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Applied Protection Motivation in Safeguarding Lessons Learned During Information Technology (IT) Disaster Recovery

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Abstract

The ultimate objective of any Information Technology (IT) service provider is to deliver uninterrupted service to customers. However, in the event of a disaster, a cause for organisations failing to meet this objective is the absence of knowledge that can guide response initiatives, namely, key lessons learned from prior disasters. In this research, the DR process and associated activities in client organisation were studied using an Action Research (AR) approach. The interview and focus group discussion was concluded that limited attention is given for the knowledge that can prevent future repetitive error and safeguard time and cost. In this study, Protection Motivation Theory (PMT) by Maddux and Rogers (1983) were used as theoretical framework to guide the simplification of the DR lesson-learned process. To safeguard lessons learned or valuable information requires a human to embrace the importance of "self-efficacy" and "response efficacy". PMT is one of the well-known theory in research sphere of health psychology. However, interestingly since 2008 PMT has been started to be applied in IT, Information Systems (IS) and Computer research areas. As per Scopus database, a total of 86 articles were published from 2008 until September 2019. This clearly indicates that PMT is one of the appealing theory and actively being used in IT, IS and Computer research. The simplified lesson-learned DR process were tested over four simulations and accepted by client organisations because they demonstrate the capability to minimise errors, which will indirectly lead to time and cost savings. The simplified process enabled the client organisations to learn from past experience and improve future responses in their DR activities.

Keywords: Information Technology, Information Systems, Disaster Recovery, Protection Motivation Theory

1 Introduction

In the present day of digitalisation, DR is considered a critical management issue faced by private and public organisations. This phenomenon is attributed to interruption of any kind of IT service, which can be truly devastating for the operational performance and reputation of an organisation (Elstien and Westbrook, 2001). According to Contingency Planning and Management, over 40% of companies that are forced to shut their doors for a minimum of three days due to a disaster will be unable to survive for more than 36 months. Zetta Survey Report (2016) indicated that 54.0% of the respondents had experienced a disaster situation or service interruption that lasted for more than 8 hours over the past 5 years, and two-thirds of the

surveyed companies lose more than USD 20,000 for every downtime. However, the financial figures increased in 2017 as another survey reported that more than 12.0% of organisations suffered a loss of ≥USD 100,000 (Disaster Recovery Journal, 2017). A key reason for the failure of IT organisations after a disaster is absence of knowledge, namely, lessonslearned information, as well as ineffectiveness of disaster preparedness (Conference Board, 2006; Li, Zhou, Zeng, Wang, Zhou, Wang, Xu, Huang, Wang, Zhang, Luis, Chen, Navlakha and Iyenger, 2017). However, the real challenge in an IT environment during a disaster is ensuring that employees have all the relevant information stored in a centralised knowledge base for rapid recovery of the IT services and the ability to safeguard any new valuable information for future use.

In this study, the selected client is one of the many other IT Multi-National Companies (MNC) in Malaysia. To understand the end-to-end DR process and actual way of working of the client organization, interview and focus group were set up with the DR team to obtain a clear picture of their current DR process and the manner by which the DR team follows it from the book. The current approach of the DR test activity flow in the client organisation is to capture lessons-learned information after the DR test activity is completed. This process is called 'DR PTR', as depicted in Figure 1. The DR team usually performs PTR a day or two after the DR test activity. This activity usually takes 48–72 hours to complete. Capturing information at a later stage can lead to missing valuable information. The researcher perceived that this process can be improvised to preserve valuable information.

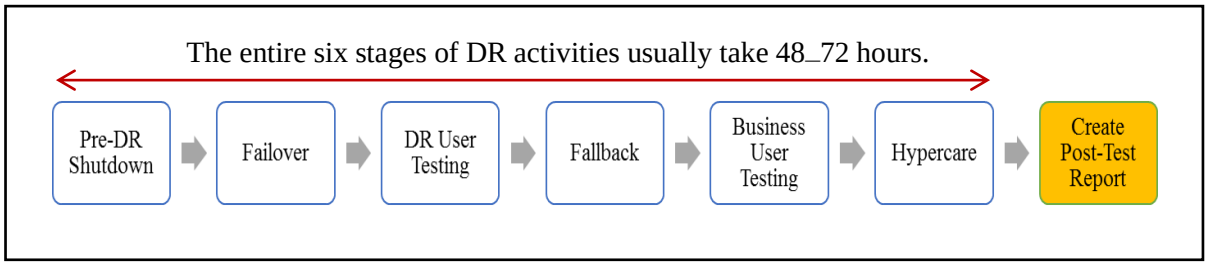

Figure 1
Current Way of Capturing Lessons Learned in Client Organisation

2 Literature Review

PMT is operationalised in terms of the 'intentions' of the stakeholders to perform a recommended precautionary behaviour (Maddux and Rogers, 1983; Milne, Orbell and Sheeran, 2002). Table 1, Maddux and Rogers (1983) explained that the motivation of an individual to save from harm is improved through four elements (i) severity, (ii) vulnerability, (iii) response efficacy, and (iv) self-efficacy. Two components from table above will be put forward in this research, namely Self-Efficacy (SE) and Response Efficacy (RE). SE and RE are the two attributes that postulate the behavioural intention during DR activities. SE is an IT engineer's ability to perform the recommended behaviour with their level of confidence, that is, safeguarding lessons learned during DR activities. RE is the belief that the recommended response, that is, using lessons-learned database for DR effectiveness, can reduce time, cost and error.

In 1995, these two researchers Compeau and Higgins, clearly explained about individuals who have elevated levels of self-efficacy concerning information systems is very determine to make use of the systems in their task compare to those individuals with diminutive selfefficacy. The same researchers also noted that the self-efficacy has been made known to encompass an

important force on individual capability to carry out behaviors. On the same context, it was concluded that self-efficacy give emphasis to the individual's ability to muddle through their daily chore (Bandura, 2008 and Rhee, Kim, and Ryu, 2009). An individual who has high probability in taking up an adaptive behavior is who has self-efficacy knowledge to protect from risk with the suggested coping method (Rogers, 1983; Lee and Larsen, 2009).
Most of individuals will have less certainty in regards to efficacy measurement, however some possibly will not enthusiastic to acknowledge it (Rippetoe and Rogers, 1987).

Coping cognitive appraisal from PMT refers to a cognitive process that evaluates an individual's capability to handle the risk (Rogers, 1983). SE describes the individual's own abilities to handle a given task (Bandura, 1977, 1991). Anderson and Agarwal (2010) reported that the SE denotes to workers' personal confidence. Ifinedo (2012) measured SE as the type of skill and measure that can be called upon to protect information. Individuals with greater levels of self-efficacy with regard to IS are much likely to employ such systems in their work environment than those with low SE (Compeau and Higgins, 1995). RE refers to individuals that own the necessary awareness or understanding the suggested procedures in safeguarding a risk, that is, the individual's probability to embrace the suggested behaviour (Rogers, 1983; Lee and Larsen, 2009).

Table 1
Maddux and Rogers (1983) Protection Motivation Theory Dimensions

Dimensions	**Descriptions**	**Sources**
Severity	Perceived severity during threatened event.	Rogers, 1975 Maddux and Rogers, 1983
Vulnerability	Perceived probability of occurrence of a threatened event.	Rogers, 1975 Maddux and Rogers, 1983
Self-Efficacy	Confidence in an individual ability to cope with threat and perform threat reducing behaviors.	Bandura, 1977 Rogers, 1975 Maddux and Rogers, 1983
Response Efficacy	Ability of the response to reduce the threat.	Rogers, 1975 Maddux and Rogers, 1983

To date, DR is a critical activity in every organisation. However, this activity does not depict as such because most organisations are focused on the daily operational activities rather than on having a DRP (Vance, Eargle, Ouimet, and Straub, 2013). That is the ordinary thinking process which is inherited by human that leads to believe the likelihood of a catastrophe beating is unimportant, as a result the pressing awareness and resources are committed apparently more burning problems. Assuming that IT organisations perceive the missing valuable information from lessons learned as the major threat (risk or concern), this theory proposes that individuals decide whether they would conduct a recommended adaptive action that is, following the proposed DR lessons-learned process. PMT has been recognised as one of the explanatory theories for predicting a person's intention to engage in protective actions (Anderson and Agarwal, 2010). Mainstream IS theories undoubtedly play a key role in understanding motives to improve the DR lessons-learned process. However, the IS field may also have its own advantages from applying theories from other disciplines. Although PMT is a well-known theory in the health psychology research domain, previous literature indicates that it is one of the appealing theories and actively used in IS research since 2008, this will be further explained in the next section.

2.1 Research Gap

As per the derived literature, this study takes an effort to fill the gap of knowledge protection in the context of DR in IT organization. A query was run in Scopus database using Protection Motivation Theory (PMT) keyword to find related publications. Scopus database was selected to derive the journals data for the reason that it is peer-reviewed literature with a wide-ranging overview of research publications. The analysis was analyzed using Microsoft Excel spreadsheet software. A total of 702 publications were found to be published between 1981 to September 2019 (Figure 2). These publications contains all types of document (total of publications), namely, Article (545), Article in Press (7), Book Chapter (13), Conference Paper (102), Conference Review (2), Note (1) and Review (32).

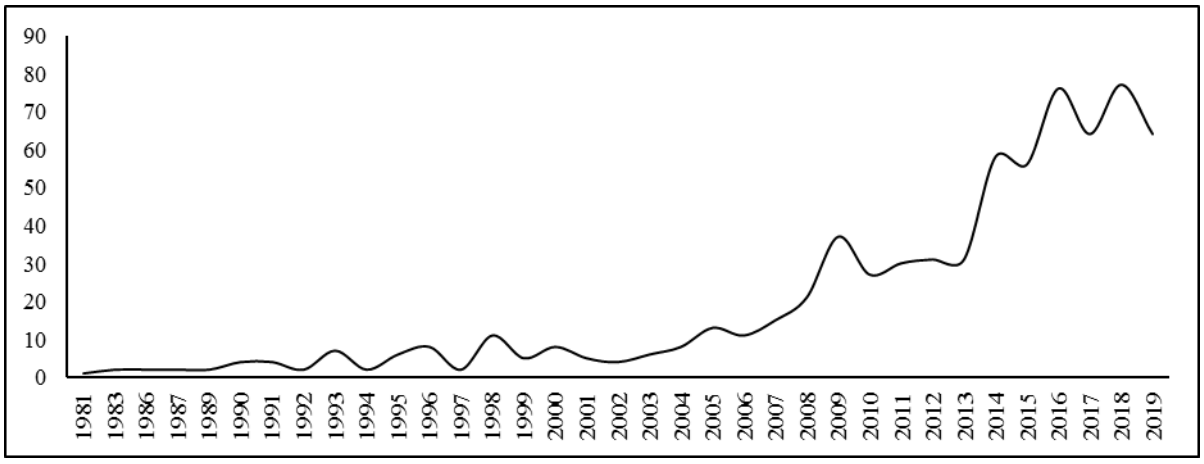

Figure 2

All Journals with Applied PMT in Scopus (1981 to September 2019)

2.2 IS, IT and Computer Journals Applied PMT

Figure 3, further analysis was performed on the 545 Articles to identify PMT applied in IS, IT and Computer journals. A search with keyword "information systems", "information technology" and "computer" was done in the column "source title" to scrutiny PMT articles which have been published in IS, IT and Computer related journals. Analysis revealed that PMT has been started to be applied in IS, IT and Computer domain since year 2008, and a total of 86 articles were published between 2008 until September 2019. The chart's linear trendline shows that there is a gradual increase from 3 articles published in 2008 to 12 articles in 2019. This clearly indicates that PMT is one of the appealing theory and actively being used in IS, IT and Computer research areas.

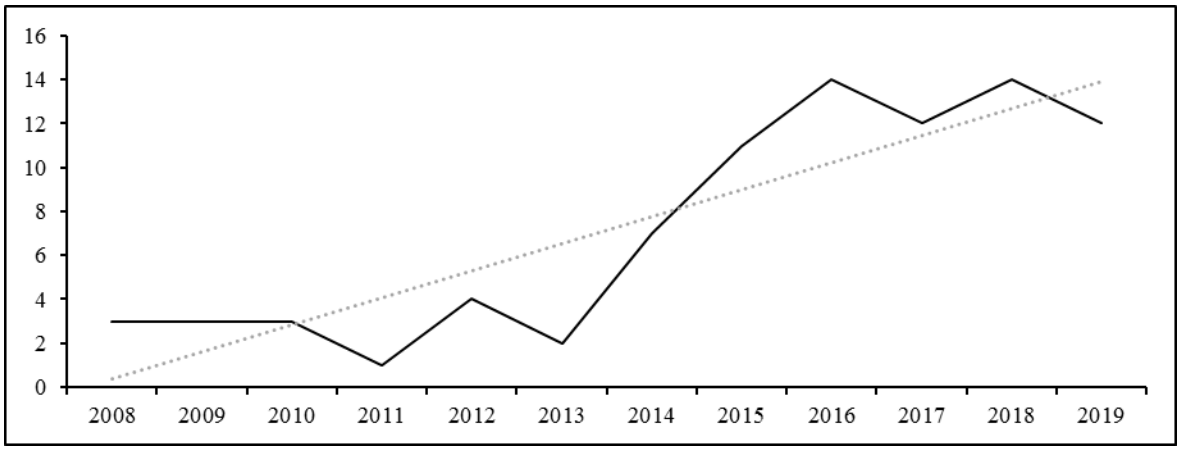

Figure 3
Applied PMT in IS, IT and Computer Journals

In addition, another deep-dive analysis was done on the 86 articles to distinguish the top journal in IS, IT or Computer that has applied PMT in their research. Table 2 below demonstrates the list of IS, IT and Computer Journals with Computer in Human Behavior, Computers and Security and MIS Quarterly: Management Information Systems were ranked as the top 3 journals with the highest usage of PMT in their studies.

Table 2
Articles with PMT Published *IS, IT and Computer Journals*

IS, IT, Computer Journals	**Total of Articles Published (2008 to September 2019)**
Computers in Human Behavior	13
Computers and Security	10
MIS Quarterly: Management Information Systems	6
Information and Management	5
Behaviour and Information Technology	5
Information Systems Frontiers	4
European Journal of Information Systems	4
International Journal of Human Computer Studies	3
Decision Support Systems	3
Journal of Management Information Systems	3
Total	**56**

2.3 Disaster Research with Applied PMT

Table 3, using "disaster" as the keyword, a simple search was performed on the abstract column for 545 papers. This will indicate the extent of PMT usage in disaster setting. A total of 15 articles were identified using PMT in their research in the context of disaster. However, only 1 article was studied in IS or IT or Computer disaster area and all the other 14 articles were published in natural or human-made disaster areas. For the natural or human-made disaster, the studies were mainly carried out on evacuation behavior during landslides, flood mitigation, precautionary behavior during earthquakes, and natural disaster emergency preparedness. The natural or human-made disaster article was looking into computer security behavior in Korean firms. The analysis evidently showing that there is a research gap of PMT in disaster context in IT organizations.

Table 3
Disaster Research with Applied PMT Publications

Authors	**Title**	**Year**	**Source Title**	**Field of Disaster Study**
Zander K.K., Richerzhagen C., Garnett S.T.	Human mobility intentions in response to heat in urban South East Asia	2019	Global Environmental Change	Natural Disaster
Marceron J.E., Rohrbeck C.A.	Disability and disasters: the role of self-efficacy in emergency preparedness	2019	Psychology, Health and Medicine	Natural or HumanMade Dis-aster

Botzen W.J.W., Kunreuther H., Czajkowski J., de Moel H.	Adoption of Individual Flood Damage Mitigation Measures in New York City: An Extension of Protection Motivation Theory	2019	Risk Analysis	Natural Disaster
Mutaqin D.J.	Determinants of farmers' decisions on risk coping strategies in rural West Java	2019	Climate	Natural Disaster
Brugger J., Hawkes K.L., Bowen A.M., McClaran M.P.	Framework for a collaborative process to increase preparation for drought on U.S. public rangelands	2018	Ecology and Society	Natural Disaster
Tang J.-S., Feng J.-Y.	Residents' disaster preparedness after the meinong taiwan earthquake: A test of protection motivation theory	2018	International Journal of Environmental Research and Public Health	Natural Disaster
Mertens K., Jacobs L., Maes J., Poesen J., Kervyn M., Vranken L.	Disaster risk reduction among households exposed to landslide hazard: A crucial role for self-efficacy?	2018	Land Use Policy	Natural Disaster
Paton D.	Disaster risk reduction: Psychological perspectives on preparedness	2018	Australian Journal of Psychology	Natural Disaster
Adhikari M., Paton D., Johnston D., Prasanna R., McColl S.T.	Modelling predictors of earthquake hazard preparedness in Nepal	2018	Procedia Engineering	Natural Disaster
Wirtz P.W., Rohrbeck C.A.	Social influence and cognitive motivational effects on terrorism preparedness: A hurdle model	2017	Health Education Journal	HumanMade Dis-aster
Kakimoto R., Fujimi T., Yoshida M., Kim H.	Factors promoting and impeding precautionary evacuation behaviour	2016	International Journal of Urban Sciences	Natural Disaster
Bell M.A., Dake J.A., Price J.H., Jordan T.R., Rega P.	A National survey of emergency nurses and avian influenza threat	2014	Journal of Emergency Nursing	Natural Disaster

Ozaki T., Nakayachi K.	Effects of descriptive norms and mutual relationships on precautionary behavior toward earthquakes	2014	Research in Social Psychology	Natural Disaster
Poussin J.K., Botzen W.J.W., Aerts J.C.J.H.	Factors of influence on flood damage mitigation behaviour by households	2014	Environmental Science and Policy	Natural Disaster
Yoon C., Kim H.	Understanding computer security behavioral intention in the workplace: An empirical study of Korean firms	2013	Information Technology and People	IT, IS, Computer Disaster

Limited studies have comprehensively focused on knowledge protection factors. PMT is slowly increasingly used in IS studies, but research on IT disaster remains limited. Hence, this study applied PMT to improve the DR lessons-learned process in IT organisations. This study is comparatively new with the contribution to non-IS theories, which is the PMT theory.

3 Methodology

The DR process and associated activities in client organisation were studied using an Action Research (AR) approach. An AR approach was used to obtain a complete picture of the DR process in client organisations. A Canonical Action Research (CAR) was utilised to test the simplification of the lesson-learned process for DR activities in client organisations. The CAR focuses on change through interventions in an organisational context, and it comprises five stages of cyclical process: (i) Stage 1 Problem Diagnosis, (ii) Stage 2 Action Planning, (iii) Stage 3 Intervention, (iv) Stage 4 Evaluation and (v) Stage 5 Reflection. This study solves the real-world problem through a realistic AR method and tests the critical success factors using the qualitative techniques.

3.1 Data Collection Method, Data Analysis Techniques and Sampling

This study is cross-sectional because the data are collected at a single point in time. Content analysis technique is used because it allows the researcher to systematically make valid interpretations from the written text to describe specific phenomena. NVivo® (version 12) is used to analyse the following two types of qualitative data designed in this study: (i) in-depth and open-ended interviews and (ii) focus group interviews. The sample population for this qualitative study consists of the DR coordinators working in the client organisation, which is an IT multinational company in Malaysia.

4 Results

The current mode of DR activity flow in the client organisation is to capture valuable information after the DR activity is completed. This process is called ‘DR PTR’ as depicted previously in Figure 1. The DR team usually performs this PTR a day or two after the DR test activity. Hence, capturing information at later stage can lead to missing valuable information. The researcher perceived that this process can be simplified to preserve valuable information.

Therefore, the researcher simplified the process to capture lessons learned during the DR test activity, and the proposed mode is depicted in Figure 4. This simplified process is tested through a simulation during the intervention stage.

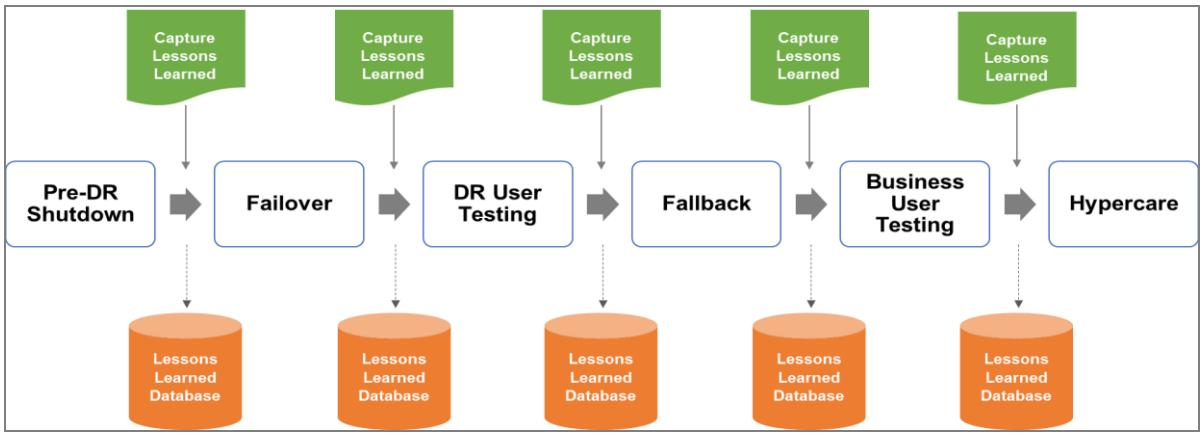

Figure 4
Proposed Way of Capturing Lessons Learned in Client Organisation

4.1 Simulation

Four simulation exercises were performed. Before each simulation exercise, an awareness session was conducted with the DR coordinators to emphasise on the two beliefs, namely, *SE* and *RE*, based on PMT model. Each awareness session duration ranged from 15 to 20 minutes. The results of the simulation were then compared with the previous DR activities conducted in 2017.

Table 4
Simulation DR Activities Details (2018)

Simulation	DR Test Name	Simulation Awareness Session	Simulation DR Test Date Start	Simulation DR Test Date End
1	Integrated Simulated Disaster — Houston	20 January 2018 19:30 MYT	20 January 2018 20:00 MYT	21 January 2018 12:00 MYT
2	Integrated Simulated Disaster — Munich Allach	21 April 2018 19:30 MYT	21 April 2018 20:00 MYT	22 April 2018 22:00 MYT
3	Integrated Simulated Disaster — Amsterdam	9 June 2018 07:45 MYT	9 June 2018 08:00 MYT	10 June 2018 08:00 MYT
4	Integrated Simulated Disaster — Munich EIP	22 September 2018 23:45 MYT	22 September 2018 00:00 MYT	23 September 2018 23:00 MYT

4.2 Error Reduction

Error reduction is measured by looking into the total number of applications that were unrestored as per the agreed Recovery Time Objective (RTO). The application was supposed to be successfully failed-over to the recovery site within the agreed RTO time. However, the application would have taken longer time to be failed-over due to a certain error or technical issue. For example, in 2018, the Integrated Simulated Disaster (ISD) DR activity for Houston had two failures compared with that in 2017 with five. This finding shows a total savings of three failures. Similarly, the results for other 3 simulations are depicted in Table 5.

Table 5
Simulation Results on Error Reduction

Simulation	**Before** 2017	**After** 2018	**Time Reduction** (Yes/No)	**Total Time Savings**
Integrated Simulated Disaster — Houston	5	2	Yes	3
Integrated Simulated Disaster — Munich Allach	0	0	No	0
Integrated Simulated Disaster — Amsterdam	7	5	Yes	2
Integrated Simulated Disaster — Munich EIP	1	0	Yes	1

4.3 Time Reduction

Time reduction is measured by looking into the RTO. RTO refers to the time frame between disruption and restoration of service. In 2017, the ISD DR activity for Houston took 2 hours, 3 minutes and 16 seconds to restore the service, whereas that in 2018 only took 1 hour, 42 minutes and 22 seconds. This finding shows a total savings of 20 minutes and 54 seconds. All the simulations results for time reduction are shown in Table 6.

Table 6
Simulation Results on Time Reduction

Simulation	**Before** 2017 (hh:mm:ss)	**After** 2018 (hh:mm:ss)	**Time Reduction** (Yes/No)	**Total Time Savings**
Integrated Simulated Disaster — Houston	2:03:16	1:42:22	Yes	00:20:54
Integrated Simulated Disaster — Munich Allach	01:29:12	01:28:05	Yes	00:01:07
Integrated Simulated Disaster — Amsterdam	02:53:05	01:34:06	Yes	01:18:59
Integrated Simulated Disaster — Munich EIP	01:47:55	01:38:10	Yes	00:09:45

4.4 Cost Reduction

Cost savings is measured by looking into the contractually agreed Service Level Agreement (SLA), which is the Critical Service Level (CSL) 5.5.2 DR test plan successfully tested. CSL is a contract term, which means critical service level. If the service level is critical, then an associated penalty risk exists if the service level performance is below 98.10%. The ISD DR activity for Houston Data Centre was conducted on 20 January 2018. The SLA performance for January will be taken for the cost savings measurement. However, no comparison with previous year is required because the SLA indicates if the performance meets the expected target or exceeds the minimum one. Table 7 shows that a 100% SLA performance was achieved in January, and a penalty amount of USD 69,541 was saved for the SLA measurement in January. All the other simulation results were presented in the same manner in Table 7.

Table 7
Simulation Results on Cost Reduction

Simulation	Expected SLA Target	Minimum SLA Target	January 2018 SLA Performance	Penalty Amount if SLA is Breached
Integrated Simulated Disaster — Houston	99.10%	98.10%	100.00%	USD 69,541
Integrated Simulated Disaster — Munich Allach	99.10%	98.10%	100.00%	USD 68,003
Integrated Simulated Disaster — Amsterdam	99.10%	98.10%	100.00%	USD 67,124
Integrated Simulated Disaster — Munich EIP	99.10%	98.10%	100.00%	USD 61,782

4.5 Summary of all Results

The results of the four simulation tests are provided in Table 8. The table clearly shows that three out of four simulation tests achieved the perceived net benefits towards the extent of solving current challenges in client organisation for DR activities. The ISD for Munich Allach Data Centre had zero error reduction, but time reduction and cost savings had a positive result. The simulation results concluded that three out of four simulations achieved the error reduction with a total count of six errors in a comparison between similar DR activities in 2017 and 2018. All four simulations successfully contributed to time reduction with a total savings of 1 hour, 50 minutes and 45 seconds and cost reduction with a total savings of USD 266,450.

Table 8
Summary of All Evaluation Results

Simulation	DR Test Name	Simulation DR Test Date	Error Reduction	Time Reduction	Cost Savings
1	Integrated Simulated Disaster — Houston	20 January 2018	Yes	Yes	Yes
2	Integrated Simulated Disaster — Munich Allach	21 April 2018	No	Yes	Yes

3	Integrated Simulated Disaster — Amsterdam	9 June 2018	Yes	Yes	Yes
4	Integrated Simulated Disaster — Munich EIP	22 September 2018	Yes	Yes	Yes

5 Discussion and Conclusion

Self-Efficacy (SE) refers to the notion that one is either capable or incapable of performing a coping behaviour (Vance et al., 2012; Rogers and Prentice-Dunn, 1997) and identified to have a vigorous consequence on the intents of protective behaviour. SE refers to the existing levels of individual abilities with regard to the recommended level of disaster preparations and its effectiveness (Bubeck et al., 2013). SE was included as a success factor in this study to measure if the DR team coordinators have great intention to capture the lessons learned whilst coordinating the DR activity.

Response Efficacy (RE) is the belief of the adaptive response will work, and taking the recommended protective action is effective in averting an undesirable threat (Vance, 2012; Floyd et al. 2000; Rogers and Prentice-Dunn 1997), that is, the ability of the response to reduce the risk (Maddux and Rogers, 1983), which is losing valuable information in this study context. RE was included as a success factor to measure if the DR team coordinators can protect valuable information whilst coordinating the DR activities.

The simulation findings of this study confirmed that the improvement of DR lessonslearned process was positively influenced by the SE and RE factor towards error, time and cost reduction. The behaviour of the individuals with SE and RE towards safeguarding valuable information is an important element. This study also provides direction to other IT organisations on safeguarding of valuable information whilst improving its efficiency in executing DR activities. As previously mentioned, valuable information can help an IT organisation minimise the errors or failures during DR activities, incurring time and cost savings. **References**

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