ITMSOC

Available online at http://itmsoc.org
Information Technology Management Society

ITMSOC Transactions on Innovation & Business Engineering 01 (2016) 21–27

ITMSOC–IBE
ITMSOC Transactions on Innovation and Business Engineering

http://www.itmsoc.org

Requirement Prioritization for Software Release Planning Based on Customer Value with Analytic Hierarchy Process

Alissara Chindapornsopit, Taweesak Samanchuen*

Technology of Information System Management Division, Faculty of Engineering, Mahidol University, Puttamonthon, Nakorn Pathom, Thailand

Received 20 January 2016; Accepted 25 August 2016

Abstract

Requirement prioritization process is a big challenge in a software company that develops software using the incremental model. Because of limitations in efforts and time, the proper requirements in proper time must be selected for implementation. A requirement prioritization framework with customer value base is introduced in this work. Four factors of customer value are extracted from the requirements, including business rules, revenue, process improvement, and technology. Analytic Hierarchy Process (AHP) is applied for calculating the weighting factors of customer value. The number of requirements is reduced to minimize the complexity of proposed framework by a filtration process. Key customer and requirement types are used as the controlled parameters in this process. The result of this study is a ranking list of requirements for a software release project. The list is ordered by the score manipulated with the weighting factors of customer value. The highest score means the highest priority. Framework performance is evaluated by stakeholders of the software release project. The stakeholders agree and accept that the proposed framework could enhance the existing manual process and the customer satisfaction.

Keywords: Requirement Prioritization, Software Requirement, Customer Value, Analytic Hierarchy Process (AHP).

1. Introduction

DELIVERING the right software features in the right time is a key success of software development business. "The customer's overall assessment of the utility of a product is based on the perceptions of what is received and what is given" [1]. In software market, the requirement engineering is very important for offering the right benefits to customer, because it is the process to address the customer's needs on a new or modified project.

Software production is driven by competition in global market. Many organizations utilize information technology (IT) system as a solution for their business. However, the business behavior is very dynamic, i.e., the strategies always change for increasing their competitiveness. While business changes, a new requirement is occurred. To respond this event, the software requirement analysis is needed to perform.

Previously, the traditional software production development model is waterfall. The software is developed sequential stage. Kotonya and Sommerville [2] introduced the five stages of software production development for waterfall model. Those are given as: requirement definition, system and software design, implementation and unit testing, integration and system testing, and operation and maintenance. However, this model consumes a long time, and the software is released to customer in the final stage.

Currently, a new proposed software development model is called "incremental model". It divides software development process into a short period of time, called "increment". Each increment contains system requirement engineering, system designing, coding, and testing. It is delivered to customer as a software package. This model does not need to complete the software develop-

*Corresponding author.
Email address: taweesak.sam@mahidol.ac.th (Taweesak Samanchuen)

e-ISSN: 2539-5904

ment for customer in one increment, but the most critical functions for customers are firstly delivered. After that other incremental or release versions with lower priority are developed until a full software version is obtained.

Because of time limitation, the incremental model has to select a set of requirements that should be firstly implemented. Moreover, there are a lot factors involved in this process, such as complexity of requirement, efforts, level of significant, technology, tools for development, and company policies. Thus, the requirement decision making process is a crucial to the success of software release project. The requirement prioritization approaches are introduced to support the decision making. In this work, this issue is addressed.

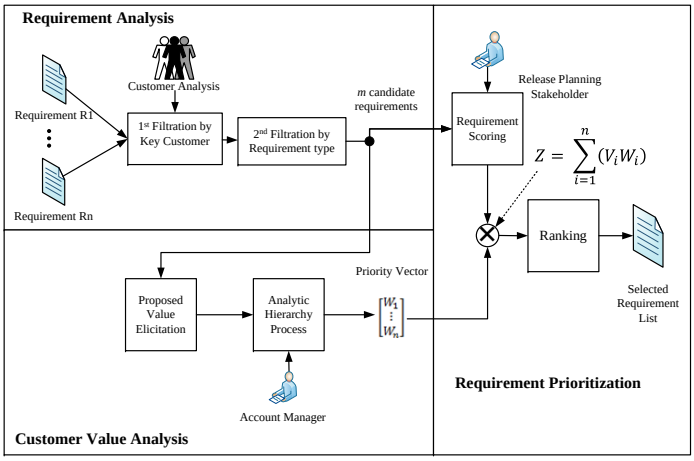

Fig. 1. Proposed framework.

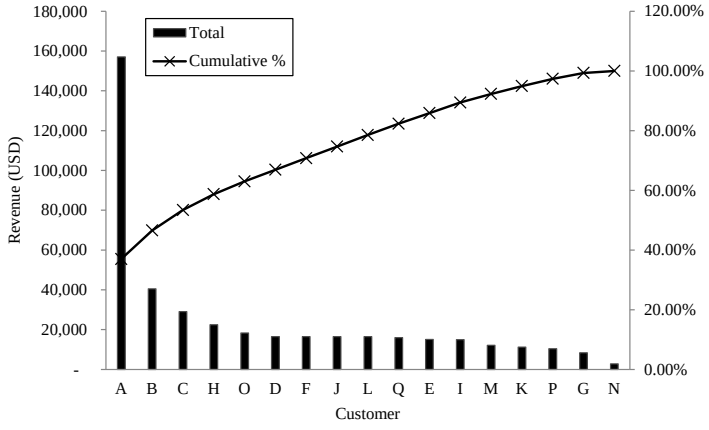

Fig. 2. Pareto chart of customer total payment.

Table 1. AHP Pairwise Comparison Value.

Important Level	Definition
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong or demonstrated importance
9	Extreme importance
2, 4, 6, and 8	Intermediate values

Table 2. Request Type of Customer A.

Request Type	Number of Requests
Change	49
Error	105
Help	23
New	11
Implement	3
Task	23
Total	**214**

Table 3. Association of Saaty's Scale and Balanced Scale with Verbal Judgements.

Verbal Description	Saaty's Scale	Balanced Scale
Equal importance	1	1
-	2	1.22
Moderate importance	3	1.50
-	4	1.86
Strong importance	5	2.33
-	6	3
Very strong or demonstrated importance	7	4
-	8	5.67
Extreme importance	9	9

Table 4. Pairwise Matrix of Customer Value with Balanced Scale.

Customer Value	CVB	CVR	CVP	CVT
CVB	**1**	4	4	5.67
CVR	0.25	**1**	4	4
CVP	0.25	4.25	**1**	1.50
CVT	0.18	4.25	0.67	**1**

Table 5. Requirement Score List with Weighting Factors.

Requirement	CVB	CVR	CVP	CVT	Z	#Rank
R1	2.10	0.69	0.49	0.14	3.42	3
R2	1.14	0.95	0.42	0.14	2.66	9
R3	1.14	0.34	0.36	0.17	2.02	13
R4	2.86	0.09	0.10	0.10	3.14	4
R5	1.53	0.52	0.39	0.19	2.63	10
R6	1.33	1.29	0.29	0.14	3.06	6
R7	1.33	0.52	0.23	0.19	2.27	12
R8	0.95	0.00	0.46	0.07	1.48	17
R9	0.57	0.00	0.26	0.10	0.93	18
R10	2.10	0.17	0.07	0.07	2.41	11
R11	1.72	1.20	0.42	0.24	3.58	2
R12	1.14	0.00	0.39	0.07	1.61	15
R13	1.91	0.52	0.33	0.19	2.94	7
R14	2.10	0.52	0.33	0.17	3.11	5
R15	1.14	1.03	0.20	0.31	2.68	8
R16	1.33	0.17	0.33	0.07	1.91	14
R17	0.95	0.17	0.33	0.14	1.60	16
R18	2.29	1.20	0.36	0.19	4.04	1

Table 6. Top 10 Ranking of Proposed Framework Associated with Ranking of Existing Process.

Requirment	Framework Ranking	Manual Ranking
R18	1	2
R11	2	8
R1	3	11
R4	4	1
R14	5	4
R6	6	6
R13	7	3
R15	8	10
R2	9	14
R5	10	5

Table 7. Result of Stakeholder Satisfaction Evaluation.

No.	Dimension of Evaluation	AM	PM	BA	AVG
1.	Improving the key customer satisfaction	3	4	4	3.67
2.	Ranking the consistency	4	3	2	3.00
3.	Supporting the release planning process	5	4	3	4.00
4.	Applying the feature for all customer	3	5	3	3.67

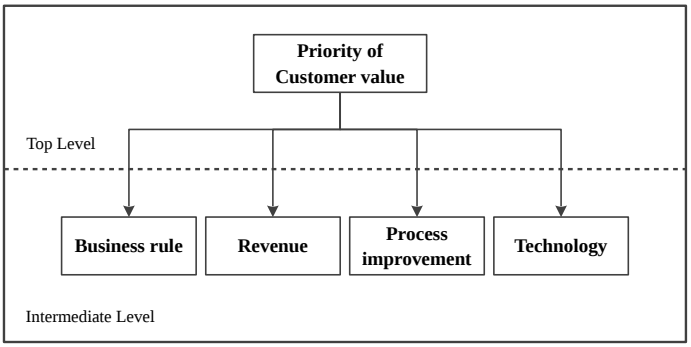

Fig. 3. AHP hierarchy for finding the customer value's priority.

2. Literature Review

2.1. Prioritization Techniques

Simple requirement prioritization has done by voting process among stakeholders. These techniques are used for convincing among the stakeholders to clarify the essential requirements. The famous techniques are introduced as follows.

Theory W is also known as Win-Win Model [3]. Negotiation is the best way to solve the different opinion among stakeholders. The success critical stakeholder is identified, then ask them to rank the requirements carefully. After that, the negotiation is performed to find the win-win situation packages of requirements. Finally, the value-based controls and monitors for win-win equilibrium through the implementation process is completed.

Karlsson and Ryan [4] proposed the prioritizing requirement based on relationship of value to cost of implementation. The customers interest the candidate requirements in view of benefit or value. Normally, a company concerns in the cost for implementation of the candidate requirement. Analytic Hierarchy Process (AHP) was applied to calculate the value-cost ratio. The results of this approach were represented in cost-value graph for using in the release decision.

Azar *et al*. [5] believed that a valid Requirement Engineering process (RE) must produce a set of candidate requirements by balancing the customer needs, the business value, the cost, and the schedule. Therefore, they introduced a novel process, namely Value-Orientated Prioritization (VOP). The VOP approach provided the fundamental needs (i.e., customer needs, business values, and project risks) to prioritize and make decision. All stakeholders were involved in the VOP for discussion and argument over one-by-one requirement.

Moreover, Greer and Ruhe [6] proposed a method to optimally allocate requirements to increments, namely EVOLVE. The method focused on balancing between the requirement and the available efforts by genetic algorithm (GA).

2.2. Analytic Hierarchy Process (AHP)

This work studies about Analytic Hierarchy Process (AHP) for support decision-making process. AHP was introduced by Saaty in 1970s [7]. AHP is a well-known method of the Multi-Criteria Decision-Making (MCDM) to search the best solution for a decision. Input data of the approach can be either qualitative or quantitative value.

The problem will be decomposed to a hierarchy. The hierarchy consists of 3 levels, given as: the top level that is a goal of decision-making, the intermediate level that is a criterion and subcriterion to determine, and the low level that is an alternatives of decision. AHP uses the pairwise comparison matrices to compare the value of preference on one element with the other one element. The preference is divided into nine levels as shown in Table 1.

To determine priority and weight of each alternative by performing the comparison matrix, AHP applies the eigenvector technique to get a weight of each criteria and a ranking of priorities from pairwise matrix. The member of matrix is inserted by this formula:

$$a_{ji} = \frac{1}{a_{ij}}. \tag{1}$$

Saaty [8] proposed the consistence by Consistency Index (CI), given as:

$$\mathrm{CI} = \frac{\lambda_{\max} - n}{n - 1}, \tag{2}$$

where, n is the size of pairwise matrix, and $\lambda_{\max}$ is the maximal eigenvalue.

The Consistency Ratio (CR) being less than 0.1 is acceptable consistency matrix. The value of CR can be calculated by:

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}}, \tag{3}$$

where, RI is the random index which is the average CI of 500 randomly filled matrices [8].

3. Framework Implementation

Our work focuses on analyzing customer values from the customer requirements in a change management system, using the extracted values as the primary factors of requirement prioritization process, and applying the AHP technique for weighting criteria. The proposed of framework is shown in Fig. 1.

The requirement prioritization framework contains 3 main processes. The first process is a requirement analysis. It is to search for the key requirements from the lower priority requirements in system. The second process is a customer value analysis. It is to elicit the customer values of product and to calculate the weight by using AHP approach. The last one is a requirement prioritization process that uses the results obtained from 2 previous parts to perform the prioritization.

3.1. Data Collection

Performing this study, the data about software development must be gathered. In this study, a set of sample data from a software company, who provides a system and service for supporting the passenger service in airline business, is used. There are two types of following data are needed, given as:

3.1.1. Customer Data

Customer data are collected from the customer's portfolio of the key customer. In this study, we focus on selling information. The key customer means the company who has more influence to the income of the company.

3.1.2. Customer Requirement Information

It is a set of data which type is the Change Request (CR). The request's type must be the new customization that requests for the new feature or the new implementation

3.2. Stakeholders of Software Release Planning

For this study, we found that the stakeholders of software release project, who should score for the candidate requirements, are 3 positions.

3.2.1. Account Manager (AM)

AM is a contact person for the customers. AM will support the customers for the issues which are found during the release periods, and will estimate the feasibility for the new requirement in business aspect. In software release planning process, AM is in role of the customer agent.

3.2.2. Product Manager (PM)

PM is an expertise of product, who knows all the product specification, the product constrains, and the customer requirements. PM knows what the product roadmap is, and can estimate the feasibility of new requirement for implementation.

3.2.3. Business Analyst (BA)

BA is an expertise for airline business, who cooperates with PM for analyzing the customer requirements and designing the specification for PM, and develops the team to implement.

These are 3 people who need to score the candidate requirements on each dimension of customer value.

3.3. Requirement Analysis

The requirement analysis is performed to extract the key requirements for software release project from abundant requirements in change management system. We determine the key requirement by aspect of the key customer. Therefore, we have to analyze who the key customer is.

3.3.1. Customer Analysis

The sample selling information is collected from the customer payment report. The company's revenue was got paid from 17 customers who are charged by their usage transactions. To identify the key customer, we apply Pareto analysis in this paper. The revenue cumulative data are utilized to create a Pareto chart for analyzing the key customer. The results are shown in Fig. 2.

Referring to Pareto principal, i.e., "80:20 rule", we found that customer A is the most important customer, because it purchased the highest amount of the service at 37.01% of the cumulative of payment. Hence, we can conclude that the customer A is the key customer of this company.

3.3.2. Requirement Flitration

From this sample data, there are 448 requests which do not assign "lose" or "On-Hold" status by customer. We need to identify the related requests from the unrelated requests. There are 2 rounds of filtration as follows.

3.3.2.1. Requirement Filtration by Key Customer

The first round of requirement filtration utilizes the results of customer analysis as the selection criteria. The results are shown in Table 2. We found that 214 requests are requested by customer A from total 448 requests. According to this process, we can eliminate the related data from 448 requests to 214 requests.

3.3.2.2. Requirement Filtration by Type of Request

For software release project, we need only requests that create the new features of system. The 214 requests of customer A is classified by type. The result is shown in Table 2. There are 6 types of customer request. Only Change, New, and Implement types can pass the filtration process and send to next step. Therefore, the result of this process is 63 requests.

Because of time limitation of this work, using all 63 requests could take long time for next process. Thus, we roughly prioritize and select 18 requests that probably include in this release project. To simplify the presentation, customer requirement is denoted by R1-R18. Remember that all of the filtered requirements must be used when the proposed framework is applied to the real application.

3.4. Customer Value Analysis

According to related study, the success of release project is considered by customer satisfaction. The customer value that will be distributed to customer is also dealed with customer satisfaction. Thus, this section describes the process of elicitation of proposed customer values and the process of AHP to determine the weight of each customer value.

3.4.1. Customer Value Elicitaion

To elicit customer value, business characteristics of all customers have to be analyzed. The business characteristic could indicate classes of benefit that customers expect from the product, while the customers of this company are airlines. After studying the business characteristics of airline software industrial, we can extract the customer value into 4 dimensions as follows.

3.4.1.1. Business Rule (CVB)

In this paper, customer's business characteristic is multi-country business. Many laws, rules, policies of countries must be followed. Moreover, the safety is very important for business. There are some specific rules that need to take action seriously. Therefore, some of customer requirement is to customize the system for responding some business rules.

3.4.1.2. Revenue (CVR)

Everybody does a business for revenue including airline. Many requirements are the requested functions or the features of software for increasing the company's revenue. Hence, the release package software should provide this value to customer.

3.4.1.3. Process Improvement (CVP)

Because of the complexity of business operation, the customers spend a lot effort to operate it. Nowadays, IT can support many process of business. It causes many requirements for improving their business process and reducing time for each task.

3.4.1.4. Technology (CVT)

In the present, e-commerce is the strategy of many companies. To be a market leader, they need to update their tools frequently for the latest technology for overtaking and taking the benefit of them to improve their business. Therefore, the technology is an important factor which could improve the customer satisfaction.

3.4.2. Priority Vecter of Customer Value

After obtaining a set of customer values, it needs to determine how each customer value influences to the others, which can be done by using AHP. The outcome is depended on situations. The priority vector can be applied as a weight factor for each customer value dimension. Thus, AHP is applied for calculating the weight of each customer value as follows.

3.4.2.1. Hierarchy Construction

The AHP hierarchy states on the top level as an objective. Our work states the problem as "the priority of customer values". In intermediate level, we stated as customer values that are "Business rule", "evenue", "Process improvement", and "Technology". Our hierarchy did not need the alternative level, because we just

need to know the weight of each value. The hierarchy is shown in Fig. 3.

3.4.2.2. Pairwise Comparison Evaluation

This process is to create a pairwise comparison form distributed to Account Manager (AM) to evaluate how important of each value is, in case of one-by-one comparing. We use the eigenvector technique to derive the weight matrix of customer value. PV = $[0.663, 0.231, 0.067, 0.038]^T$ is the priority vector result of business rule, revenue, process improvement, and technology, where $(.)^T$ is the matrix transpose. Principal eigenvalue = 4.610 and CR = 22.3%. As proposed by Saaty [7], CR which is less than 10% is acceptable matrix. Thus, the balanced scale is used to improve consistency, proposed by Pöyhönen *et al*. [9]. The balanced scale, Saaty's scale, and their matching with verbal judgments are given in Table 3.

The balanced scale is applied to improve the consistency of matrix. Therefore, the new pairwise matrix from this modification is represented in Table 4. From Table 4, the eigenvector technique derives eigenvalue = 4.212, CR = 7.5%, and PV = $[0.572, 0.258, 0.098, 0.072]^T$. Now, CR is less than 10% which is acceptable value.

3.5. Requirement Prioritization

At this point, all requirement parameters are archived, including the candidate requirements, the customer value, and the priority vector for customer value. This state consists of scoring the candidate requirements, calculating the score, and ranking the requirements to derive the priorities of each requirement, respectively.

3.5.1. Scoring Requirement

The candidate requirement lists are distributed to all stakeholders (AM, PM, and BA) for scoring each requirement referring to each customer value, where the minimum score of 0 means that the requirement does not provide the benefit in this value aspect, and the maximum score of 5 means that the requirement absolutely provides the benefit in this value aspect.

After receiving requirement scores from the stakeholders, the average score of each factor and requirement is calculated. Then, we calculate the total score by multiplying the average score of each factor which weighting factor is obtained from previous section, i.e., PV = $[0.572, 0.258, 0.098, 0.072]^T$. The equation for calculating the total score is given as:

$$Z = \sum_{i=1}^{n} V_i W_i, \tag{4}$$

where, Z is the total score of a requirement; V_i is the average score of the i-th customer value; W_i is the weighting factor of the i-th customer value; and n is the number of customer values. The calculated result of this process is represented in Table 5. From Table 5, we can see that the highest score is 4.04 given by R18, while the lowest score is 0.93 given by R9.

3.5.2. Ranking Requirement

In this section, the candidate requirements are ordered according to the total score in Table 6. This is the outcome of this implementation. This ranking list will be a decision support for the management team in order to select the requirements for implementation of the next incremental software package.

Because of resource limitation as previously described, only some requirements could be selected for the next incremental software package. For example, only the first 10 ranked requirements of all 18 requirements are selected for implementation. This set of requirement is called "the selected requirement". The left of candidate requirements, which do not select for the upcoming software release, will be selected for the further software release.

4. Result Evaluation and Discussion

To confirm the potential of the proposed framework, the evaluation process is demonstrated in this section, which consists of three processes. The first process is to evaluate the ranking consistency. The second process is to evaluate the stakeholder satisfaction. The last process is to interview the stakeholder about framework acceptation as discussion.

4.1. Ranking Consistency Evaluation

To create the benchmark of this study, after we got the candidate requirement, AM is asked to rank the list manually. The list is ranked by the most customer preference. It is the existing method in this company.

To evaluate the ranking result, the top 10 ranking customer preference from AM is used to compare with the top 10 ranking result of framework from Table 6. We can obtain the result as given in Table 6.

According to the results in Table 6, from top 10 requirements, there are only 2 requirements, i.e., R7 and R8, that are not listed in the top 10 ranking of proposed framework. We can say that the difference between the result of the proposed framework and the result of the conventional process is 20%.

4.2. Stakeholder Satisfaction Evaluation

To evaluate the stakeholder satisfaction of the proposed framework, the experts were asked to evaluate the framework in 4 dimensions. The dimensions for evaluation also include four categories, given as: improving the key customer satisfaction, ranking the consistency, supporting the release planning process, and applying the feature for all customers. Score of 5, the highest score, is represented as strongly agree level and Score of 1, the lowest

score, is top represented as strongly disagree level. The result of stakeholder satisfaction is given in Table 7.

The satisfaction evaluation of proposed framework results in Table 7. It shows that the most satisfied dimension of stakeholder is the category of supporting the release planning process with its average score of 4.00. Improving key customer satisfaction and applying feature for all customer get are the equal score of 3.67. The lowest score of 3.00 is given to the category of ranking the consistency.

4.3. Stakeholder Discussion

To sum up the discussion of stakeholders, they accept the ranking result of framework. It makes the process of selecting requirement for software release planning process easier. It eliminates the time of review requirements meeting, the release direction is clear to all stakeholders. However, there are some comment that the framework should be concerned with the internal organization factors, e.g., resource available, cost, version compatibility, and so on.

5. Conclusions

The software prioritization framework is developed for the software release planning process in incremental model. The proposed framework consists of 3 main parts, i.e., the requirement analysis which is a process for looking through the proper candidate requirements for the prioritization, the customer value analysis which is a process for eliciting the customer values as the factors for decision making in the prioritization process, and the prioritization process which is a process for generating the prioritized requirements list for the software release planning process. Performance of this work was evaluated by comparing the framework results with the results taken from the traditional process. Moreover, stakeholder interview was also performed to confirm about the exceptional of framework results. The top 10 ranking members are close to members of the traditional process results, and the stakeholder interview confirmed that they accepted the framework result and gave some suggestion about other factors of project management, e.g., timeframe, efforts, etc.

References

1. Zeithaml VA. Consumer perceptions of price, quality, and value: A Means-End model and synthesis of evidence. Journal of Marketing. 1988 Jul;52(3):2–22. Available from: http://dx.doi.org/10.2307/1251446.
2. Kotonya G, Sommerville I. Requirements engineering with viewpoints. Software Engineering Journal. 1996 Jan;11(1):5–18. Available from: http://dx.doi.org/10.1049/sej.1996.0002.
3. Boehm B, Kitapci H. In: Dutoit AH, McCall R, Mistrík I, Paech B, editors. The WinWin approach: Using a requirements negotiation tool for rationale capture and use. Berlin, Heidelberg: Springer Berlin Heidelberg; 2006. p. 173–190. Available from: http://dx.doi.org/10.1007/978-3-540-30998-7_8.
4. Karlsson J, Ryan K. A cost-value approach for prioritizing requirements. IEEE Software. 1997;14(5):67–74. Available from: http://dx.doi.org/10.1109/52.605933.
5. Azar J, Smith R, Cordes D. Value-Oriented requirements prioritization in a small development organization. IEEE Software. 2007 Jan;24(1):32–37. Available from: http://dx.doi.org/10.1109/MS.2007.30.
6. Greer D, Ruhe G. Software release planning: an evolutionary and iterative approach. Information and Software Technology. 2004 Mar;46(4):243–253. Available from: http://dx.doi.org/10.1016/j.infsof.2003.07.002.
7. Saaty TL. What is the analytic hierarchy process? Mathematical Models for Decision Support. 1988;p. 109–121. Available from: http://dx.doi.org/10.1007/978-3-642-83555-1_5.
8. Saaty RW. The analytic hierarchy processwhat it is and how it is used. Mathematical Modelling. 1987;9(3-5):161–176. Available from: http://dx.doi.org/10.1016/0270-0255(87)90473-8.
9. Pöyhönen MA, Hämäläinen RP, Salo AA. An Experiment on the numerical modelling of verbal ratio statements. Journal of MultiCriteria Decision Analysis. 1997 Jan;6(1):1–10. Available from: http://dx.doi.org/10.1002/(SICI)1099-1360(199701)6:1⟨1::AID-MCDA111⟩3.0.CO;2-W.

Biographies

Alissara Chindapornsopit received the B.Sc. degree in Information technology and Communication in 2010 and M.Sc. in Information Technology Management in 2015 from Mahidol University, Thailand.

In 2010, she joined a software company in a role as programmer and business analyst to service human resource solution for healthcare industry. In 2014, she started working as Quality Assurance in a company that provided online booking engine for airline industry.

Currently, she is a senior programmer and consultant for ERP application and interesting API technology.

Taweesak Samanchuen received his B.Eng. degree from King Mongkut's University of Technology, Bangkok, Thailand, and M.Sc. and Ph.D. degrees from Sirindhorn International Institute of Technology, Thammasat University, Pathumthani, Thailand.

Since 2014, he has been with Mahidol University, Nakhon Pathom, Thailand, where he is currently the Faculty Member of Technology of Information System Management Division.

Previously, he taught at Silpakorn University, Nakhonpathom, Thailand. He also worked at Medalist-Vision Co., Ltd. and Mida Medalist Entertainment Plc.

His research interests include Spread Spectrum, Communications, Wireless Sensor Network, and Analytic Hierarchy Process.