A Case Study of Cloud-Based Business Continuity Model[1]

Felix Nyadzani Kutame[1[0000-0003-0121-3123]], Nixon Muganda Ochara[2[0000-0001-5736-7901]], Armstrong Kadyamatimba [3[0000-0002-9638-0858]], Alexander Sotnikov[4[0000-0003-2985-3704]], Igor Fiodorov[5 [0000-0003-2335-0452]] , Yury Telnov[6[0000-0002-2983-8232]]

[1,2,3] University of Venda, Thohoyandou Limpopo, South Africa
[4] Joint Supercomputer Center of the Russian Academy of Sciences, , Moscow, Russia.
[5,6]Plekhanov Russian University of Economics, Moscow, Russia;
[1]kutamef@yahoo.com, [2]muganda.ochara@univen.ac.za,
[3]armstrong.kadyamatimba@univen.ac.za; [4]ASotnikov@jscc.ru,
[5]Igor.Fiodorov@mail.ru; [6]Telnov.yuf@rea.ru;

Abstract. Contemporary cloud-based computing is crucial for the efficient delivery of ICT systems to users, as well as for versatile disaster recovery and business continuity management (BCM) platforms. Based on the need for efficient and fault-tolerant port operations, this paper proposes a cloud-based business continuity model (BCM) for the container terminal operations (CTO) in South Africa. The paper adopted a qualitative research approach as the basis for determining the requirements for the proposed cloud-based BCM. The results that provided the rationale for the proposed model revolved around the need for look at critical functions of CTOs, assessing the impact of ICTs on CTOs, looking at the influence of current BCM practices and focusing on a future architecture of BCM that is context-specific. The proposed Cloud-Based BCM for CTOs was therefore anchored on these results to propose a low cost, low configuration model with robust communications capabilities.

Keywords: Business Continuity Planning, Cloud-Based BCM, Container Terminal Operations, Digitalization

1 Introduction

Contemporary cloud-based computing is crucial for the efficient delivery of ICT systems to users, as well as for versatile disaster recovery and business continuity management (BCM) platforms. Prior research recognizes that Business continuity and efficiency are key factors for the development of port ICT systems [1]; and that such systems need to be designed using effective fault-tolerant techniques like Disaster Recovery (DR) solutions [2]. Based on the need for efficient and fault-tolerant port operations, this paper proposes a cloud-based business continuity model for container

[1,2,3,4,5] The study was funded by RFBR and NRF according to the research project № 19-57-60004//20

[6] The study was funded by RFBR according to the research project № 19-07-01137 A

[4] The work done within the framework of the state assignment (research topic: 065-2019-0014 (reg. no. AAAA-A19-119011590097-1)

Copyright © 2021 for this paper by its authors. Use permitted under Creative Commons License Attribution 4.0 International (CC BY 4.0).
Proceedings of the of the XXIII International Conference "Enterprise Engineering and Knowledge Management" (EEKM 2020), Moscow, Russia, December 8-9, 2020.

CEUR-WS.org/Vol-2919/paper3.pdf

terminal operations (CTO) in South Africa. The emphasis of the paper is on exploring current BCM practices that can aid in the development of a model for Digital Business Continuity for container terminal operations if there is a loss of centralized ICT systems.

The paper is structured as follows: the first part looks at how prior research is informing the current focus on developing a model for business continuity operations; this is followed by an explication of the research framework and the research methods that formed the "blue print" for this study. The third paper of the paper provides and analysis and interpretation of the results; while the final section focuses on the conclusions, theoretical and practical implications of the and suggestions for future research.

2 Related Works

Long standing research in business continuity planning and disaster recovery ensures the long-term viability of organizations [3]; compliance to government regulations and to international standards [4] and results in the reduction of supply chain disruptions, enhance disaster resilience and promote a more robust economy [5]. Particularly for organizations, any system downtime lead to reputational damage, lost trade and impacts on long-term projects; thus, firms are beginning to realize that BCM and DR solutions are critical to success [6]. Business continuity thus needs to be properly planned, tested and reviewed in order to be successful. However, despite the realization that BCM and DR solutions are critical for the success of organization, prior research acknowledge the dearth of application of BCM particularly in publica sector agencies [7]. Ports, considered as a key cluster of economic activity for nations, are typically run as public enterprises, with minimal research confirming the application of BCM in these entities [8].

3 Research Methodology

A qualitative methodology, employing the use of case study of the ports in South Africa was adopted in this study. A purposive sampling technique was to identify and interview 26 participants (Operations supervisors, ICT administrators, Safety officers, BCM and Risk officers) regarding the perspective and experiences on the effect of ICT unavailability on CTO in ports based in Durban, Port Elizabeth, East London and Cape, South Africa. The data collected was analyzed thematically and the findings formed the basis for the development of an architecture for a Cloud-Based BCM.

4 Analysis of Results

Thematic analysis of the interview data resulted in the following major themes (Figure 1).

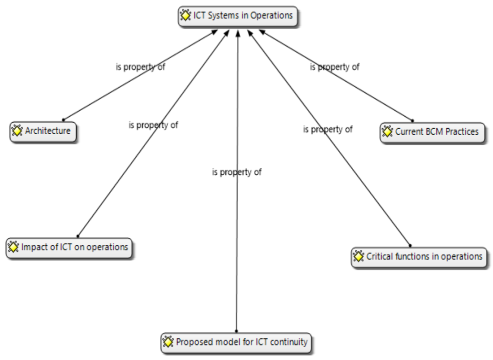

Fig. 1. Major Themes

Key insights emerging from the major themes that provided a motivation for the development of the Cloud-Based BCM for CTO are as follows.

5 Current BCM Practices

Interviewees were requested to indicate how BCM was handled at their terminals at the time of the interviews. Since BCM practices normally encompass the entire organization, respondents were asked questions that related specifically to BCM in the context of the loss of ICT systems. The findings indicated that there was no viable BCM planning in place, with majority of the respondents pointing a finger to the low level of maturity of BCM implementation in their organizations. Results further indicated that although the maturity level was low, some basic foundations for BCM at container terminals were in place. The respondents indicated that there were some ideas on how BCM could be conducted including operating the gates manually, segregating the terminal into sections that can be operated on separately, and by requesting more manpower. The entire BCM planning is currently based on manual and paper-based methods.

6 Critical Functions in Operations

Results indicated that stack-checking, reefer-checking, container movement, housekeeping and planning, were critical functions in container terminals. These functions, which were deemed important, also have their own modules in the TOS and are therefore an indication of what the BCM scope should be covering. From the qualitative results, it was established that ICT systems improved the manner in which operations were conducted, including processes for straddle carriers (straddle are machines that are used to move containers). Respondent remarks illustrated that operations including verifications of container positions, were operations that respondents felt were some of the most important at the terminal.

7 Impact of ICT on Operations

The second-order thematic analysis identified the following sub-categories – safety, unsafe use of radios, ease of use, old computer system and manual system. For instance, the interviewees indicated that due to the use of old computer systems, there are always challenges even when the ICT system is unavailable. That the old computer system only allowed for performing minimal operations; however, if the workload increases, then operating becomes a challenge. Further, that when the ICT systems becomes unavailable, results suggest that working manually requires (1) a large number of people to perform duties per shift, (2) performing manual capturing of documents (3) that operations be a labor-intensive process. Further, that with the loss of the ICT system, the result is unsafe working practices such as communication over radios, which is an unsafe practice in CTO environments.

8 Proposed Model for ICT Continuity

One of the questions that interviewees had been asked was whether they thought there should be an improvement in the present operations processes. Results from interviews indicated that there were certain functions that could be performed manually, provided the number of containers that needed to be moved was small. Manual operations could also only be performed on discharges only because the containers were being placed into the care of the container terminal. Results showed that containers can never leave the terminal if the ICT system is down.

Results suggest that it was still possible to run operations manually even in the larger terminals. However, these results also indicate that manual methods may be used partially or in special cases. This would still leave other operations largely abandoned and thus would not relieve the pressure brought on about by the loss of the TOS. Respondents did however conclude that going forward, working manually would eventually impact the CTO negatively. That going forward, there was need to consider and an ICT based business continuity solution. Suggestions from the respondents centered on making further enhancements on available TOSs that would allow them to be restored easier. Enhancements for the TOS included use of independent applications that could perform vessel planning for the TOS. Infrastructural solutions were also suggested such as using the cloud. There were also concerns about the bad state of the telecommunications infrastructure of South Africa which made ICT systems to be unreliability.

9 Architecture

Even though the theme of "Architecture" is linked to the previous one on "Proposed Model for ICT Continuity", it deserved an independent treatment since the respondents kept referring to an old architecture compared to the new architecture. Particularly for systems administrators, there was constant reference to the need to setup a system centrally instead of having each terminal host its own iteration of the TOS. They indicated the advantages of such an implementation compared to a distributed solution. Suggestions by respondents included separating environments which did not share information between terminals, robustness of some systems compared to others and low resource requirements. Other remarks about the architecture also revealed that it was possible to use third-party systems to provide business continuity for the TOS. Thus, decentralization of the database was an unattractive option for the systems administrators. That a centralized system was viewed as being advantageous due to its reduction of complexity (due to multiple databases which would require maintenance) and as a single source of data. This would help eliminate some of the problems that can cause system downtimes.

10 Cloud-Based BCM Architecture for Container Operations

The figure below captures the proposed architecture for BCM for port operations.

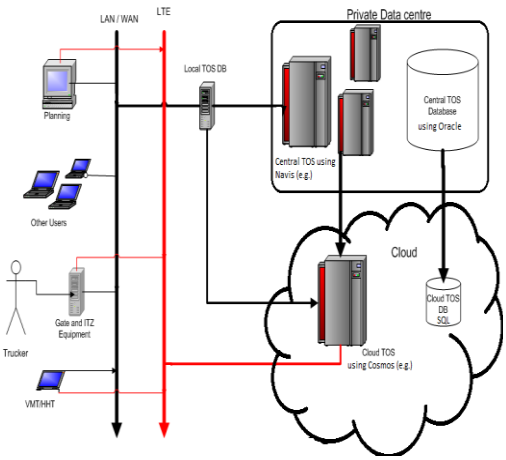

Fig. 2. Cloud BCM Architecture

The illustration depicts the model by showing it with two different connections consisting of two different colors: black for the private LAN and WAN connections and red for the LTE connection. In the conceptual model, all digital devices that need to access the TOS can do so via the LAN and WAN links. However, only those that run critical functions, i.e. planning, gate control and Vehicle Mount Terminals and Handheld Terminals (VMTs & HHTs) can have direct links via LTE to the cloud. The local TOS DB and the central TOS DB will replicate information with the standby TOS DB via the WAN link. The Cloud BCM model is designed in such a way that makes it ready for switch-over with minimal interaction from operators or system administrators. The critical features of the conceptual model are its cost effectiveness, low specification configuration, real time transactions and a robust communication configuration.

Ensuring a low-cost specification is imperative, as the cost of enterprise IT is growing due to nonlinear expansion of IT resource's requirements [9]. Cloud-based nature not only provides cost effective BCM, but also allows for flexibility that makes operations at container terminals be sustainable. Having a cost-effective solution will lessen the impact of cost for high availability systems. The other critical feature of the Cloud BCM model relates to the low specification configuration of the proposed architecture. The cloud provides a platform for designing BCM architectures that minimizes the complexity of systems. For instance, in the case of the proposed Cloud BCM architecture, using a low specification configuration lowers costs for the standby TOS implementation. Generally, in an active/passive cluster failover configuration, one or more passive or standby nodes are available to take over for failed nodes. Only the primary node is used for processing. When a node fails, the standby node takes over the resources and the identity of the failed node. The services provided by the failed node are started on the standby node. After the "take over", clients are able to access the services unaware that the services are being provided by a different node.

The low configuration architecture of the Cloud BCM conforms to a heterogenous active-passive configuration. In this configuration, the cloud-based TOS DB is not weighed down by performance issues that typically afflict the central TOS DB. A lower specification implementation may be used in line with BCM expectations that during a "failover", the BCM implementation does not necessarily provide the same level of functionality or performance [10]. This is because the Cloud BCM is meant for critical operations functions only, in order to keep operations running during a disruption. Other functions such as yard planning and berth planning are not required for live operations and therefore do not need to be catered for in the standby server. They are performed prior to operations and are only needed if changes are being made.

The proposed Cloud BCM conceptual model for port operations is not system or software-specific [11], although its idea was generated from the Navis N4 implementation at Transnet Port Terminals (TPT) in South Africa. The basic common feature of the model is a real-time transaction (See figure below).

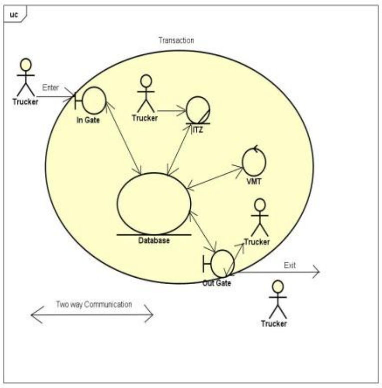

Fig. 3. Conceptual Model of a Transaction

In a container terminal operation, a transaction involves the basic transfer of a container from point to point and the concomitant actions that lead to and result from the container transfer. For example, a container drop-off transaction (typically an export transaction) will involve a truck entering the terminal gates, proceeding to the drop off interchange area, where a straddle carrier transfers the container from the truck to the yard and the truck exiting the terminal. A transaction is triggered by an input event such as a truck announcing its arrival at the gate. The transaction commences and directs the truck via different contact points such as gates and interchange areas. Within the transaction more input events such as VMTs add work instructions that facilitate container movement. Completed transactions are committed to the central TOS DB while incomplete transactions are held in cache at the local TOS DB.

In in the proposed transaction model, a cloud-based TOS DB is added, which is updated in real time by both the local TOS DB and the central TOS DB. The database architecture is a 'Standby Database' [12] which is a type of failover system in which there is minimal activity from the standby database itself. In this configuration, the cloud TOS DB does not participate in the processing of the database as a distributed database would require but maintains an Active-Passive configuration. For this configuration, the TOS is of a different vendor. Such a configuration renders this setup a heterogeneous environment. The idea is to have a completely independent implementation of the TOS database in the cloud.

The conceptual model of the communication feature of the Cloud BCM architecture is depicted in the figure below. Currently, the communication in the system flows from the input event, which is triggered by a user, to the local TOS DB and then to the central TOS DB before being saved and closed. When we add the cloud TOS DB, we add an alternative path in which the input event can access the cloud TOS DB directly and then save and close the transaction. The addition of the alternative path provides a robust communication model that improves the process of switching to a 'failover' mode. The proposed communication model illustrates the communication links configured in an Active-passive (HSDA) configuration showing how information will flow from the beginning of the transaction until closure. In the illustration, if any of the LAN and WAN links fail, the transaction can still be completed by directly going into the cloud TOS DB. An LTE connection is used for this connection due to its high bandwidth capability. The input event represents all inputs (gate transactions, OCR and sensor information, VMTs, HHTs and PCs used by equipment controllers) that feed information to the databases. For full redundancy, all the devices will need to have a separate connection from the regular one which is used under normal circumstances. The database therefore becomes dual-meaning. Either it is the central TOS DB during normal operations, or it can represent the cloud TOS DB during a disruption. Other than this change, the transaction remains the same.

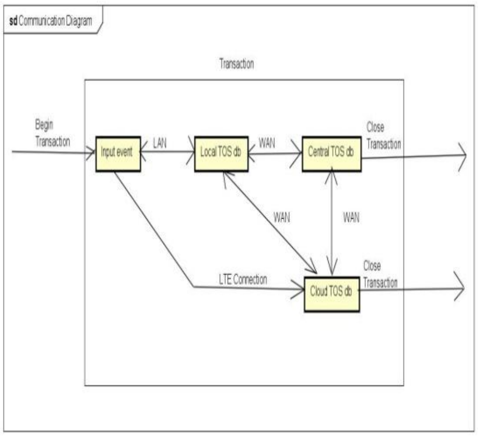

Fig. 4. Robust Communication Model

Thus, such a model would need to be a lighter version that would not involve too much complexity.

11 Conclusion

Robust implementation of BCM continue to a challenge, despite increasing digitalization. The results of this study confirm that using an ICT Cloud-based BCM implementation is a necessary antecedent to operations during systems failures. When implemented, the Cloud BCM model provides an alternative low cost, low configuration and robust communication architecture which is critical for port operations. The implications of such a Cloud BCM are twofold: the first relates to the implications of the increasing pervasiveness of 4G networks, and the increased pace of development of 5G networks. These developments, and the concomitant affordability of digital devices will make Cloud-Based BCM the primary disaster recovery strategy for port operations, particularly in Africa where communications platforms are increasingly mobile-based [13]. Secondly, as enterprise and inter-organizational ICT platforms become anchored on the open Internet (of things) backbone, the ‘shared’ ownership of the Internet will further drive down the costs of configuring Cloud BCMs and also simplify complexity; while enhancing interoperability of systems. Further research can explore how these developments can help in refining the proposed Cloud BCM in specific port operations, not only in specific regions only, but also globally.

References

1. D. Bosich, R. Faraone, and G. Sulligoi, “Modeling and Analysis of the Port of Trieste Electrical Distribution System,” in 2018 IEEE International Conference on Environment

and Electrical Engineering and 2018 IEEE Industrial and Commercial Power Systems Europe (EEEIC/I&CPS Europe), 2018, pp. 1–5.
2. J. Mendonça, E. Andrade, P. T. Endo, and R. Lima, "Disaster recovery solutions for IT systems: A Systematic mapping study," J. Syst. Softw., vol. 149, pp. 511–530, 2019.
3. H. F. Cervone, "Disaster recovery planning and business continuity for informaticians," Digit. Libr. Perspect., vol. 33, no. 2, pp. 78–81, 2017.
4. O. H. Alhazmi, "A Cloud-Based Adaptive Disaster Recovery Optimization Model.," Comput. Inf. Sci., vol. 9, no. 2, pp. 58–67, 2016.
5. J. Levy, P. Yu, and R. Prizzia, "Economic Disruptions, Business Continuity Planning and Disaster Forensic Analysis: The Hawaii Business Recovery Center (HIBRC) Project," in Disaster Forensics, Springer, 2016, pp. 315–334.
6. P. Timms, "Business continuity and disaster recovery--advice for best practice," Netw. Secur., vol. 2018, no. 11, pp. 13–14, 2018.
7. A. H. A. Hamid, "Limitations and challenges towards an effective business continuity management in Nuklear Malaysia," in IOP Conference Series: Materials Science and Engineering, 2018, vol. 298, no. 1, p. 12050.
8. P. W. de Langen and E. Haezendonck, "Ports as clusters of economic activity," The Blackwell companion to maritime economics. Blackwell, Oxford, pp. 638–655, 2012.
9. N. Ahmad, Q. N. Naveed, and N. Hoda, "Strategy and procedures for Migration to the Cloud Computing," in 2018 IEEE 5th International Conference on Engineering Technologies and Applied Sciences (ICETAS), 2018, pp. 1–5.
10. [N. Bajgoric, "Towards an always-on e-business," Routledge Companion to Risk, Cris. Secur. Bus., 2018.
11. S. Robinson, G. Arbez, L. G. Birta, A. Tolk, and G. Wagner, "Conceptual modeling: definition, purpose and benefits," in Proceedings of the 2015 Winter Simulation Conference, 2015, pp. 2812–2826.
12. T. J. Teorey, S. S. Lightstone, T. Nadeau, and H. V Jagadish, Database modeling and design: logical design. Elsevier, 2011.
13. N. J. Van Rensburg, A. Telukdarie, and P. Dhamija, "Society 4.0 applied in Africa: Advancing the social impact of technology," Technol. Soc., 2019.
14. D. Bosich, R. Faraone, and G. Sulligoi, "Modeling and Analysis of the Port of Trieste Electrical Distribution System," in 2018 IEEE International Conference on Environment and Electrical Engineering and 2018 IEEE Industrial and Commercial Power Systems Europe (EEEIC/I&CPS Europe), 2018, pp. 1–5.
15. J. Mendonça, E. Andrade, P. T. Endo, and R. Lima, "Disaster recovery solutions for IT systems: A Systematic mapping study," J. Syst. Softw., vol. 149, pp. 511–530, 2019.
16. H. F. Cervone, "Disaster recovery planning and business continuity for informaticians," Digit. Libr. Perspect., vol. 33, no. 2, pp. 78–81, 2017.
17. O. H. Alhazmi, "A Cloud-Based Adaptive Disaster Recovery Optimization Model.," Comput. Inf. Sci., vol. 9, no. 2, pp. 58–67, 2016.
18. J. Levy, P. Yu, and R. Prizzia, "Economic Disruptions, Business Continuity Planning and Disaster Forensic Analysis: The Hawaii Business Recovery Center (HIBRC) Project," in Disaster Forensics, Springer, 2016, pp. 315–334.
19. P. Timms, "Business continuity and disaster recovery--advice for best practice," Netw. Secur., vol. 2018, no. 11, pp. 13–14, 2018.
20. A. H. A. Hamid, "Limitations and challenges towards an effective business continuity management in Nuklear Malaysia," in IOP Conference Series: Materials Science and Engineering, 2018, vol. 298, no. 1, p. 12050.

21. P. W. de Langen and E. Haezendonck, "Ports as clusters of economic activity," The Blackwell companion to maritime economics. Blackwell, Oxford, pp. 638–655, 2012.
22. N. Ahmad, Q. N. Naveed, and N. Hoda, "Strategy and procedures for Migration to the Cloud Computing," in 2018 IEEE 5th International Conference on Engineering Technologies and Applied Sciences (ICETAS), 2018, pp. 1–5.
23. N. Bajgoric, "Towards an always-on e-business," Routledge Companion to Risk, Cris. Secur. Bus., 2018.
24. S. Robinson, G. Arbez, L. G. Birta, A. Tolk, and G. Wagner, "Conceptual modeling: definition, purpose and benefits," in Proceedings of the 2015 Winter Simulation Conference, 2015, pp. 2812–2826.
25. T. J. Teorey, S. S. Lightstone, T. Nadeau, and H. V Jagadish, Database modeling and design: logical design. Elsevier, 2011.
26. N. J. Van Rensburg, A. Telukdarie, and P. Dhamija, "Society 4.0 applied in Africa: Advancing the social impact of technology," Technol. Soc., 2019.