PCI, HIPAA and GLBA, including solutions such as: fine-grained privileges and role-based access control.

As already cited, with regard to Churchman’s nine conditions, Swanson (1994) added an ‘observer’ as the tenth condition on a system’s conception, “who is able to evaluate S in terms of its design integrity. Thus, every designer has a critical observer looking over his or her shoulder”. In case of an ‘always-on’ IS, this person can be identified as an IT-auditor responsible for IT auditing operations.

4 Implementation drivers – continuous computing enablers

In modern e-business, information technologies are implemented with the main objective of achieving ‘always-on’ computing or ‘always-on’ IS. In today’s dominant client-server or client-cloud information architectures, such an IS is supported by several continuous computing technologies implemented within server operating environment which consists: servers, server operating systems, application servers, storage systems (technologies), and network technologies. Figure 5 presents the role of ‘always-on’ IS and its continuous computing technologies in achieving ‘always-on’ business. It is presented within a so-called ‘onion model’ of such an infrastructure and shows the components as layers.
The infrastructure includes the major technology enablers of an ‘always-on’ ARE based on several types of continuous computing technologies implemented within an integrated IT-platform called ‘server operating environment’. These technologies are identified according to Churchman’s condition no. 4 (teleological components which coproduce the measure of performance of S).

Such an environment is identified as a core technology layer of an ‘always-on’ IS. It contains server hardware technologies, core server operating system, server ware, and server applications for enhancing availability ratios. It includes several continuous computing and HA-oriented hardware and software technologies and features such as: 64-bit processors, 64-bit server operating systems, multi-core processors, L1/L2/L3 cache technology, ECC, MEC, memory double-chip spare, automatic deconfiguration of memory and processors, hot-swappable components, fault-tolerance, redundant units, automatic failover, system recovery, reloadable kernel, online upgrade, crash handling, SMP, VLM/VLDB, virtualisation, RAID, tape, virtual tape, D2D, DAS, online backup, data vaulting, mirroring, shadowing, snap-shoot, hot sites, clustering, disaster recovery sites, storage virtualisation, database mirroring, failover clustering, database snapshots, snapshot isolation, peer-to-peer replication, log shipping, resilience-to-link-failures,
network virtualisation, virtual application networks, fibre channel failover, software-defined networking, redundant components, redundant paths, IP multi-pathing, virtual network devices, dual home link, Ethernet ring protection, bi-directional forwarding detection, virtual cluster switching, firewall, IDS/IPS, and malware/SPAM filtering.

Continuous computing technologies listed above are in line with Churchman’s condition no. 4 (S has teleological components which coproduce the measure of performance of S). They are aimed at enhancing the availability, reliability and scalability ratios of information infrastructures are implemented in reengineering traditional ISs into ‘always-on’ IS. The mission-critical component of such an infrastructure in today’s dominant client-server or client-cloud computing architecture is a server operating environment as a collection of server, server operating system and serverware features that are aimed at enhancing the system uptime. Most widely used continuous computing technologies are classified in five modules including several HA features implemented on the following levels: servers, server operating systems, application servers, networks, and storage. They are implemented and administered by system and network administrators. Such an infrastructure can be organised ‘on-premises’ (standard client-server architecture) or within the cloud computing provider’s premises (client-cloud architecture).

5 Case analysis – server operating platforms for ‘always-on’ ISs

In order to support the conceptual model of an ‘always-on’ IS, the following IT vendors are shortly analysed in the form of key server operating environment features that can be used in reengineering IS: HP, IBM, Microsoft, SUSE, and Oracle. These server operating platforms are presented as integrated sets of Churchman’s teleological components, in our case, HA technologies, which coproduce the measure of performance of S.

Among several versions of operating systems created and supported by selected vendors, the following server operating platforms are analysed:

- HP’s HP-UX (http://www.hpe.com)
- Microsoft’s Windows Server (http://www.microsoft.com)
- SuSE Linux (http://www.suse.com)
- IBM AIX (http://www.ibm.com)
- Oracle Solaris (http://www.oracle.com).

Figure 6 presents a short SWOT analysis of these five server operating platforms as to their general features and HA features:

- **HP’s HP-UX** includes several HA technologies such as HPE service guard, HPE virtualisation continuum, HPE Systems insight manager, and HPE helion cloud system. However, HPE announced recently migration from Itanium-based servers and HP-UX platform to Linux-based containers running on standard × 86 servers.
- **IBM’s AIX** offers a set of built-in HA technologies such as Power HA, availability factory, HA clustering, power HA system mirror, and DB2 HA/disaster recovery.
Oracle’s Solaris supports a number of HA-solutions such as maximum availability architecture, application continuity, on-line system reconfiguration, recovery manager, oracle secure backup, data recovery advisor, zero data loss appliance, database shadowing. However, oracle dropped Solaris from the roadmap in 2017.

Microsoft Windows Server provides several features related to continuous availability such as: recovery procedures and assistance for high IT service uptime and recovery, NIC failover, cluster failover manager, Hyper-V replica, support for SQL server mirroring and always on, online corruption repairs, support for NUMA-aware scalability, online corruption repairs and always on dashboard.

SuSE Linux includes HA features within the SuSE Linux enterprise HA extension which is included as an add-on product.

Figure 6  A SWOT analysis

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Windows Server</th>
<th>SUSE Linux</th>
<th>AIX</th>
<th>Oracle Solaris</th>
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</thead>
<tbody>
<tr>
<td>- Powerful platform, 30 years in use</td>
<td>- Basic Applications</td>
<td>- Open platform</td>
<td>- Powerful platform, 30 years in use, Integrated with IBM’s SPARC platform</td>
<td>- Powerful platform, Sun Server platforms (SPARC, x86)</td>
</tr>
<tr>
<td>- High availability features</td>
<td>- Application Development Tools</td>
<td>- High availability features</td>
<td>- High availability features</td>
<td>- Oracle DBMS</td>
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<tr>
<th>Weaknesses</th>
<th>Windows Server</th>
<th>SUSE Linux</th>
<th>AIX</th>
<th>Oracle Solaris</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Run only on HP</td>
<td>- Applications</td>
<td>- Applications</td>
<td>- Run only on IBM</td>
<td>- Sun Server platforms (SPARC, x86)</td>
</tr>
<tr>
<td>- Vendor lock-in</td>
<td>- Server and Application development tools</td>
<td>- Vendor visibility, Maintenance and support lifetime</td>
<td>- Vendor lock-in</td>
<td>- Oracle DBMS</td>
</tr>
<tr>
<td>- License costs</td>
<td>- Costs of application servers and application development tools</td>
<td>- Licensing confusion</td>
<td>- License costs</td>
<td>- MySQL DBMS</td>
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<tr>
<td>- Current state</td>
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<tr>
<th>Opportunities</th>
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<tr>
<td>- Commercial and free UNIX platforms</td>
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<td>- Commercial and free UNIX</td>
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<tr>
<td>- Proprietary OS (Open VMS, z/OS, ...)</td>
<td>- Proprietary OS (Open VMS, z/OS, ...)</td>
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<td>- Proprietary OS (Open VMS, z/OS, ...)</td>
<td>- Proprietary OS (Open VMS, z/OS, ...)</td>
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</table>

6 Conclusions and future research directions

Both conceptual and implementation frameworks have been proposed for reengineering traditional business ISs into ‘always-on’ IS. ISs that enable continuous computing and BC. Conclusions and lessons learned are as follows:

- Traditional requirements with regard to business ISs identified some 30 years ago (efficient data processing, reporting, and managerial support) are being replaced in the e-business age by the requirements related to BC and ‘always-on’ business.

- Modern IS-infrastructures that are expected to provide continuous business operations require redefining the concept of IS by adding the attribute ‘always-on’.

- Enterprise servers and server operating systems that run business-critical applications have become critical when it comes to application availability. They have an important business perspective due to their role in minimising the costs of downtime.

- Features of the five server operating systems analysed in the case section demonstrate the transition to a BC-oriented server operating environment which plays a crucial role in achieving ‘always-on’ business.
A framework based on Churchman’s (1971) nine-condition systemic model identified additional dimensions, primarily those related to human aspects (the client, the designer, and the decision maker). It reflects some critical aspects of modern IS engineering such as objectives and measures of performances (HA and HA ratios), requirements from environment (continuous data access, ‘always-on’ business), teleological components (continuous computing technologies), and managerial aspects (the roles of CIOs, system admins, and BC managers). As such, presented framework can be used in the projects of transforming or migrating traditional business ISs into ‘always-on’ IS, particularly by focusing on the following holistic (systemic) dimensions:

- Business-oriented and customer-oriented IT-infrastructure driven by the requirement of being ‘always-on’.
- BC, identified as main objective of business system in the e-business age.
- Redefined role of measures of system performances, focusing primarily on system downtime/uptime ratios and their role in overall financial results of the company.
- Implementing continuous computing technologies in the form of teleological components within the IS infrastructure.
- Redefining the roles of clients, system designers, and decision makers particularly those of CIO, CEO, BC managers and system/network administrators.

Future research directions can be identified around the following research topics:

- Developing methodologies and methods for organisation-wide implementation of ‘always-on’ IS.
- Developing the role of system and network administrators and BC managers: from managing routine system/network operations towards a more comprehensive role in enhancing BC.
- Implementing ‘always-on’ IS in different models of IT-architectures: on-site premises versus cloud computing.
- Positioning the concept of always-an IS within the IT-compliance regulations and standards.
- Addressing managerial issues in integrating system/network administration, BC management, risk management, security management and organisational management.

References


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