Exostructure Services for Infrastructure Resources Optimization

JosephNg, P.S.[1,2], KamilMahmood, A[2], Kang, C.M.[2], Choo P.Y.[3], Wong S.W.[3], Phan K.Y.[3], Lim E.H.[3]
[1]*Faculty of Computer and Information Science,*
University Technology Petronas, Bandar Seri Iskandar, 31750, Tronoh, Perak, Malaysia.
[2]*School of Computing & Creative Media,*
KDU University College, Jalan Kontraktor U1/14, Seksyen U1, 40150 Shah Alam, Selangor, Malaysia.
[3]*Faculty of Information & Communication Technology,*
University Tunku Abdul Rahman, 31900, Kampar, Perak, Malaysia.
josephnps@hotmail.my

***Abstract*—The emerging challenges for Malaysia medium sized enterprises to remain competitive is testing and stressing the extent of the capacity and even the capability of IT infrastructure, especially regarding on its resource utilization for cost effective sustainability during this time of economic uncertainty. They are stuck in between the larger enterprises that enjoy economies of scales and the much smaller enterprises with insufficient baseline to motivate contribution. This research evaluated two theories from Harvard University: Commodity of IT infrastructure and Disruptive Technology for its suitability and ascertain its adaptability to a localized environment. Primary data collection via mass survey is conducted for exploratory analysis. The findings show significant imbalance IT infrastructure investment decision and the reasons behind, supported by the statistical evidences collected. The paper then seeks to establish a new cost effective virtualization framework for them to plan ahead. As infrastructure investment requires a longer period to yield positive contribution, early implementation will prepare them for the next bull run.**

***Index Terms*—Cloud Computing; Economic Turbulence; Exostructure; Framework; Grid Computing; IaaS; ICT Infrastructure; Small And Medium Sized Enterprise; Virtualization.**

I. INTRODUCTION

The MSEs have been a significant contributor to Malaysian economy, with over one billion Ringgit to the total Malaysia Gross Domestic Productivity (GDP) [1]. As the MSEs are not as big as their larger Multi National Corporation (MNCs), however, it continues to play a much bigger role than the Small Enterprises. While the Internet of Things (IOT) enables and empowers the MSEs with the digital tools that results in reduced shared cost while enlarging their business opportunities. Understandably, as production sales are demand driven with challenging cycles, the need for on-demand shared services is unavoidable with 54% increase in IT spending [2]. Therefore the research aims to deliver the following objectives as shown in Table 1.

The MSEs face serious resource poverty with fragmented IT operation that focused on day to day tactical strategies. The MSEs also lacked in relevant research on the utilization of infrastructure optimization due to the perceived low monetarily commercial and volume value when compared to larger multinationals. Past researches have shown that many MSEs have over invested in IT infrastructure and this has inevitably increased the operation cost and by extension, hampered their business sustainability [3]. But with the advancement in IT resources outsourcing, MSEs should be able to embrace much more complex solution or better. Kun [4] has suggested that as MSEs start to grow, they should "*invest in information technology, which allow the organization to process more information without overloading the communications channels*". The advance and maturation of technology that have over time integrated into standard operating procedures like automated manufacturing have pushed MSEs to be much more efficient thus enabling their global competitiveness. The above mentioned challenges have led to the formation of the research questions shown in Table 2. This paper aims to provide a theoretical framework for the development of a cost efficient barebone virtualized network for the MSEs.

Table 1
Research Objective

RO1 : How can MSEs maximize available infrastructure investment distribution?
RO2 : How can MSEs minimize implementation difficulties?
R03 : How can MSEs improve their critical processes?
R04 : How can MSEs priorities their IT budget?

Harvard University' Nicholas Carr's [5][6] believe that technology is a "commodity product" and therefore can be applied to MSEs to gain competitiveness. This statement is supported by George [7] paper "*Outsourcing and Globalization: The View from the United States"*. Furthermore, technology chasing is an expensive management decision and impractical for MSEs with limited financial consideration. Simply said, MSEs only need to reuse a working technology from MNC and their best practise but just in a smaller scale.

Table 2
Research Questions

RQ1 : What are the level of IT infrastructure investment distribution at MSEs?
RQ2 : What are the implementation difficulties faced by MSEs?
RQ3 : What are the critical processes at MSEs?
RQ4 : How does the IT budget being distributed at MSEs?

The theory on disruptive technology formulated by Christensen Clayton [8] from Harvard University that focus on "product life cycle" distortion can be a lesson learnt for in the case of *"Disruptive technology: How Kodak missed the digital photography revolution"* by Lucas & Goh [9]. Although the newest and most sophisticatedly attractive technology can make the enterprises standout from the crowd but when is the best commercial period to invest into this technology? This is where MSEs need to adopt a technology that provide sufficient unique competitiveness to standout from the saturated rivalry.

Lee [10] has stressed that "*the success of a firm depends on its ability to take advantage of the technology shifts to innovate in their business models and eventually to compete differently"*. MSEs with their known resources constraints and the complexity of managing advance technology, virtualization is the best options for MSEs [10][11]. However, considering that 73% of the respondents in Kappelman [12] survey still used their internal infrastructure, it shows there is plenty of room for improvement.

JosephNg's [13]research have highlighted the management concerns about the challenges of scarce resources and the complexity of IT infrastructure within the MSEs and "*should continue to invest in optimized IT infrastructure despite the economic turbulence*". As infrastructure investment requires broader and longer timeline to yield positive results, this quantitative findings will help to address the important action needed to be taken for MSEs to move forward.

II. Methodology

This research compiles mass survey data to explain the phenomenal sequence that support for resources optimization [14][15][16][17]. The research is a continuation from the previous qualitative work by JosephNg [13]. The sequence of qualitative and quantitative studies help to provide explanation to IT infrastructure investment challenges faces by MSEs. The information collected were correlated for its significances to the impact of the research problems as summarized in Table 3.

Table 3
Research Methodology [16][19]

Research Dimension	Explanatory Sequential Design
Research Methodology	Quantitative Generalization
Research Methods	Self-guided random survey (Operation Level)

We run the test using Statistical Package for Social Science to extract the Spearman Rank Order Correlation to calculate and test the statistical strength between the sets of ranked data accordingly. As rho focuses on the rank relationship rather than categorization while avoiding making any assumption about the nature of its non-parametric metrics, it was selected for this research [20][21].

The quantitative data collection and generalized exploratory analysis is used to statistically support the outlier discussion in JosephNg [13] qualitative research. 122 top management staff and executive have responded to the survey which was distributed by IT students who were undergoing their undergraduate final year internship onsite in various enterprises across Malaysia.

III. Results And Discussion

Although MSEs are moving towards to becoming a large enterprises, most of them are still very skeptical about infrastructure investment.

Figure 1 shows that an alarming 35% of MSEs infrastructure are either under invested (18%) or over invested (17%). As the resources becomes scarcer, it is important to ensure maximum infrastructure utilization. Technology, especially IT infrastructure is a time sensitive investment as some enterprises prefers to "wait and see" while others jump immediate into the bandwagon. However, IT infrastructure requires maturity period to stabilize and then yield positive contributions.

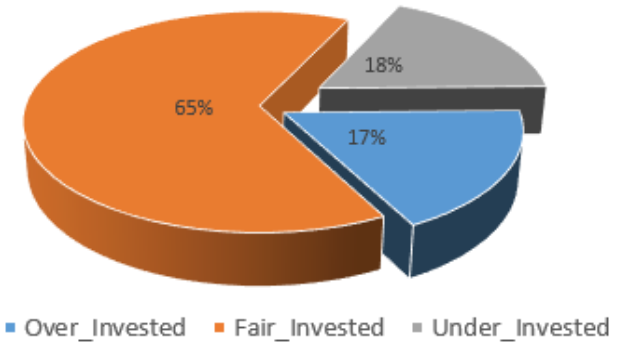

Figure 1 : Investment Level

Although Figure 2 of our research also shows that 45% of MSEs faces difficulties in budget constraints during implementation where they are stuck in between the financial might of larger enterprises with increasing volume output when compare to the smaller enterprises. These resource constraints have affected their lack of coordination within the internal department have caused 16% of their implementation problems. Without sufficient budget to implement appropriate technology modernization to communicate with important stakeholders, they continue to inherit these coordination challenges. This could have been initiated from their lack of product knowledge (19%) that is their second largest causes of implementation difficulties and could also be due to their lack of budget. The 11% internal and external issues could have been derived from the inability to acquire new knowledge due to the budget constraint and also the smaller sales volume due to the limited sales turnover that demotivate supplier's full support to the MSEs.

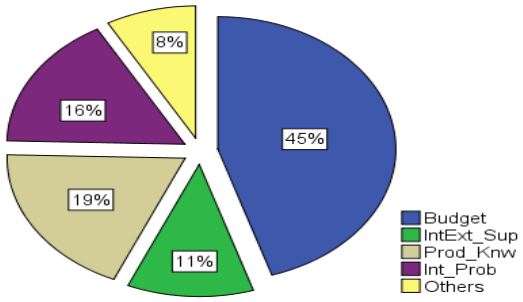

Figure 2 : Implementation Difficulties

Table 4
Critical Process

	Client	Supplier	Branch	Internal
Client	1.000	0.282	-0.200	-0.365
Supllier	0.282	1.000	-0.396	-0.519
Inter_Branch	-0.200	-0.396	1.000	-0.162
Within_Internal	-0.365	-0.519	-0.162	1.000

MSEs have two distinct and exclusive critical process groups, namely Client with Supplier (Sig = 0.02 > 0.01 level) and Branches with Internal (Sig = 0.074 > 0.05 level). Whenever MSEs focus on the client process, they will then pressure their supplier to fulfil its supply chains as shown in Table 4 with a positive correlation of 0.282. The positive relationship here shows the importance of having an integrated solution that can be accessed by both client and supplier. As MSEs are still expending and have limited branches and organizational structures, their emphasis will be on their internal inter-departmental processes as shown by the negative correlation. However, as infrastructure requires more resources and time to fine tune their business process re-engineering, it is highly critical therefore that their infrastructure are able to grow together with the business as their enterprises grows or consolidate whenever there is a market downturn. However as MSEs focus on their client processes, they tend to place internal activities such as restricting as a lower their priorities over branch and internal activities. This proposition can be confirmed from the results shown in Figure 2.

Table 5
Competitive Critical ICT Investment

	Hardware	Software	Maintain	Consultant
Hardware	1.000	0.298	-0.155	-0.571
Software	0.298	1.000	-0.275	-0.44
Maintain	-0.155	-0.275	1.000	-0.152
Consultant	-0.571	-0.44	-0.152	1.000

In Table 5, Maintenance has a significant level of 0.089 over Hardware and also has a significant level of 0.096 over Consultancy at the typical 0.05 level. The negative and very weak correlation coefficient (-0.155) between Hardware and Maintenance is due to the investment of new hardware and thus requires lesser maintenance charges as shown in Table 5. Larger enterprises will refresh their desktop device every three years while server will be around four years. While embedded technology becomes more advanced, stable and affordable, the competitive advantage of technology uniqueness becomes more saturated. More significantly is the expert advice of the Consultant that will reduce the need for further Hardware investment.

The Consultant also has a negative moderate coefficient of -0.440 in Software investment that allows fuller information extraction from. However as MSEs face stiffed budget constraints, the emphasis is to outsource their minor and unrelated IT infrastructure operations and maintenance as they focus on their core business requirements. This is where the consultants can be just be providing a knowledge based advice or solution that can include products and integrations. The solutions can also be provided to multiple clients from various MSEs for economies of scale or specialization services.

A. Exostructure As a Service (EaaS)

The infrastructure shown in Figure 3 is a virtual server that is created from the virtualization of various underutilized local devices. Each of devices is configured with virtual client to create a virtual server in order to form a grid service that will host the application software (SAP's ERP) into a Software as a Service (SaaS) platform or as an Infrastructure as a Service (IaaS) like shared virtual office to small emerging enterprises. The devices will then be reconnected to the virtual server to access the application software as if it was a normal server. As the number of client's device increase, the demand for processing capabilities of the virtual servers would also increase and this is supported by the same increase in desktop. Thus this parallel increment provides a cost effective demand versus supply of resources. EaaS is also contractible when the economy is volatile and slowing down. Since the service is established from available running device and as the device is being removed out, so will the sized of the services. Therefore it limits the wastage of unused resources and promotes investment efficiencies. This elastic service is highly efficient as it dynamically adjust itself as the MSEs move along it life cycles. More importantly, EaaS was designed to address the 35% of unfairly IT infrastructure investment highlighted from the survey in Figure 1.

EaaS will utilize existing available infrastructure and therefore helps to minimize budget challenges as described in Figure 2. These budget can then be channel to acquire more product knowledge to reduce internal problems or improve internal and external support within the MSEs.

Integration is a solution to bring both the client and supplier into the heart of operations, yet MSEs faced serious resources constraints to house these external stakeholders within their challenging resources. By hosting ERP into the cost effective EaaS to provide value added Customer Relationship Management (CRM) and extending their Just In Time (JIT) with Supply Chain Management (SCM), MSEs can increase the competitive advantages. Although MSEs is in the infancy stage of growing but knowing that IT infrastructure requires longer time to yield positive contribution while virtualization requires migration planning and infrastructure re-engineering, this is the right moment for electronic business communities with expanding overseas branches.

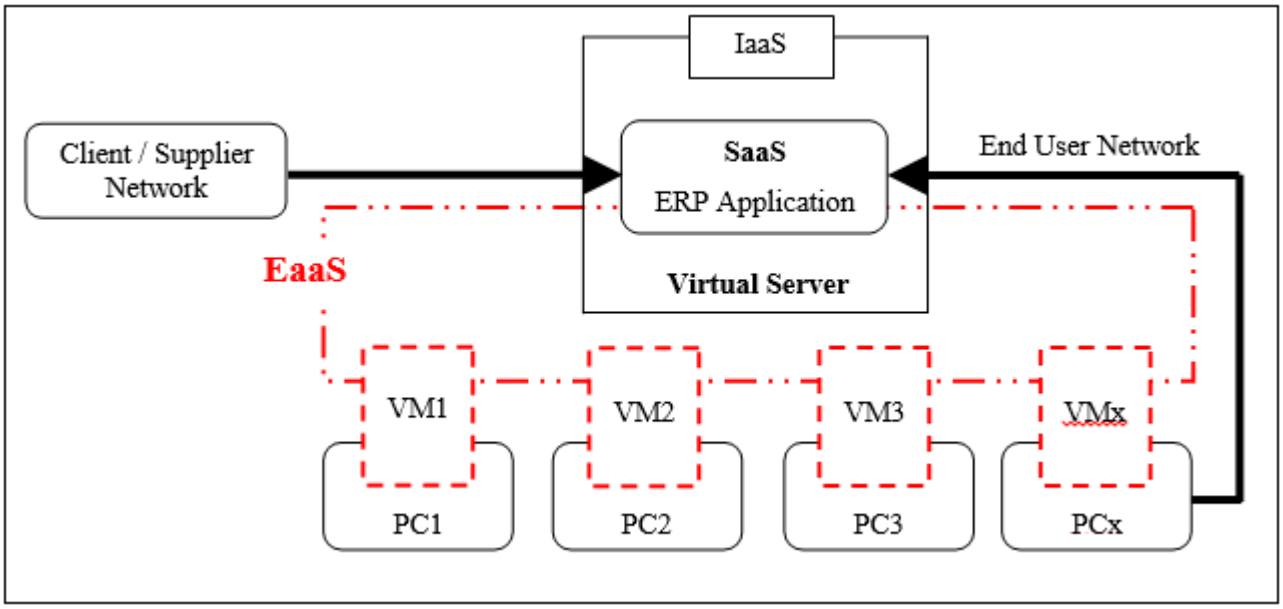

Figure 3 : EaaS Logical Architecture [13]

The EaaS shown in Figure 3 provides the technology uniqueness that supports the sustainability of the MSEs during an economic turbulence. It helps them to remain competitive and able to penetrate into the larger and more lucrative multinational market places. The solution is the provision of a new virtual service that reconsider the budget distribution challenges faces by many MSEs. With the creation of a multi access platform, the EaaS enables both groups of critical process owners from Client with Supplier and Internal versus Branches to be addressed. Moreover, it can also be used for faster local access while supporting disaster recovery. As EaaS is a shared service, it will help to minimize implementation difficulties plus maximizing infrastructure investment.

IV. Conclusion

As Malaysia continues to ride the negative economic outlook and political instability [22], MSEs must be prepared to make changes, especially from an IT infrastructure perspective. Despite the resource constraints, virtualization has provided resource maximization for MSEs to continue to provide dominance to the national productivity persistently. While the economic turbulence may remain unruly, the solution to IT infrastructure provisioning can still be recouped by using the existing available underutilized operation devices within budget. As virtualization is inherited from the proven MNC implementation, the semantic risk is mitigated from best their best practices.

The localized virtual services still have plenty of room for fine tuning and therefore provides opportunities for greater research into the EaaS implementation. This adopted quantitative research framework development has provided a platform to solicit more extensive research in future. It also serves as a reference for further development during a turbulence economy which is happening now and will continue for the next few years as SunBiz wrote in its 2016 article about Malaysian "*Manufacturing conditions worsen*" [23].

References

[1] Tsai, K.H. & Hsu, T.J. (2012), Linking cross functional collaboration, innovation performance and competitive intensity: towards a medicated moderation perspective, *Asian Journal of Technology Innovation*, V20, I1, pp. 113-126.

[2] Vinotharan, K. (2014), IT spending to rise for small business, Malaysian Reserve, 3 September 2013, pp. 6

[3] JosephNg, P.S., Mahmood, A.K., Choo, P.Y., Wong, S.W., Phan, K.Y. and Lim, E.H. (2013), Battles in Volatile Information and Communication Technology Landscape : The Malaysia Small and Medium Enterprise Case, *International Journal of Business Information System*, ISSN 1746-0972, V13 N2 2013; pp. 217-234

[4] Kun, S.I., Grover, V. & Teng, James T.C. (2013), Research Note, Do large firms becomes smaller by using information technology?, *Information Systems Research*, V24, I2, pp. 470-491.

[5] Carr, N.G. (2003), IT Doesn't Matter, *Harvard Business Review*, May, 2003, pp. 41-49

[6] Carr, N.G. (2005), The End of Corporate IT, Computerworld (May), *MIT Sloan Management Review*, Spring 2005, V46 N3, pp. 66-73

[7] George, J.F., Valacich, J.S. & Valor, J. (2004), Does IT Still Matter?, *Twenty-Fifth International Conference on Information Systems*, pp. 1039-1048

[8] Clayton M. Christensen, (2006), The Ongoing Process of Building a Theory of Disruption, *Journal of Product Innovation Management*, V23, I1, pp. 39-55.

[9] Lucas, H.C. and Goh, J.M. (2009), Disruptive technology: How Kodak missed the digital photography revolution, *Journal of Strategic Information Systems*, V18, I1, pp. 46-55.

[10] Lee, C.Y., Park, H.J. and Park, Y.T. (2013), Keeping abreast of technology driven business model evolution: a dynamic patent analysis approach, *Technology Analysis and Strategic Management*, V25, I5, pp. 487-505.

[11] Chandio, F. H., Abbasi, M.S., Nizamani, H.A. & Nizamani, Q.U.A., (2013), Online banking information systems acceptance: A structural equation modelling analysis, *International Journal of Business Information Systems*, V12, N2, pp. 177-193.

[12] Kappelman, L., Luftman, J. and McLean, E. (2014), SIM IT trend study

2013, Symposium, November 2013, Boston, http://bit.ly/1asjfDN, Accessed on 18/01/2014

[13] JosephNg, P.S. & Kang, C.M. (2016), Beyond Barebone Cloud Infrastructure Services: Stumbling Competitiveness During Economic Turbulences, Journal of Science & Technology, 24(1), pp. 101-121.

[14] Venkatesh, V., Brown, S.A. and Bala, H. (2013), Bridging the qualitative-quantitative divide: Guideline for conducting mixed methods research in information systems, *MIS quarterly*, V37, N1, pp. 21-54.

[15] Paliokaite, A. (2012), The relationship between organisational foresight and product innovation in small and medium sized enterprises, *8th International PhD Conference, School on National Systems of Innovation and Economic Development*, Globelic Academy

[16] Kang, C.M., JosephNg, P.S. & Isa, K., (2015), A Study on Integrating Penetration Testing Into the Information Security Framework for Malaysian Higher Education Institution, *The International Symposium on Mathematical Sciences and Computing Research*, Ipoh, Malaysia

[17] JosephNg, P.S. et. al., (2015), Beyond cloud infrastructure services in medium size manufacturing, *The International Symposium on Mathematical Sciences and Computing Research*, Ipoh, Malaysia

[18] JosephNg, P.S., Mahmood, A.K., Choo, P.Y., Wong, S.W., Phan, K.Y. and Lim, E.H. (2014), IaaS Cloud Optimization during Economic Turbulence for Malaysia Small and Medium Enterprise, *International Journal of Business Information System*, V16, N2, pp. 196-208, ISSN 1746-0972,

[19] JosephNg, P.S., Mahmood, A.K., Choo, P.Y., Wong, S.W., Phan, K.Y. and Lim, E.H. (2015), Barebone Cloud IaaS: Revitalization Disruptive Technology, *International Journal of Business Information System*, V18, N1, pp. 107-126, ISSN 1746-0972

[20] Bafrouei, K.B., Sarlak, M.A., Mahmoudi, S.M. and Jandaghi, G., (2013), An investigation into the effects of applying management information systems (mis) on managers' decision making in university case studies: University & higher education institutes in the city of Qom, International journal of economy, management and social sciences, 2(6), pp. 387-395.

[21] Nia, K.E and Roohipur, M.M.M., (2013), Management information systems and its relationship organizational structure (Case study of Rasht City Bank), Interdisciplinary journal of comtempary research in business, V5, N1, pp. 1139-1144.

[22] Tong (2016), Turbulent start to 2016, Investing, The Edge, Jan 11-17, pp 12.

[23] SunBiz (2016), Manufacturing conditions worsen, 5 January 2016, *SunBiz*, pp. 16