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Sustainability Analysis of Bintulu Hospital Information System Through e3value and i* Modeling

Sim Yee Wai [a], Cheah Waishiang [b,*], Muhammad Asyraf Bin Khairuddin [b] and Azmi Jaini [b]

[a] *Faculty of Computing and Engineering, QUEST International University, Perak, Malaysia*
[b] *Faculty of Computer Science and Information Technology, Universiti Malaysia Sarawak, 94300, Malaysia*
Corresponding author: [*]wscheah@unimas.my

***Abstract*— As a pivotal supporting arm and the driving force to ensure better healthcare services, the Hospital Information System (HIS) provides the backbone support for efficiently managing the hospital's operations and services. Against the backdrop of the current economic situation and the uncertainties in the grim global economic outlook, it is crucial to optimize the cost of the information system while meeting the objectives. This paper contributes to introducing a technique to optimize the public Hospital Information System funding in Malaysia. It explores the prolonged financial viability of the HIS in Bintulu, East Malaysia, through e3Value methodology. The e3value methodology can evaluate the financial sustainability of HIS projects and can serve as a tool for early requirement analysis on future HIS deployment. From the e3value model, it is interesting to discover that actors contribute positive revenue to the hospital, allowing the hospital to generate more profit, which benefits the Government. However, actors that give negative revenue might affect future financial status. Based on the result, the recommendations presented in this paper are very crucial to ensure the continued financial sustainability of HIS. The e3value model offers early requirement study analysis and structured analysis with systematic approaches compared to the existing method. Although the work can measure the financial sustainability of the HIS, other sustainability dimensions like technological sustainability, environmental sustainability and social sustainability are yet to be explored and worth investigating in the future.**

***Keywords*— Value-based software engineering; information system; financial sustainability models.**

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I. INTRODUCTION

Hospital Information System (HIS) is introduced to public hospitals as one of the measures to improve the healthcare sector [1], [2]. Before HIS, the hospital staff must manage and integrate clinical, financial, and operational information that grows with the practice. This data was organized manually, which was time-consuming and failed to deliver the desired efficiency level.

To date, the HIS is deployed at 18 public hospitals in Malaysia. The Government funds all hospitals that utilize HIS, but two issues are addressed. The first is how long the Government can financially support the system. The second question is to what extent the funding can be used in managing the HIS. Therefore, it is imperative to address this often-overlooked issue and conduct a deeper analysis. The review shows limited empirical research to explain the sustainability of HIS implementation in the long run [3]–[8]. None of the methods is used to assess HIS sustainability, and none of the reports discusses the sustainability of HIS projects. Currently, the Government has numerous existing budgeting systems, such as the 'Anggaran Belanja Mengurus' (ABM), which applies an operational budget for each fiscal year and maintenance fees for the HIS system. However, the notion of sustainability is not considered in the budgeting system, such as the ability to sustain the HIS system upon the completion of the HIS budget.

This paper introduces a technique to evaluate the HIS through e3value methodology. In this paper, the e3value methodology is used to analyze the cash flow of all parties involved in the monetary activities within the scope of HIS. The analyzed results can be used to make informed decisions to improve the hospital's financial health. In this case, the hospital management will be able to determine the actor that makes a profit to provide positive revenue to the healthcare provider, leading to the sustainability of HIS project.

Several studies were conducted to analyze the implementation of HIS projects in Malaysia. Collectively, those research aims to understand the HIS projects' effectiveness, efficiency, financial viability, reproducibility, and portability [2]. It has been reported that despite the importance of HIS for the physicians, the level of implementation of such a system in Malaysia's public hospitals is still very low due to various issues which are associated with challenges in humans, technology and infrastructure, software limitation, and support [2], [9]–[11]. Some work has been conducted to identify the low adoption of HIS in Malaysia's public hospitals. The result of the study led to the introduction of a new framework for HIS adoption.

From the review, research work is absent specifically in evaluating the sustainability of HIS projects in the long run. Indeed, most of the studies are focused on the usability of the HIS projects. The financial sustainability aspect of HIS has been overlooked, and with finite funds to work with, there is a need to conduct research in this area to obtain new insight into assessing HIS projects.

II. Materials and Method

To evaluate the HIS project, e3value methodology is adopted and extended. e3value methodology is a conceptual modeling approach to define how economic value is created and exchanged within a network of actors [1], [12]–[22]. The e3value is founded on requirements engineering and underlying conceptual modeling techniques borrowed from the information systems community. It is used to model the net cash flow among the actors and assess their profitability. Meanwhile, it has been investigated in our early work to understand the technology changes in ICT4D [23], [24].

In this research, the e3value methodology coupled with the i* model was adopted when assessing the financial sustainability of the HIS system. With the combination, the financial factors that contributed to HIS sustainability can be analyzed in greater depth. The systematic approach of the modeling process consists of 6 steps starting with identifying all the actors and their goal dependencies, as shown in Figure 1. This is followed by determining the monetary actor, constructing the e3value model, analyzing the data, and finally presenting the recommendations. The steps are elaborated in detail as in Figure 1.

A. Step 1: Actors and Roles

An actor's role represents each actor's responsibilities in the hospital organization. For example, the Medical Director has several duties to ensure the smooth operation of the healthcare services, including overseeing administrative operations at a strategic level and resolving medical-related issues. These roles provided valuable information to construct a Goal Dependencies Model in the i* model which reflects an actor's dependencies on other actors to achieve the primary goals. The goal models' details can refer to the following works [25]–[28].

B. Step 2: Goal Dependencies in i Modeling*

Based on the information gathered from the actor's role, the Goal Dependencies Model was derived, as depicted in Figure 2. The model showed fifteen (15) actors with their own goals to achieve and the dependencies between the goals.

C. Step 3: Monetary and Non-Monetary Value Actors

Segregating the actors into two distinct categories of Monetary and Non-monetary Value Actors enabled the identification of the actors directly involved in the economic aspect of the hospital's operations. Table 2 shows these categories which were divided according to the actors' roles and goal dependencies discussed in the previous section.

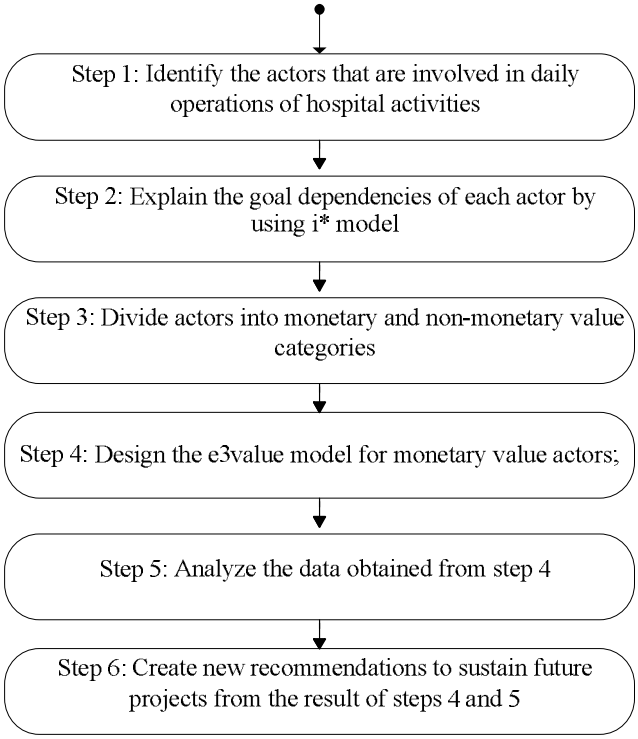

Fig. 1 Model to evaluate ICT4D projects

TABLE I
ACTORS AND ROLES IN A PUBLIC HOSPITAL

Actor	Roles
Hospital Director	Ensuring the delivery of quality healthcare services in the hospital such as: • advising Medical Officer on medical issues. • monitoring the hospital revenue and fee collection by verifying and approving genuine transactions. • ensuring the usage of HIS by all the staff in the hospital. • ensuring the efficiency of the procurement process in the hospital.

The main category of this work is the Monetary Value actor that consists of MOH, Finance Officer, Medical Staff, HIS Contractor, Citizen Patient, Non-Citizen Patient, Consumable Supplier, Internet Provider, Power Provider, HospiMart Operator, Canteen Operator, and Administration Staff. The Ministry was selected as the Monetary Actor because they provided the funding of the HIS project. Although the Finance Officer was identified as the Monetary Actor but needed to be replaced by the Healthcare Provider actor in the e3Value model. This is considering the Finance Officer is the main personnel involved directly with almost all financial

transactions in the hospital organization. Medical and administration staff contributed to the monetary value in the e3Value model on their expenditures in daily operation within the hospital facilities. HIS contractor received their payment from the Government to maintain the HIS service in the hospital. Citizen and non-citizen patients paid the medical treatment charge, and the consumable supplier received their payment to provide the consumable item. Utility bills also need to be paid to the power and internet provider. Finally, the canteen and HospiMart operator paid their space rental to the hospital in order for them to provide the food and drink.

The Non-Monetary Value Actors are also crucial in determining the sustainability factors of the HIS project. However, this thesis mainly emphasizes the project's financial aspect and would probably consider the Non-Monetary Actor for future research analysis.

TABLE II
MONETARY AND NON-MONETARY VALUE ACTOR

Monetary Value Actor	Non-monetary Value Actor
1. MOH (Ministry of Health)	1. Hospital Director
2. Finance Officer	2. IT Manager
3. Medical Staff	3. Procurement Committee
4. HIS Contractor	4. Head of Department
5. Patient (Citizen)	
6. Patient (Non-Citizen)	
7. Consumable Supplier	
8. Internet Provider	
9. Power Provider	
10. HospiMart Operator	
11. Canteen Operator	
12. Administrative Staff	

D. Step 4: Monetary Value Actor through e3value Editor

The actors identified under the Monetary Value category were used to construct the e3value model to illustrate each monetary value actor's net cash flow in the daily hospital operations. The cash flow data of each actor was included in the e3value model. Table 3 shows the approximated operational cost, utility cost, and rental space for Bintulu Hospital to standardize the analysis calculations. The yearly cost is used. It is important to mention that the values used in this table do not reflect the real data as it is subjected to privacy issues. Meanwhile, the financial sustainability model is shown in Figure 3.

Operation and Maintenance (O&M) Cost of HIS Project is approximately RM15 million for a contract period of 3 years. However, for the purpose of the analysis and to standardize the calculation of the data, this thesis decided to analyze each data for one year. After dividing the O&M cost by three years, its yearly cost is RM5 million. As shown in the table, all Monetary Value Actors' cost were calculated manually to get the '1 Year Cost' data.

In this research, the result of net cash flow is automatically generated by the e3Value Editor on each actor, whether the actor is making a profit or not in the organization. The data of the result is exported to the Microsoft Excel file to generate a report on the financial viability of the actors. The analysis results are shown in the next section.

TABLE III
APPROXIMATION OF COST, UTILITIES, AND RENTAL PER ANNUM

No.	Monetary Value Actor	Contract Cost & Period	1 Year Cost
1	O&M Maintenance Cost	RM 5,000,000	RM 5,000,000
2	Consumable Cost	RM 200,000 (2 years)	RM 100,000
3	Internet Bill	RM 5,000 (monthly)	RM 60,000
4	Electric Bill	RM 40,000 (monthly)	RM 480,000
		Revenue	
5	Canteen Rental	RM 5,500 (monthly)	RM 66,000
6	HospiMart Rental	RM 3,000 (monthly)	RM 36,000

III. RESULTS AND DISCUSSION

From the e3value model, we can conduct the financial sustainability analysis as elaborated in this section.

A. Step 5: Monetary Value Data Analysis

With the furnished data, results of the net cash flow were automatically generated by the e3value editor on each actor regardless of whether the actor is generating a profit. The results were presented in a Microsoft Excel worksheet, which serves as a financial viability report of the actors.

TABLE IV
HEALTHCARE PROVIDER (HP) ACTOR TOTAL NET PROFIT FROM E3VALUE EDITOR

No.	Monetary Value Actor	Debit (RM)	Credit (RM)	Total Net Profit of HP Actor in a Year (RM)
1	MOH Funding	-	5,000,000	
2	O&M Maintenance Cost	5,000,000	-	
3	Consumable Cost	100,000	-	
4	Internet Bill	60,000	-	
5	Electric Bill	480,000	-	
6	Canteen Rental	-	66,000	
7	HospiMart Rental	-	36,000	
8	Patient (Citizen) - Medical Treatment (HIS)	-	219,000	
9	Patient (Non-Citizen) - Medical Treatment (HIS)	-	766,500	
Total:		640,000	1,087,500	447,500

Table 4 shows the profit the HP actor gains throughout the fiscal year simulated via e3value Editor. The Consumable Supplier actor was included in the analysis to supply HIS consumable item for HP. The cost incurred to pay the supplier is approximately RM100,000 a year, and the actor gains this

profit. Meanwhile, HP has to bear the cost in order to get the item. As for the Citizen Patient actor, each time they enter the hospital facilities, it is assumed that they will go to the canteen or hospiMart to buy food and drink. The cash flow of the Citizen Patient actor ideally has a negative value as their expenditures in the hospital facilities lead to negative results. This benefits HP's cash flow as it provides a profit of RM219,000. Similarly, the Non-Citizen Patient expenditures have given HP a profit of RM766,500.

The HP actor also received positive cash flow from the space rental charges. The actors that contributed to the positive cash flow of HP are the Canteen and HospiMart Operator actors. The Canteen Operator actor paid the rental charges of RM66,000, and the HospiMart Operator actor paid RM36,000 to use the hospital's facilities. A combined profit of RM102,000 from both actors in a year has helped HP gain the profit.

The Medical and Administration Staff actor in the e3Value model is assumed to get free of charge each time they receive medical treatment through HIS service. However, for the calculation via the e3Value model, a zero value is required to be entered in the e3Value Editor software. The value of RM0 for both actors' value ports is generally because all Government Staff use 'Guarantee Letter' every time they receive treatment in public hospitals. However, both actors produced a negative cash flow due to their expenditures on the hospital facilities.

The overall analysis of the e3Value model showed that the main actor, the HP actor, gains its profit from the actors of Citizen Patient, Non-Citizen Patient, Canteen Operator, and HospiMart Operator. As explained earlier, a yearly net profit of RM447,500.00 gained by the HP actor appeared to be a positive result, but it is not sufficient to pay back the fund of RM5 million provided by the Ministry in one year. It will take more than eleven years for the Government to get the cashback if the same approach continues to be implemented in the future. Table 4.20 shows the profit that the HP actor gains throughout the fiscal year simulated via e3Value Editor.

B. Step 6: New Approach and Recommendation

From the cash flow pattern illustrated in the e3value model, the following approaches are recommended for the future to cover the maintenance cost of HIS or to gain profit out of its daily operation activities:

1) Increase Canteen Rental Fee: The existing rental fee is RM5,500 per month or RM66,000 per year. It is recommended to increase the fee by 50% more to RM8,250 per month with a total of RM99,000 in a year.

2) Increase HospiMart Rental Fee: The HospiMart monthly rental fee should increase by 50% to RM 4,500. This will provide a rental fee of RM54,000 per year, which gives an additional RM18,000 a year. As presented in Table 5, the total profit of the HospiMart Operator is RM759,100. With the proposed increment on the rental fee, the HospiMart operator will still profit RM741,000.

TABLE V
HOSPIMART OPERATOR ACTOR PROFIT FROM E3VALUE EDITOR

No.	Monetary Value Actor	Debit (RM)	Credit (RM)	Total Profit of HospiMart Operator Actor in a Year (RM)
1	Patient (Citizen)	-	438,000	
2	Patient (Non-Citizen)	-	54,750	
3	Medical Staff	-	273,750	
4	Admin. Staff	-	28,600	
5	Rental Fee (in a year)	36,000.00	-	
Total:		36,000.00	795,100.00	759,100.00

3) Increase Non-citizen Patients Visiting Public Hospital: Most of its revenue comes from non-citizen patients. Bintulu has a sizeable expatriate population working in the oil and gas sector. Several measures have to be taken to attract the companies to encourage their foreign staff to receive treatment in public hospitals. Further investment should be made to improve the medical facilities; the hospital should also house more medical expertise, provide better services and introduce affordable medical fees compared to private hospitals. To reduce the investment costs, the hospital could solicit benefactions from Non-government Organizations (NGOs) for medical facilities or equipment. However, recruiting more medical expertise will elevate the cost of emolument (salary) for the HP, but this cost is not included in the analysis of this paper as their expertise will be an asset to the HP. More medical facilities, an array of expertise in different medical fields, and affordable medical fees could double the number of non-citizen patients and improve customer retention. This could generate a profit of RM1,533, 000 per year.

4) Practice Power Saving Exercise: It was understood that the hospital has registered in an energy conservation program conducted by a private agency. The hospital should take this opportunity to fully implement the advice from the expert personnel in order to achieve a reduction in electricity consumption. Assuming that the yearly electricity bill can be reduced to RM 300,000, the hospital could save up to RM 180,000. This will help to reduce overhead costs.

5) Additional Actor of Nursery Operator: Additional onsite childcare facilities such as workplace nurseries are worth considering. The existing room space can be utilized, and external childcare operators can be engaged to run this facility. The hospital staff may use this facility for a fee. This brings convenience to the hospital staff as they are spared from picking their children up from other childcare facilities. This also provides peace of mind about their child's well-being and the quality of care received. Considering this facility operates on weekdays from 6 am to 6 pm, the monthly electricity usage is estimated to be RM200, with a total yearly cost of RM 2,400. Setting a rental fee of RM 4,000 per month will offset the utility bill and increase the positive revenue for the hospital.

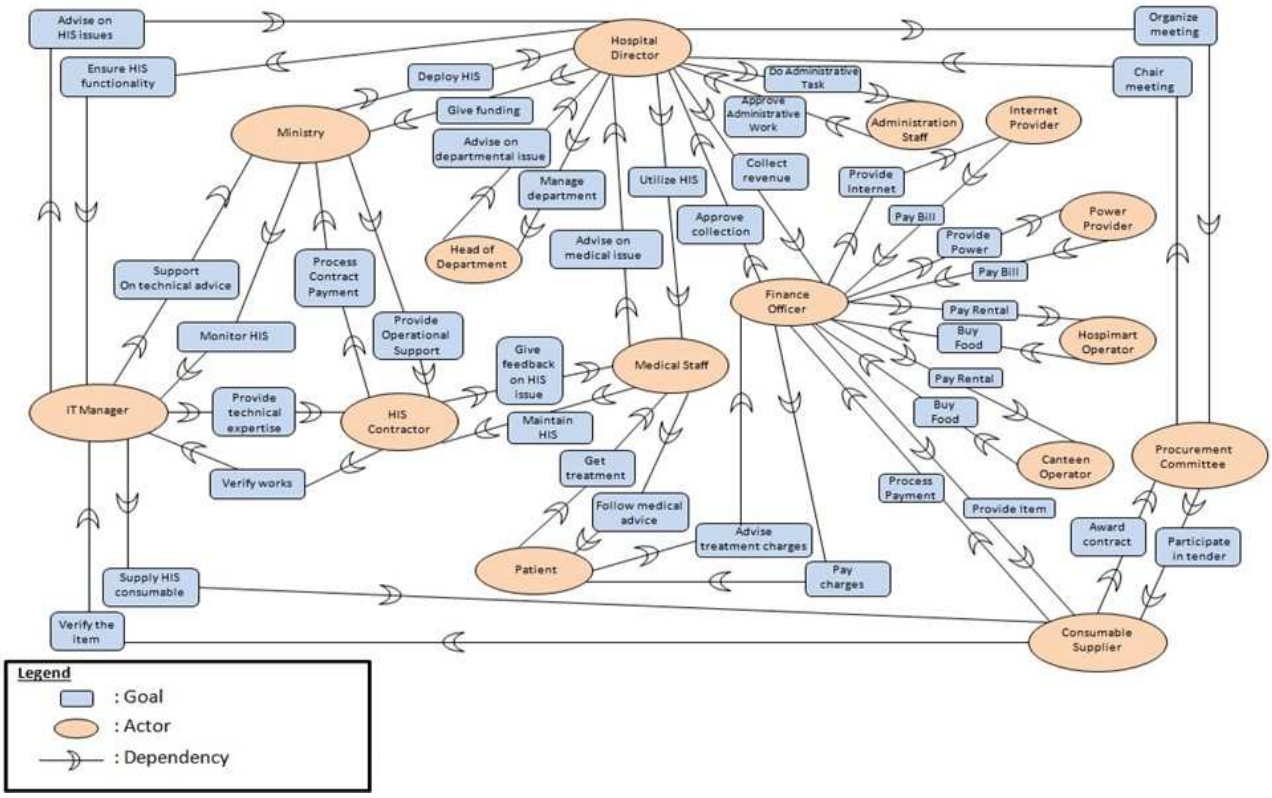

Fig. 2 i* model (dependency modeling) for Bintulu Hospital

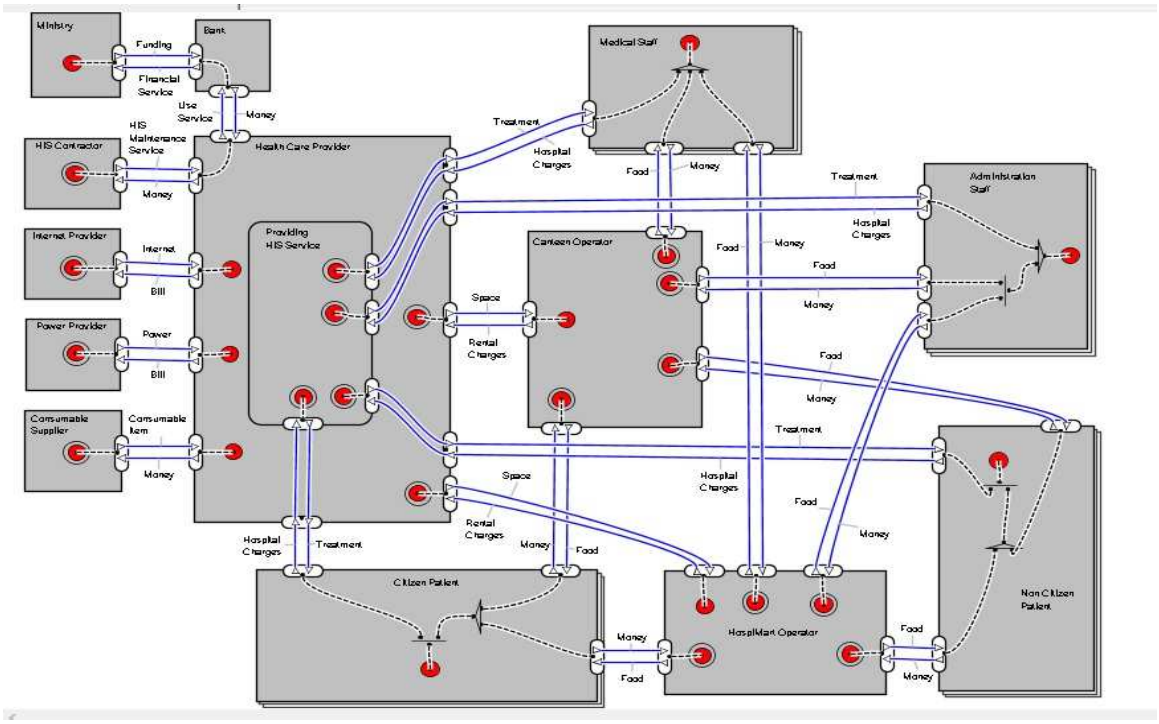

Fig. 3 e3Value model for HIS

A detailed walkthrough of the financial sustainability analysis conducted through e3value methodology is presented in the previous section. The case study is used to validate the feasibility of the proposed methodology. And it has shown that the methodology is able to provide a structured method and has the potential to provide in-depth financial analysis to evaluate the sustainability of the HIS in the long run.

A budget is a financial plan for a defined period, often one year. It may also include planned sales volumes and revenues, resource quantities, costs and expenses, assets, liabilities and cash flows. A budget process refers to the process by which

Government creates and approves a budget, which is the Ministry of Finance prepares worksheets to assist the department head in preparation of department budget estimates. The federal budget is the Government's estimate of revenue and spending for each fiscal year. The revenue for Governments comes from taxes. Federal spending is on activities that benefit the public good. Almost all Governments spend on public safety and defense, health, transportation and trade. In giving the best health facilities to the public, the Ministry of Health has introduced a system called Hospital Information System (HIS) to accommodate the medical staff capturing patient data systematically to ensure a secured patient database system in public hospital. This has increased the cost of spending more money to maintain the HIS.

As mentioned before, 'Anggaran Belanja Mengurus' (ABM) is the Government's operating budget management system and it is used to estimate the operating cost in preparation for the budget allocation in the next fiscal year. It is usually prepared by the Government's department during the current year and is submitted to the MOH before the end of each year. However, this system is used to estimate the entire department's operating cost and it is not specifically a budget planning system for HIS maintenance.

With the proposed methodology, we introduce an alternative method to assess the HIS in detail specifically on the financial sustainability of HIS. A general comparison was made between ABM and e3value methodology and is presented in Table 6. This further validates the effectiveness and the efficacy of e3value methodology in evaluating the financial sustainability of HIS project.

From the recommendations based on empirical evidence, it can serve as future references for the healthcare provider to help the MOH in sustaining the HIS project. Threat validity: In this study, the operation cost of customer support from IT company is excluded from the analysis because the scope of the study is specifically on maintenance cost. The cost of emolument (salary) was also not included in this analysis as well. Although it is one of the costs in the Government sectors, but it does not have a direct relationship with the system. All the figures used in the calculations assume to protect the confidentiality of the actual data.

TABLE VI
COMPARISON OF EXISTING APPROACH AND NEW METHODOLOGY

No.		New Approach (through e3Value methodology)	Existing approach (ABM)
1	Early Requirement Study	√	X
2	Model	√	X
3	Structured Analysis	√	X
4	Budgeting Plan (e.g., ABM, e3Value cash flow)	√	√

Threat validity: In this study, the operation cost of customer support from IT company is excluded from the analysis because the scope of the study is specifically on maintenance cost. The cost of emolument (salary) was also not included in this analysis as well. Although it is one of the costs in the Government sectors but it does not have a direct relationship with the system. All the figures used in the calculations assume to protect the confidentiality of the actual data.

IV. CONCLUSION

This paper presents a methodology for the financial sustainability analysis of HIS projects through e3value methodology. This methodology provides a structured approach to analyze the economic factors that affect HIS. The results from this study prove that the e3value methodology can be used as a tool or method in managing the cash flow and the report produced will be useful for strategic planning. This is particularly important to improve the financial status of the healthcare provider by formulating a strategy to boost the revenue or profit in the long run. The analysis allows the health provider to better understand the present situation, and with that a proactive plan can be created to address the pressing need. As shown from the case study, if all the suggested recommendations are to be implemented, the healthcare provider will be able to contribute back the money to MOH in 3 years or less as compared to the current condition of 11 years. The methodology is also able to provide deeper insight into each actor to determine the impact of each actor on the financial status. This methodology can be applied across different domains and the future work will include how the methodology is able to assess the social sustainability of the HIS project. The combination of e3value and agent simulation [29], [30] is our current direction.

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