An alternative IT investment framework based on university learning model in asset management

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Abstract: Ideally with no constraints on the budget, an investment in information technology should be easy and straightforward. Conventional method for the IT investment is adapted from the existing financial techniques which focus mainly on the returns from the assets invested. However, due to specific natures of an IT asset, financial techniques may become inappropriate and misleading. This paper proposes an alternative investment framework for the information technology assets by utilising the experiences of experts since its installation. To utilise these experiences in the proposed investment framework, the learning curve is constructed and represents as the organisational learning model in costs, performance and risks according to the asset management framework. College of Arts, Media and Technology within Chiang Mai University is used as the case study. The results have shown that the alternative investment framework performs better than conventional evaluation methods and leads to the most suitable investment option.

Keywords: CommonKADS; knowledge engineering; organisational learning model; university IT asset management.


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1 Introduction

Undeniably, information technology (IT) and its countless applications have become increasingly important to both individual and business contexts as well as being integral parts of daily activities (Jacks et al., 2011). For individual, IT allows people to live their life smarter in almost every aspect. This also includes freedom and flexibility to connect to sources of information, either for entertainments or educational purposes. As for the business or organisational context, the advance in IT provides company with competitive advantages and could assists in the development of innovation. This has resulted in rapidly growing adoption of IT, and unavoidably translates into huge investment budgets (Patrakosol and Lee, 2009).

Ideally, with no constraints on the budget, an investment in IT should be easy and straightforward. However, as mentioned earlier, this indicates huge investment budget, and could put financial burden to the company. Furthermore, this is not helped by the fact that IT is regarded as a cost centre, and represents sunk costs of the company investment budgets. Traditionally, there is no explicit, direct relationship between the IT invested and the company’s revenue. The IT manager and/or the person responsible for the decision could find themselves in a very difficult position to convince and justify IT investment.

The above notion is applied to every industry. Education or academic sector is no exception, and most of the time university finds itself in this similar situation. Within university, IT is regarded as one of the main infrastructures, and utilised extensively from the management to academic support. These are for examples, IT support in the laboratory, IT support for administration and documentation, or IT for organisation management (office automation, human resources, management information system, or government financial management information system). Note here that this paper differentiates between the IT and the information management system (IS) since it only focuses on the IT only. Essentially, in broad sense, IT in this paper means the computers, hardware, software, telecommunication, internet and resulting technologies. This is in contrary to the IS which refers to the design of the information flow within the organisation. Typically, a fixed portion of the overall annual budget is dedicated to IT related activities ranging from investment to operation and maintenance (O&M) (Li et al., 2009). This organisational policy unintentionally leads the university to focus mainly on the short-term investment strategy where only the cheapest solution is of interest with no clear direction/strategy to optimise the overall benefits. Moreover, the delay in the procurement process due to the annual budget allocation usually leads to obsolete technology acquired at the time of delivery. Eventually, this results in the complexity of the IT system with diversified life cycle.
An alternative IT investment framework based on university learning model

This is where the concept of asset management could assist in the investment of the IT assets. Instead of looking at the IT asset individually or separately, the asset management provides the framework to manage the IT assets systematically by balancing costs, performance, and risks over its life cycle (Hook et al., 2009). This is challenging, especially for the IT asset with relatively short life cycle. According to Moore’s law, the improvement in technology and the cost reduction is at two folds every 18 months (Cavin et al., 2012). Moreover, the specific nature of the IT asset with no direct relationship to the company’s revenues, especially in university context, makes it very difficult to justify in terms of investment. To successfully develop the IT investment framework based on the concept of the asset management, three elements (cost, performance, and risk) mentioned earlier are of important. This paper attempts in doing that, and proposes alternative method to model cost and performance associated with IT asset. More specifically, this paper proposes that learning curve of the experts can be constructed systematically, and represents the organisational learning model of the university in the IT asset management. This learning curve shows the relationship between costs/risks and the expert’s knowledge accumulated through working experiences.

Knowledge engineering (KE) approach is applied in this paper to model the economic and service performance of the IT asset. Unlike conventional methods when considering costs and performance of the IT asset, this approach overcomes the incomplete and unstructured nature of the data and information needed. Instead, experiences and knowledge of the experts having been working on the IT asset are utilised and modelled. This can then be constructed as learning curve and represents organisational learning model of the university when managing the IT asset. Typically, according to the concept of asset management, there are different phases when managing the asset. These include engineering design, procurement, construction and commissioning, and O&M. Since costs in other phases can be considered as a one-off, this research proposes to construct the organisational learning model across the life cycle of the IT asset from the O&M perspective. Hence, the organisational learning model can be categorised into corrective, preventive, predictive and proactive maintenance. Experiences and knowledge are then captured from experts in each category and provides rationale behind decision making activities of the IT asset as well as the strategy in problem solving which could then be used as part of the IT investment framework.

2 Overview to IT investment and asset management

In this section, the concept of the IT investment is discussed in more details. In another word, conventional evaluation methods to decide the most suitable option for the IT investment are explored and investigated. The following sub section then presents the concept of the asset management which is applied as the governing framework to develop the organisational learning model for the proposed IT investment framework.

2.1 Review of IT investment methods and tools

Universally accepted method for the evaluation of the IT investment is not evident and usually fragmented (McShea, 2009). However, based on the evaluation criteria, they can be categorised into the economic approach and the socio-technical approach (Handzic,
The economic approach focuses on the quantification of the costs and benefits of the IT investment project financially while the socio-technical approach takes into account both quantifiable and non-quantifiable aspects of the IT investment project such as innovation.

The economic approach can be seen from many conventional financial methods applied to quantify and justify the benefit of the IT project. Typically, these financial techniques are already used to evaluate the return from the assets invested. These include for examples, return on investment (ROI), net present value (NPV), or internal rate of return (IRR). These conventional methods assist in the quantification of risks and payoff for the investment project. Generally speaking, profit is of important to the company, and hence it is convenience to measure the investment from the accountability using the financial methods mentioned above. However with regards to the IT asset, there is no direct relation between IT investment and the company’s revenue (Ferguson and Hadar, 2011). Furthermore, these conventional methods typically evaluate the future benefits of the investment project as known which is in contrary to the IT investment situations (rarely known). The above financial methods may lead to inappropriate or most of the time incorrect investment decision on the IT assets. There have been an attempt to extend the conventional ROI to include both the tangible and intangible aspects of the IT project from the investment’s perspective. However, it is found that due to the increased complexity, this could offset the benefits it actually brings (Karadag et al., 2009).

The evaluation technique based on the real option analysis (ROA) have also been developed and introduced. The ROA provides the useful framework to make strategic decision by providing the capability to price the underlying investment project. Since it is the right not the obligation to invest in the project, it values the ability to wait and learn before investing (Liao and Ho, 2010). However, due to the short life cycle of IT assets according to Moore’s law, this ROA may not be applicable.

Multi criteria decision making (MCDM) tools have also been applied to develop the evaluation technique for the IT investment. Fuzzy logic and goal programming have been applied together with the ROA as an alternative tool for the strategic IT investment (Zandi and Tavana, 2011). ROA was used to prioritise the investment options according to its value. Fuzzy logic was then used to quantify the risks associated with each investment option. Finally, fuzzy preemptive goal programming model was used to combine the two values (values and risks) to determine the most suitable IT investment option. It can be seen from the above reviews that since the conventional financial evaluation method is typically disconnected from the human and organisational component, the focus is mainly on the accounting and financial aspects. Moreover, the compatibility of the IT project invested to the existing portfolio needs considering. The fuzzy multi criteria decision model has been developed and introduced (Chou et al., 2006).

Due to the limitation of the conventional financial evaluation method mentioned above, more researches have gradually been interested in the evaluation technique based on the socio-technical approach and the hybrid between these two (Lee et al., 2008). An evaluation technique utilising the business case have been proposed (Irani et al., 2014). To guarantee that the IT project invested align with the stakeholder’s requirements and the organisation business process, the business case of the IT project is constructed containing all possible scenarios for the utilisation of the IT project invested.
Since the decision making activities for the IT investment relates to many factors (costs, benefits, and risks) from the human and organisation’s perspective, some researches have opted to focus on the knowledge components and the learning issues of the human expert in the IT investment decision (Irani et al., 2009). The fuzzy expert system based knowledge mapping have been developed and proposed as an inductive learning guideline in the IT investment for the human expert within the organisation. Although it has proved that explicit and tacit knowledge on the investment can be exploited through knowledge mapping, the research presented in this paper encompasses and makes further contribution in the different technique used to elicit and model the experiences involved and the learning issues based on the asset management.

More common and basic method for the IT investment is budget costing. Typically, the budget costing for each financial year relies heavily on former year budget with no real consideration to the business condition and strategic management of the organisation (Park et al., 2010). In another word, the IT investment budget is set as a percentage of the overall company budget relatively to previous year. Frequently, this could either result in over budgeting or insufficient budget to actually make serious IT infrastructure improvement. Moreover, since this method neglects the business condition, this tends to implicitly put focus more on the spending rather than vice versa. That is to determine the IT investment budget strategically from the business condition of the company. However, within this competitive context and limited resource scenario, budget constraint is unavoidable and could potentially effect the investment in the IT assets and infrastructure.

Although the above financial evaluations assist in the IT investment to a certain degree, they seem to disconnect from the business/organisation context. The IT governance looks at the IT as one of the organisation assets, and hence must also be managed and strategically aligned with the business context. In this research, the learning model of the university in asset management (learning curve) is constructed and utilised together with the service performance to develop the proposed IT investment framework.

This framework focuses on improving the decision making on the IT related activities as well as justifying the business value from the IT investment.

### 2.2 Proposed IT investment framework based on the asset management

Due to the characteristic nature of the IT asset mentioned earlier, more specifically with no direct relation to the company revenues, the IT investment framework based on the concept of the asset management is developed and represents the governing framework for the economic and service performance models. This IT investment framework proposes an alternative framework to assist company in the management of the IT asset. This framework facilitates most suitable decision making under pre-specific constraints/performance level by optimising cost, performance and risk while satisfying stakeholders at the same time. Figure 1 shows the high level concept of the proposed IT investment framework asset management.
Figure 1 shows the high level concept of the proposed IT investment framework based on the asset management. This framework resolves IT related decisions by balancing between ‘economic performance’ and ‘service performance’. The economic performance represents costs and risks associated with an IT asset whereas the service performance focuses mainly on fulfilling stakeholders’ satisfaction. Since the IT equipment is accounted as an asset, not a cost centre, it indicates the life cycle of itself. Hence, this research proposes that the economic performance is modelled as a learning curve with different states across the life cycle of the IT asset. These are corrective maintenance, preventive maintenance, predictive maintenance, proactive maintenance and strategic maintenance. Experiences associated with each state mentioned previously are then translated into cost and risks utilising the KE methodology (Schreiber, 2000). By applying the KE methodology, the economic performance can then be modelled into ‘O&M task’ across life cycle, ‘inference’ representing what to think to complete that task, and ‘domain concepts’ containing how and why to think associated with each inference. With this elicitation technique, the costs and risks associated with the IT asset can then be embedded into the domain concepts. This paper then utilises these domain concepts as the reasoning guideline or strategy in solving the investment problems and decision making in the service performance model.

Typically, service performance of the IT asset can be measured in many different ways (Franke, 2012). These are for example, usability, availability, reliability or security. This really depends on the focus of the evaluation. To overcome the problem of incomplete data/information required and to be compatible with the economic performance proposed in this framework, the service performance is modelled in terms of its quality focusing especially on the investment perspective. That is ‘functions divided by requirements’. Stakeholders are categorised into ‘top executive’, ‘key users’, and ‘IT manager’. Ideally, if the functions equal requirements, it indicates that the IT investment
is optimal and meets all the requirements. Practically however, this is not always the case. It is either functions are greater or lesser than requirements. Hence, to incorporate the different quality expectations of each stakeholder and to meet all the stakeholders’ expectations, experiences/knowledge from the economic performance must be utilised to adjust and optimise the solution within the feasible space. This proposed method is different and considered as the contribution to the existing tools. Instead of collecting and utilising the statistical numbers as variables for the calculation in the service performance, this paper uses the reasoning/domain concepts in the economic performance model as the variable for the calculation in the service performance. This provides greater flexibility to solve the IT investment problems while at the same time balancing all but different stakeholder’s satisfaction.

This section explores conventional financial methods to evaluate the IT investment options which could lead to incorrect resource allocations when considering the characteristics of the IT asset. It then presents and explains the IT investment framework based on the asset management proposed in this paper as an alternative framework. The next section then illustrates the modelling techniques used in this research to develop the economic and service performances of the IT asset. Note here that, these economic and service performances are modelled through the learning curve of experts which represents the organisational learning model of the university when managing the IT assets. The utilisation of the organisational learning model to construct the IT investment framework based on the asset management is one of the key contributions of this research.

3 KE and learning organisation

3.1 Overview of KE

This section discusses a methodology proposed in this paper to assist in the development of the organisational learning model in asset management of the proposed IT investment framework. The KE methodology is applied to capture, analyse and model the knowledge from the learning processes of the university in the IT asset management context. In short, KE is a newly emerging discipline influenced by an advance in the development of the IT. KE provides the scientific methodology to analyse and engineer knowledge. The widely used methodology is CommonKADS which is a knowledge analysis and data structuring program (Schreiber, 2000).

Generally, learning processes of the university when managing its IT assets start from the beginning of the initial operation of its first IT investment. After that, this ‘how-to-do’ knowledge occurs and be learned on the daily basis at all levels (i.e. individual, team, system and organisation). From the asset management’s perspective, this includes the knowledge on ‘how-to’ assemble and de-assemble equipments, schedule resources, diagnose faults and events, monitor incidents, and assess risks during O&M as well as adapting to business changes (Lai, 2001). Normally, these learning processes are collectively gained over a period of time, and the knowledge can be lost with the workers when they leave an organisation.
As previously mentioned, data and information collected in all processes play an important role in the O&M of the assets (Galusha, 2001). By translating this information and data into useful knowledge, the asset management program can then be effectively developed. KE can assist the organisation in maintaining and making use of this otherwise lost knowledge systematically. It provides methodologies to design and construct knowledge systems. In other words, it provides heuristic approach to capture, analyse, model and utilise expert’s knowledge within the organisation. Hence, together with KE methodology (CommonKADS), the learning organisation theory is also utilised and applied in this paper. The organisational learning is defined as a continuous process of creating, acquiring and transferring knowledge accompanied by a modification of behaviour to reflect new knowledge and insights and to produce a higher level asset (Garvin, 2000).

3.2 Proposed organisational learning model of university in the IT asset management

As mentioned previously, in this paper the IT equipment is regarded as an asset with its life cycle, rather than conventional view of a cost centre. From the asset management’s perspective, the economic performance of the IT asset is modelled into costs and risks across its life cycle. This learning curve represents the proposed organisational learning model of the university in the IT asset management, and can be illustrated in Figure 2.

Figure 2  Proposed organisational learning model of university in the IT asset management

Figure 2 shows the framework to model the economic performance with regard to O&M of an IT asset. This replicates and represents the learning model (learning curve) based on experience collectively gained over a period of time. It is a time consuming process with many parties involved to develop the common best practices. Hence, it requires a step-by-step development from breakdown to proactive maintenance. CommonKADS, the KE methodology, offers some useful inference templates to elicit and structure
knowledge framework (Schreiber, 2000). These include for example, templates for planning, diagnose, scheduling, monitoring and assessment. These templates provide useful guideline for interview, analyse, model and utilise knowledge relevant to the O&M of an IT asset from the experts. The appropriate template to capture the relevant knowledge (cost and risk) of an IT asset can be demonstrated as followed.

3.2.1 Breakdown maintenance

In the beginning, the knowledge from manufacturers and instruction manual books are thoroughly studied. Then, new knowledge on ‘how-to operate’ and ‘how-to maintain’ assets in real workplace situation is developed with regard to cost and risk associated with it. In this step technical supervisors are always required on hand to assist in some critical tasks. The working procedures in O&M are explicitly developed for knowledge sharing and dissemination among knowledge workers. This can also be called ‘routine planning knowledge, and hence, the ‘planning template’ is utilised.

3.2.2 Corrective maintenance

In the early period of the operation, the operators and maintenance workers collaboratively learn to diagnose IT asset, processes and failures. Experience and knowledge in failures and events are collectively gained by the workers. This allows the workers to develop the knowledge on ‘how-to identify’ the faults in each particular failure and/or event as well as costs and risks associated with it. This can also be called ‘diagnosis knowledge’. Note that this knowledge is extended and enhanced from the breakdown maintenance. Hence, to capture this ‘how-to-repair’ knowledge, the ‘diagnosis inference template’ is selected.

3.2.3 Preventive maintenance

With the knowledge gained in the previous step, the operators and maintenance workers can then attempt to schedule the activities and their existing local resources. This is to minimise costs in order to prevent unplanned outage from faults and unpleasant events. This involves the development of their resource’s scheduling and optimisation techniques. This is also called ‘preventive maintenance’ or ‘calendar-based maintenance’ scheme. Note that the opportunity costs and/or the availability are also taken into account in the scheduling. Heuristic-based techniques can be implemented to optimise the maintenance scheduling problems. Hence, the ‘scheduling inference template’ is selected to capture this type of knowledge.

3.2.4 Predictive maintenance

With more knowledge gained over a period of time, this helps the workers to be able to detect some incidents or some conditions. In another word, this is ability to predict the likelihood of faults and events. With the ability to predict the potential future failure, this allows the appropriate O&M actions to be conducted immediately when a discrepancy conditions are found. This ability is called ‘predictive maintenance’ or ‘condition-based maintenance’. As a consequence, the ‘monitoring inference template’ is selected.
3.2.5 Proactive maintenance

This maintenance scheme is based on historical records of equipment (IT asset) failures and its design information. This knowledge assists in the assessment of the equipment life time and its part’s life-cycle, and also in the decision making process of the organisation to refurbish or replace some equipment proactively before its expected life time. Risk factors are also abstracted by the experts for each asset category. To categorise the types of the asset risks, knowledge on equipment design, failure history records, O&M practices, environment, disaster, health, and/or safety is necessary. This maintenance scheme is called ‘proactive maintenance’. To reduce the risks by refurbishment and replacement, the methods such as ‘risk-based inspection’ and ‘reliability centred maintenance’ can be utilised within this maintenance scheme. Hence, to capture this type of knowledge, the ‘assessment inference template’ is selected.

With the proposed modelling methodology explained above, the cost and risk (economic performance) of an IT asset can be modelled into reasoning concepts. Useful knowledge is translated into rationale for decision making activities regarding costs and risks in the service performance model while satisfying different requirements from all stakeholders (top executive, key user, IT manager). Hence, this proposed approach to solve the IT investment problem extends beyond solely relying on the conventional financial evaluation method, and contributes to the alternative method to incorporate economic and socio-technical aspects together. It can be seen from Figure 2 that the costs and risks of an IT asset reduce over time with regard to actions taken.

3.2.6 Example knowledge model based on proposed learning curve

In this subsection, an example knowledge model constructed by applying the KE methodology explained above is given. Note here that, this knowledge model is constructed according to the organisational learning curve in asset management proposed in this research. As explained in Section 3.2, the proposed learning curve can be divided into five knowledge models. These are the knowledge model on breakdown, corrective, preventive, predictive and proactive maintenances. An example knowledge model on corrective maintenance can be illustrated in Figure 3.

Figure 3 Example knowledge model on corrective maintenance, task-subtask (see online version for colours)
Figure 4  Example knowledge model on corrective maintenance, task-inference (see online version for colours)

Figure 5  Example knowledge model on corrective maintenance, inference-domain (see online version for colours)

3.3 Service performance model of proposed IT investment framework

In the previous subsection, the proposed method to construct the organisational learning model of the university in IT asset management is explained. This model represents the learning curve of the experts and organisation when dealing with the IT assets. The rule-based and reasoning guideline contained in the learning model can then be used to reach the IT investment decision. That is to balance and optimise the requirements from all stakeholders involved. Unlike other evaluation methods, the IT investment decision presented in this paper evaluates the IT investment options in terms of the quality of the option to each stakeholder, and attempts to find the suitable quality accepted by all stakeholders. Hence, this subsection provides and explains the modelling method used in
this paper to construct the ‘service performance’ model of the proposed IT investment framework based on the university learning model in asset management.

As mentioned previously, the service performance can be measured in many different ways. This includes for example, usability, availability, reliability or security, and the selection really depends on the focus of the evaluation. However, these measurement indexes rely mainly on the historical data to perform statistical analysis, and most of the time incomplete. Hence, to overcome the problem of incomplete and be compatible with (be able to utilise) the rule based of the economic performance in this framework, the service performance is modelled in terms of its quality focusing especially on the investment perspective to the stakeholders. Hence, the service performance is equal to functions divided by requirements. Functions mean services the IT assets invested can perform and the requirements mean the services the stakeholders wish. This can be illustrated in equation (1).

\[
\text{Service performance} = \frac{\text{Functions}}{\text{Requirements}}
\]

In this paper, the stakeholders are divided into three entities with different objectives. Firstly, on one end is the top executive who makes the investment decision and allocate the financial budget for the IT investment. The main objective of the top executive would be to allocate the financial budget effectively, and get the most out of every investment. In other words, the top executive would not overpay to get more functions than required, or at most allow functions to meet all the requirements. On the other end is the IT manager whose main objective is to be allocated with as much budget as possible for the IT investment. As a result, functions are usually greater than realistically required to perform services. This second entity of the IT manager can also be thought of as the representation of the users within the organisation. The last entity is the key user or the key expert who most of the time acts in the middle to balance between the top executive (economically preferred) and the IT manager (serviceability preferred). The key user or expert does this balancing by utilising the knowledge constructed in the form of the organisational learning model (Section 3.2).

3.4 Balancing mechanism of the proposed IT investment framework

According to equation (1), since this research categorises the stakeholders involved in the IT investment decision into three parties, there are three service performance functions for the consideration. Conventionally, the investment decision can be based on the objective of one stakeholder. This could either be the top executive or the IT manager. This is simple, but to reach the IT investment decision this way would surely neglect other stakeholders’ satisfactory. Another way is to optimise the three service performance functions to find the IT investment option which meets the objectives of all the stakeholders involved. Unlike other evaluation methods, the service performance model in this paper utilises reasoning concepts/rule-based concepts which contains knowledge on costs, risks and performances of the IT asset. Furthermore, this proposed evaluation method provides greater flexibility to reach the IT investment decision.

In order to formulate the balancing mechanism or the decision making model of the proposed IT investment framework, the implication of the service performance proposed in equation (1) is analysed and given in Table 1.
According to the equation (1) and the implication given in Table 1, it can be seen that the most satisfactory scenario is when the IT investment results in the balanced situation (functions exactly equals the requirements of all the stakeholders) which is hardly possible practically. Over and under investment indicates ‘opportunity costs’ and ‘not enough functions’ situations respectively. As a consequence, these over and under investments could lead to lesser satisfactory of each stakeholder from the balanced situation (highest point).

Hence, in simplest form, the behaviours of these three stakeholders can be represented by the parabolic equation as given in the equation (2).

\[
\text{Stakeholder behaviour(value or quality)} = -(x - a)^2 + b
\]  

(2)

where

- \(a = 0.5\) for the top executive (based on the implication given in Table 1)
- \(a = 1\) for the key expert (based on the implication given in Table 1)
- \(a = 1.5\) for the IT manager (based on the implication given in Table 1)
- \(b = 1\) for the most satisfaction.

Furthermore, based on the equation (2), the behaviour of each stakeholder and the balancing mechanism can then be simulated and illustrated in Figure 6.

**Figure 6** Simulated behaviours of stakeholders in the service performance model (see online version for colours)
Figure 6 shows the simulated behaviours of all the stakeholders (top executive, IT manager, and key user/expert) and the possible balancing activities. It can be seen that each entity feels most satisfied when the objective is met. This is represented by the value equal to one at the top of the relevant graph in Figure 6. Any other numbers on the same graph would then represent the dissatisfaction of that entity arisen from particular reasons. With the simulated scenario shown in Figure 6, service performance being equal to 0.5 (or functions is lesser than requirements) is when the top executive is most satisfied. On the other hand, when the IT manager is most satisfied is when he/she can get more functions than required (or service performance being equal to 1.5 in Figure 6). To consolidate the opposite objectives of the top executive and the IT manager, the key user/expert needs to balance the satisfaction of the service performances of these two entities. These balancing activities can be illustrated as the graph in the middle of Figure 6. When considering the satisfaction of all the stakeholders involved, this creates the so-called feasible space where the key user or the key expert needs to utilise the knowledge (rules or reasoning) of the organisational learning model in IT asset management (economic performance model) proposed in the previous section. These could include, for example, refurbishing some existing IT assets together with the new investments to lessen the budgets or relocate the existing IT assets to perform similar tasks with lower service quality required. All this is to optimise and find the most suitable solution which is accepted by all stakeholders. Furthermore, the utilisation of the knowledge model on IT asset management could alter the shape of the graphs shown in Figure 6 to provide greater flexibility to reach the IT investment decision while taking into account constraints presented. Note here that, the shape of the graph shown in Figure 6 could be different if the accepted level of each stakeholder differs from the simulated scenario. As a consequence, the so-called feasible space would look different, and the key user or key expert would need to utilise more or less knowledge to balance the service performance of all parties.

In this subsection, the service performance model of the proposed IT investment framework based on the university learning model on asset management is explained. It can be seen that the proposed service performance model focuses on evaluating the quality of the IT investments shown in equation (1). To make most suitable decision on the IT investment, the organisational learning model which represents the strategy in problem solving and contains the constructed knowledge (costs, risks, and performances) throughout the life cycle in the form of learning curve is of important. Together, the organisational learning model (economic performance) and the investment quality (service performance) represents the alternative IT investment framework based on the university learning model on asset management in this paper. The next section then provides the case study and results when applying this framework with the College of Arts, Media and Technology (CAMT) within the Chiang Mai University.

4 Case study

In previous sections, the high level concept of the proposed IT investment framework based on the learning model in asset management is given. As explained earlier, the learning model of the university in asset management is constructed by applying the KE methodology. It contains experiences of the experts on ‘how to’ and ‘why’ associating with costs and risks when managing the IT asset across its life cycle. Together with the
An alternative IT investment framework based on university learning model

service performance model, the knowledge concepts from this learning model can be used in the balancing mechanism of the proposed IT investment framework to determine the most suitable investment option.

This section then discusses case studies and results from applying the proposed IT investment framework. Please note here that although in CAMT the IT assets covers software, server, printer, personal computer, network, motion and CAD/CAM, only the personal computer is selected to verify the validity and practicality of the proposed IT investment framework. This is due to the fact that, in the university context, the personal computer represents the majority of the investment budget, and least obvious direct relationships to the organisation revenues.

4.1 General description of case study

CAMT within the Chiang Mai University is used as the case study. CAMT was established in July 2006 to strategically support the country development outside the capital including IT city, e-handicraft and e-tourism. It received the huge initial endowment from the central and local government agencies to cover building infrastructure and research/academic supporting facilities. This endowment totalled approximately 240 million bahts which included 80.5 million bahts for the initial IT investment. Another 2 endowments for IT related activities were provided in year 2007–2008 at 10 and 7 million bahts respectively. The categorisation of the initial IT investment for CAMT can be illustrated as shown in Figure 7.

Figure 7  Categorisation of the initial IT investment for CAMT (see online version for colours)

Figure 7 shows the categorisation of the IT assets for CAMT with the initial investment budget in 2006. It can be seen that to fulfil and support the mandate of CAMT the initial investment in IT assets and infrastructure included software, server, printer, personal computer, network infrastructure and motion capture equipment with CAD/CAM. As mentioned previously, only the personal computer is selected to verify the advantages of
the proposed IT investment framework. In more details, the initial investment budget for the personal computer in CAMT can be classified into three different duties based on academic support in CAMT. These are the personal computer as the academic support for the animation department, the software engineering department, and the modern management and IT department with different expected duties or functions from the personal computers invested.

In the animation department, the personal computer needs high specifications with very fast computer processing unit in order to compute two dimension graphic, three dimension graphic and rendering. Additional to the very fast computer processing unit, the very fast VGA card and large amount of RAM are also needed, as well as the high speed SSD hard disk.

In the software engineering department, the personal computer needs high specification with very fast computer processing unit to support the activities in the software development and programming. Additionally, the large amount of RAM and high speed SSD hard disk are also needed.

In the modern management and IT department, only the normal personal computer with average speed computer processing unit is required. This personal computer is for the administrative functions in the office and general administrative software. Additionally, regular RAM and high speed hard disk are needed.

In summary, the classification of the personal computer invested in CAMT and its different duties and functions in each department is presented in Table 2. Please note here that this classification is essential in this research for the purpose of predetermining the expected quality of the investment option. Then, the investment option can be decided accordingly. This is different from other evaluation methods where the future quality of the investment option is unknown.

### Table 2

<table>
<thead>
<tr>
<th>Duty/Function</th>
<th>CPU</th>
<th>GPU</th>
<th>RAM</th>
<th>Disk space/speed</th>
<th>Total function</th>
</tr>
</thead>
<tbody>
<tr>
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*Figure 8* Typical investment option at the end of the asset life cycle (see online version for colours)
An alternative IT investment framework based on university learning model

Ideally, with no constrains on the financial investment budget, all relevant assets could be replaced by the new assets when the performance drops from the accepted level. However practically, this is not always the case, and replacement usually occurs when their life cycles is reached as shown in Figure 8. Note here that, in this research, the life cycle of the IT assets within CAMT is designed to be three years. This scenario can be seen as the representation of the investment strategy typically used within university (CAMT included).

Figure 8 shows the typical investment option used in CAMT and within the university in general. As mentioned previously, since the life cycle of the IT asset is designed at three years in this research, the replacement point of the new IT assets (investment) is then at three years (or at the end of its life cycle). Although this investment method is simple, it represents the conventional view of the IT asset as the cost centre within CAMT. However practically, this does not always presents the most suitable investment option since the function of the IT asset reduces over its life cycle as well. Moreover, the budgeting usually tends to drop every year. As a result, CAMT needs an alternative investment framework to balance both economic and service aspects. In this research, the investment framework utilises the learning model of experts in asset management.

In the following subsections, test beds are presented as a case study to validate the advantages and applicability of the proposed investment framework. In another words, these test beds represent different investment scenarios/options.

4.2 Test bed 1

In this research, the test bed 1 represents the conventional view where the investment occurs at the end of the life cycle. In this research, it is designed at three years. Furthermore, since the personal computer is classified according to each department based on its functions/duties, the replacement of the new personal computer is then purchased into three groups. These are the personal computer for the animation department, the personal computer for the software engineering department and the personal computer for the modern management and IT. Additionally, with this investment option, the costs for O&M need to be included. The investment pattern of the test bed 1 can be illustrated in Figure 9.

Figure 9 Investment pattern of the test bed 1 (see online version for colours)
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An alternative IT investment framework based on university learning model

The results of the test bed 1 can be seen in Table 3.

Table 3 shows the results of the test bed 1 where replacement of the new personal computer is invested differently for each department, and it occurs every three years (or at the end of the life cycle). It can be seen from Table 3 that the total cost of investment across nine years (three life cycles) is at 61,720,000 bahts. This can be divided into 25,480,000 bahts for initial investment at year 1, 19,620,000 bahts as an investment for the second life cycle, and 16,620,000 bahts as an investment for the third life cycle respectively.

4.3 Test bed 2

In this research, the test bed 2 still represents the conventional view where the investment occurs at the end of the life cycle. Again, in this research, it is designed at three years. However, instead of replacing the new personal computer to fit different duties/functions for each department, in this test bed, the personal computer with lowest specification (for the modern management and IT department) is purchased, and then perform additional upgrade to fit requirements of other departments appropriately. This represents the view of the organisation to keep the budget as low as possible while satisfying the functionality/reliability to a certain degree.

In more details, the replacement (or the new investment) in the test bed 2 focuses on purchasing the personal computer with the specification of the modern management and IT. However, some of them are then upgraded with VGA card, RAM and SSD to match with the requirement of the animation department. Some of them are then upgraded with RAM and SSD to match with the requirement of the software engineering department. This investment scenario occurs every three years or at the end of the life cycle. Additionally, with this investment option, the costs for O&M as well as the costs of the upgrade need to be included. The results of the test bed 2 can be seen in Table 4.

Table 4 shows the results of the test bed 2 where the personal computer with the lowest specification (for the modern management and IT department) is purchased with additional upgrade for other departments. Similarly, it occurs every three years (or at the end of the life cycle). It can be seen from Table 4 that the total cost of investment across nine years (three life cycles) is at 59,320,000 bahts. This can be divided into 25,480,000 bahts for initial investment at year 1, 18,620,000 bahts as an investment for the second life cycle, and 15,220,000 bahts as an investment for the third life cycle respectively.

4.4 Test bed 3

In this research, the test bed 3 represents different investment option other than the conventional view shown in the test bed 1 and 2. In this test bed 3, rather than purchasing the personal computer and consider it as assets of the organisation, the rental of the personal computer is preferred. Similar to the test bed 1, the rental of the personal computer is divided into three groups to match with requirements from different departments within CAMT as mentioned earlier. Please note here that, with this investment option, the costs of O&M as well as the costs of upgrade are not included. The results of the test bed 1 can be seen in Table 5.
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Results of the test bed

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</tbody>
</table>
Table 5 shows the results of the test bed 3 where the rental of the personal computer for different department is preferred. Similar to other test beds, it occurs every 3 years (or at the end of the life cycle). It can be seen from Table 5 that the total cost of investment across nine years (three life cycles) is at 66,400,000 bahts. This can be divided into 25,480,000 bahts for initial investment at year 1, 22,320,000 bahts as an investment for the second life cycle, and 18,600,000 bahts as an investment for the third life cycle respectively.

4.5 Test bed 4

In this research, the test bed 4 represents the investment scenarios of the proposed IT investment framework based on the university learning model in asset management. Still, this investment follows the designed life cycle of the IT asset set at three years. Furthermore, the costs of the O&M as well as the costs of the upgrade are included. When deciding on the investment option, this test bed utilises the knowledge/experiences of the experts in the learning model as shown in Section 3.2.6.

Firstly, experiences from the corrective maintenance are explicated. These are experiences from the corrective actions performed during the O&M activities in the first year. These corrective actions include analysing and fixing of the personal computer related problems when the complaints occur (CAMT incident system). Knowledge on ‘how-to’ and ‘why’ relating to the corrective actions is exchanged and transferred among IT staff (knowledge users) to develop the best practice. With the knowledge on the corrective actions, the IT staff can then develop the most suitable plan to prevent the similar incidents from occurring again. In another word, the knowledge is elevated from the corrective maintenance to the preventive maintenance.

With the preventive maintenance, the functions/duties of the personal computer are maintained above or at least at the accepted level. Hence, the knowledge on “how to upgrade” is performed at the second year as part of the maintenance actions to maintain the functionality of the existing personal computers. Based on experiences from the preventive actions accumulated, the knowledge on prediction and assessment of the possible risks can then be developed to regularly monitor the status of the personal computer and take actions to mitigate the consequences of the incidents respectively. In another word, the knowledge is then enhanced from the preventive actions to predictive and proactive maintenances. The relocation of the personal computer is conducted when the risks of it performing the existing duties are assessed. This is to relocate the personal computer from its existing service functions to lower service functions (change functions) while reducing the risks and the consequences.

In summary, with the knowledge developed and experiences accumulated as the learning model in asset management, the corrective and preventive actions are performed during the first year. Then, upgrade actions for the personal computer of the animation and software engineering departments is performed during the second year of the investment. This is to maintain the service functions of the personal computer to still perform the acceptable level of the animation and software engineering departments. Then, at the end of the life cycle (year 3), only the personal computer of the animation department is replaced by new investment. The existing personal computer of the animation department (already upgraded) is relocated to the software engineering
An alternative IT investment framework based on university learning model

department. Similarly, the existing personal computer of the software engineering department (already upgraded) is then relocated to the modern management and IT department. The investment pattern of the test bed 4 is shown in Figure 10.

**Figure 10** Investment pattern of the test bed 4 (see online version for colours)

By following this investment option from the proposed alternative investment framework based on the university learning model in asset management, the costs of investment can be reduced while satisfying all relevant stakeholders as well as maintaining the functionality and reliability of the assets. Hence, in year 2, the relevant costs are 1,400,000 bahts for the upgrade actions, and 540,000 bahts for the O&M actions. In total, the costs associated in year 2 are 1,940,000 bahts. In year 3, the relevant costs are 7,000,000 bahts for the new investment of animation department, and 540,000 bahts for the O&M actions. In total, the costs associated in year 3 are 7,540,000 bahts. The results of the test bed 4 can be seen in Table 6.

From Table 6 shows the results of the investment option which follows the learning model on asset management proposed in this research. It can be seen that with this alternative investment framework the investment is spread across the asset’s life cycle. The actions include an upgrade to the existing personal computers, new purchase of the personal computer with highest specification required, and relocation of existing personal computers to other departments with reduced requirements. Please note here that these actions are performed repeatedly across the whole life cycle and every life cycle. It can be seen from Table 6 that the total cost of investment across nine years (three life cycles) is at 58,470,000 bahts. This can be divided into 25,480,000 bahts for initial investment at year 1, 19,120,000 bahts as an investment for the second life cycle, and 13,870,000 bahts as an investment for the third life cycle respectively.
Table 6: Results of the test bed 4

<table>
<thead>
<tr>
<th>Cash flow year</th>
<th>Detail</th>
<th>ANI</th>
<th>SE</th>
<th>MMIT</th>
<th>Grand total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Price</td>
<td>Qua.</td>
<td>Total</td>
<td>Price</td>
<td>Qua.</td>
</tr>
<tr>
<td>1</td>
<td>Initial cost</td>
<td>99,000</td>
<td>100</td>
<td>9,900,000</td>
<td>80,000</td>
</tr>
<tr>
<td>2</td>
<td>Upgrade</td>
<td></td>
<td>-</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>O&amp;M</td>
<td>180,000</td>
<td>1</td>
<td>180,000</td>
<td>180,000</td>
</tr>
<tr>
<td>3</td>
<td>Upgrade</td>
<td>8,000</td>
<td>100</td>
<td>800,000</td>
<td>6,000</td>
</tr>
<tr>
<td></td>
<td>O&amp;M</td>
<td>180,000</td>
<td>1</td>
<td>180,000</td>
<td>180,000</td>
</tr>
<tr>
<td>4</td>
<td>Renew PCs</td>
<td>70,000</td>
<td>100</td>
<td>7,000,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>O&amp;M</td>
<td>180,000</td>
<td>1</td>
<td>180,000</td>
<td>180,000</td>
</tr>
<tr>
<td>5</td>
<td>Renew PCs</td>
<td>55,000</td>
<td>100</td>
<td>5,500,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>O&amp;M</td>
<td>180,000</td>
<td>1</td>
<td>180,000</td>
<td>180,000</td>
</tr>
<tr>
<td>6</td>
<td>Renew PCs</td>
<td>50,000</td>
<td>100</td>
<td>5,000,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>O&amp;M</td>
<td>180,000</td>
<td>1</td>
<td>180,000</td>
<td>180,000</td>
</tr>
<tr>
<td>7</td>
<td>Renew PCs</td>
<td>45,000</td>
<td>100</td>
<td>4,500,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>O&amp;M</td>
<td>180,000</td>
<td>1</td>
<td>180,000</td>
<td>180,000</td>
</tr>
<tr>
<td>8</td>
<td>Renew PCs</td>
<td>40,000</td>
<td>100</td>
<td>4,000,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>O&amp;M</td>
<td>180,000</td>
<td>1</td>
<td>180,000</td>
<td>180,000</td>
</tr>
<tr>
<td>9</td>
<td>Renew PCs</td>
<td>37,500</td>
<td>100</td>
<td>3,750,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>O&amp;M</td>
<td>180,000</td>
<td>1</td>
<td>180,000</td>
<td>180,000</td>
</tr>
</tbody>
</table>
4.6 Results, analysis and discussion

In the previous subsections, the case study is presented to validate the advantages and applicability of the proposed investment framework in the form of different test beds. This subsection then analyses the results and provides discussion on the proposed investment framework when comparing to the existing conventional investment methods based on financial evaluation techniques.

4.6.1 Actual investment costs of each test bed

The actual investment cost of each test bed is given in Table 7. Please note here that the actual costs of investment include the costs of new investment, the costs of upgrade, and the costs of O&M actions. Furthermore, the actual costs of investment cover the full three life cycles of the IT asset (the personal computer in this research).

Table 7 The actual investment costs of each test bed (see online version for colours)

<table>
<thead>
<tr>
<th>Actual cost</th>
<th>Initial cost</th>
<th>Actual cost</th>
<th>Actual cost</th>
<th>Actual cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cycle1</td>
<td>Cycle12</td>
<td>Cycle3</td>
<td>(Year 0-8)</td>
</tr>
<tr>
<td>Alternative A</td>
<td>25,480,000</td>
<td>19,620,000</td>
<td>16,620,000</td>
<td>61,720,000</td>
</tr>
<tr>
<td>Alternative B</td>
<td>25,480,000</td>
<td>18,620,000</td>
<td>15,220,000</td>
<td>59,320,000</td>
</tr>
<tr>
<td>Alternative C</td>
<td>25,480,000</td>
<td>22,320,000</td>
<td>18,600,000</td>
<td>66,400,000</td>
</tr>
<tr>
<td>Alternative D</td>
<td>25,480,000</td>
<td>19,120,000</td>
<td>13,870,000</td>
<td>58,470,000</td>
</tr>
</tbody>
</table>

Table 7 shows the actual investment costs of each test bed. It can be seen that if the evaluation technique is solely based on the conventional financial evaluation (capital budgeting) and excluding the results from the investment framework proposed in this paper (Alternative D), an investment option shown in the test bed 2 will be selected. This is because it presents the cheapest investment costs including upgrade when comparing it with other investment options. This is due to the fact that this investment option chooses to purchase the lowest quality personal computer which is surely cheapest, then upgrade some of them accordingly to fit the requirements of other departments. However, this investment option also increases risks and reduces reliability of the service performance during year 2 and 3. This is evident from more complaints for the corrective actions in the test bed 2 compared to others. With the proposed investment framework considered, an alternative D indicates the cheapest actual investment costs in long term, and performs better than others. This is also confirmed in the present value analysis given in the following sub sections.

4.6.2 Present value analysis

In the previous subsection, the analysis and discussion on the actual costs are given. Although this financial evaluation method is typically used in CAMT (and other faculties within the university) due to its simplicity, the investment decision focusing solely on the actual costs of the investment could be misleading. This can be seen from the results shown in Table 7 where the investment option indicated presents greater risks and reduced service reliability. This subsection then illustrates the investment decision by analysing the present values of costs and benefits of each investment options.
As reviewed in the literatures, the present value is also one of the common financial evaluation techniques used when analysing different investment options. The equations for the present values of costs and benefits used in this research are given in equation (3).

\[ PV = \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \cdots + \frac{C_n}{(1+r)^n} \]

\[ NPV = C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \cdots + \frac{C_n}{(1+r)^n}. \]

Please note here that the benefit in this research is measured by the satisfaction of students from the personal computers invested as a proportion to the tuition fees paid. The results of the present values of costs and benefits from each test bed can be seen in Table 8.

<table>
<thead>
<tr>
<th>Present value</th>
<th>PV of benefit – PV of cost</th>
<th>Year 0–11</th>
<th>Year 3–11</th>
<th>Year 6–11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative A</td>
<td>−11,393,634.38</td>
<td>−5,086,213.02</td>
<td>−3,449,686.44</td>
<td></td>
</tr>
<tr>
<td>Alternative B</td>
<td>−15,562,775.75</td>
<td>−9,921,486.43</td>
<td>−5,316,347.28</td>
<td></td>
</tr>
<tr>
<td>Alternative C</td>
<td>−13,111,608.24</td>
<td>−7,190,804.88</td>
<td>−4,343,069.26</td>
<td></td>
</tr>
</tbody>
</table>

In Table 7, the investment decision based on the actual costs would indicate that the investment option in the test bed 2 is preferable since it presents the cheapest of all. However, when considering the present value of costs and benefits as shown in Table 8, this is not the case and it is actually the worst investment option compared to others. Furthermore, the investment option in the test bed 3 (rental) presents the highest amount of costs since interests and premiums are included and spread throughout the rental period. This investment option is suitable for the organisation with limited annual investment budget. With the present values analysis, the investment option in the test bed 1 is the most preferable while still maintain the service performance within the acceptable limit.

### 4.6.3 Present value analysis with proposed investment framework

In this subsection, the investment option in the test bed 4 is included in the present value analysis. This investment option in the test bed 4 utilises the knowledge from the learning model in asset management and translates this knowledge into effective maintenance actions to reduce costs and risks, and maintain the performance and benefits. The results of the present value with the investment option in the test bed 4 is given and compared in Table 9.
An alternative IT investment framework based on university learning model

Table 9

<table>
<thead>
<tr>
<th>Present value</th>
<th>PV of benefit – PV of cost</th>
<th>PV of benefit – PV of cost</th>
<th>PV of benefit – PV of cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year 0–11</td>
<td>Year 3–11</td>
<td>Year 6–11</td>
</tr>
<tr>
<td>Alternative A</td>
<td>−11,393,634.38</td>
<td>−5,086,213.02</td>
<td>−3,449,686.44</td>
</tr>
<tr>
<td>Alternative B</td>
<td>−15,562,775.75</td>
<td>−9,921,486.43</td>
<td>−5,316,347.28</td>
</tr>
<tr>
<td>Alternative C</td>
<td>−13,111,608.24</td>
<td>−7,190,804.88</td>
<td>−4,343,069.26</td>
</tr>
<tr>
<td>Alternative D</td>
<td>−3,726,161.00</td>
<td>4,141,472.85</td>
<td>1,434,102.54</td>
</tr>
</tbody>
</table>

It can be seen from Table 9 that the investment option in the test bed 4 shows the best possible investment decision comparing to others. Not only the investment costs are relatively low, the benefits are also high. Instead of performing the corrective actions when the service performance drops, this proposed investment framework classifies and sets the service performance requirements of each department. Then, it constructs maintenance actions from accumulated experiences to perform upgrades, relocation and replacement when needed. The results given in Table 9 can also be illustrated as in Figure 11.

Figure 11 Comparisons of present values of each investment options (see online version for colours)

Figure 11 shows the comparisons of the present values from each investment scenario. It can be seen that in most cases the investment costs are usually greater than benefits. This is due to the fact that the IT investment in the university does not relate directly to the revenues or financial productivity. However, university has no choice, but to keep spending to support the academic activities. Hence, this proposed investment framework...
can assist the university in the most suitable investment decision/actions and make the most of its investment budgets.

5 Conclusions

Unlike conventional evaluation methods, the alternative investment framework based on the university learning model in asset management proposed in this paper overcomes the difficulties of incomplete and unstructured data needed. Moreover, it encompasses the conventional view, and covers both the tangible and intangible aspects of the investment option. By applying the concept of asset management, IT in this research is considered as an asset with its own life cycle, and hence can be managed. The proposed investment framework evaluates the investment options by balancing costs, performances and risks associated with the asset (tangible and intangible aspects). This is surely different from conventional view which considers IT as the cost centre resulting in the emphasis on financial evaluation technique.

To assist in the decision making for the most suitable investment option, this research proposes and proves that the university learning model in asset management can be constructed and utilised. The results given in this paper show that by applying the KE methodology (CommonKADS) the learning curve of the experts can be developed systematically and contains knowledge model across the life cycle of the IT asset. Furthermore, this paper shows that the service performance model focusing on the quality of investment option and the balancing mechanism proposed are more applicable and provides greater flexibility.

Since IT investment in the university does not relate directly to the revenues or financial productivity, the evaluation method based on the financial technique would result in bad investment scenarios most of the time. However, university has no choice but to keep spending on the IT infrastructure to support the academic activities and to maintain the satisfaction of the stakeholders. This investment obligation can also be found with other organisations where the investment in the IT cannot be mapped to the revenues, and hence, the proposed investment framework is still applicable. Unlike the conventional evaluation methods, the proposed IT investment framework can assist the university to choose the most suitable investment option by considering the costs and benefits across the whole life cycle. Furthermore, it assists in deciding the most suitable maintenance options to minimise costs and risks as well as maintaining the service performance. This could then allow the university to make the most of its investment.

References


