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Extending Use Case Point (e-UCP) mechanism for Cost Estimation and Priority for the Renewable Energy Monitoring System

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Abstract

In this time, it is installing monitoring system to constantly manage the renewable energy system. Even if each renewable energy has unique properties, it may produce electric power based on climate change. Also, the structural heterogeneity among the existing monitoring systems hinders real-time information integration and interoperability of data. In order to solve problems, a monitoring system for integrated management need be developed. To develop a successful monitoring system, development cost and effort estimation are necessary. Previous studies extracted and verified the requirements priority based on use case point [3]. But, this method does not yield his/her effort estimation results. As a result, our existing research is difficult to systematic and rational planning for the system development. This paper applies the improved use case point to the effort estimation of software development. The proposed method enables the effort estimation per use case.

Key Words: Renewable Energy Monitoring System, Use Case Point, Effort Estimation, Use Case Priority, Use Case Verification

1. Introduction

Recently, countries around the world are faced with the following problems: Continued increment in the world population, the instability of oil price, the exhaustion of energy. As an alternative solution for recent energy problems, countries around the world are paying much attention to renewable energy (for example: solar thermal, photovoltaic, geothermal, etc.). But, each renewable energy has unique properties and electric power production varies with climate change (for example: wind, sunshine, etc.). Also, Renewable energy is converted into electrical energy. Therefore it may have a fire risk and cause damage for humans. Therefore, each country has installed a monitoring systems to manage the renewable energy. Yet, the structural heterogeneity among the existing monitoring systems hinders real-time information integration and interoperability of data. An integrated monitoring system needs developing to address this problem.

Developing a successful monitoring system requires estimating cost and effort spent on system development. It is effective to estimate cost and effort at an earlier stage of a project [2]. Previous studies extracted and verified the requirements priority based on use case point (UCP) [3]. However, this method does not yield effort estimation results. Therefore, existing research is difficult to systematic and rational planning of the system. To address this problem, ventilation in Han-ok. Paper-covered doors and windows not only keep the balance of temperature but also absorb and reflect sound, just like breathing in and breathing out the sound. The arch-shaped ceiling and rafters also contribute to reinforcing low frequency sound. As a result, the wooden floor has less energy loss in low frequency sound as proved by impulse response test as well as the case of Geo-mun-go, a Korean traditional musical instrument.

References

[1] T.S. Park, D.J. Sheen, A Study on the thermal environment evaluation of Han-ok considering solid model of building elements. *Journal of the Korea Academia-Industrial Cooperation Society*, Vol. 14, No. 2, 955-961, 2013.

[2] W.H. Lee, M.S. Kim and M.J. Bae, "A study on the analysis of Han-ok (the Korean traditional houses) acoustical characteristics," *The Journal of the Acoustical Society of America* (JASA), Vol. 138, September 2015.

[3] S.G. Bae, W.H. Lee, and M.J. Bae, "A Study on Low Frequency Noise of Dehumidifier using Acoustic Characteristics," *International Journal of Engineering and Technology*(IJET), Vol. 8, No. 1, pp. 235-237, February-March 2016.

[4] E. Zwicker and H. Fastl, *Psychoacoustics - Facts and Models*, Springer, 1990.

[5] S.G. Bae, W.H. Lee, and M.J. Bae, "A Study on Sound Characteristics of Home appliances Noise using Psychoacoustics Parameters," *International Journal of Engineering and Technology*(IJET), Vol. 8, No. 3, pp. 1606-1610, June-July 2016.

[6] ISO 3745. Acoustics – Determination of sound power levels of noise sources using sound pressure – Precision methods for anechoic and hemi-anechoic rooms, 2003.

[7] S.G. Bae, W.H. Lee, and M.J. Bae, "A Study on Improving the Overloaded Speech Waveform to Distinguish Alcohol Intoxication using Spectral Compensation," *International Journal of Engineering and Technology*(IJET), Vol. 7, No. 5, pp. 1957-1964, February-Oct 2015.

[8] Doo-Heon Kyon and Myung-Jin Bae, "An analysis of the acoustic characteristics of forest sounds," *Journal of the Acoustical Society of America*(JASA), pp. 2412-2412, Acoustical Society of America, May 2014.

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this paper applies the improved use case point to the effort estimation of software. This approach applies to the renewable energy monitoring system. The extracted use case point means that we decide to develop system based on the priority of use cases. This paper consists as follows. Chapter 2 describes the structure of renewable energy monitoring system and cost estimation using extended use case point (e-UCP) model. Chapter 3 elucidates the effort estimation method for monitoring system using the improved use case point. Chapter 4 describes case study. Finally, chapter 5 presents the conclusion and suggestion for future studies.

2. Related Works

2.1 Renewable Energy Monitoring System

The existing renewable energy monitoring system is limited to a particular domain. Likewise, each company develops a distinct monitoring system. However, to provide an efficient monitoring service, the interface for diverse renewable energy property information should be standardized and integrated. A standardized and integrated system is easily interoperable with the existing renewable energy system.

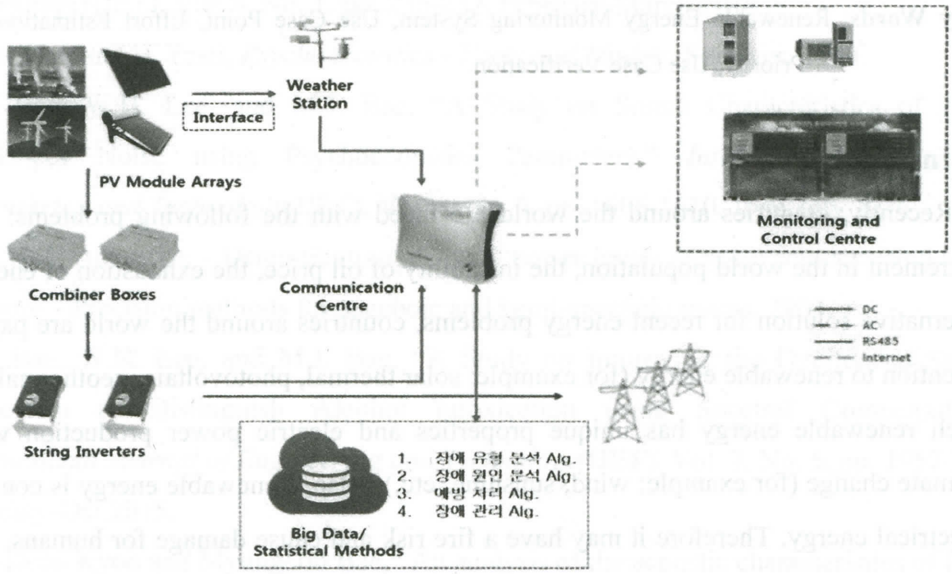

Fig. 1. Renewable Energy Monitoring System

Figure 4 shows the structure of the renewable energy monitoring system using the standard interface.

2.2 Cost Estimation using an Extended Use Case Point (e-UCP) Model

Periyasamy proposed an extended use case model focused on each use case details. This model estimates the cost based on the use case diagram of the developed software products [6]. The extended use case method consists of Actor, Use case, the relation between actor and use case, the relation between actors, the relation between use cases and the narrative of each use case. It is important that the narrative describes the omissions of the use case diagram. But, the other relations extracted from the use case diagram. The e-UCP method calculates the unadjusted use case point (UUCP). It is included unadjusted actor weight, unadjusted use case weight and unadjusted use case narrative weight. The unadjusted use case point values are adjusted using the technical complexity factor (TCF) and environment factor (EF). The final result is an adjusted use case point value. The e-UCP method uses the same TCF and EF weights, as given in the original UCP method.

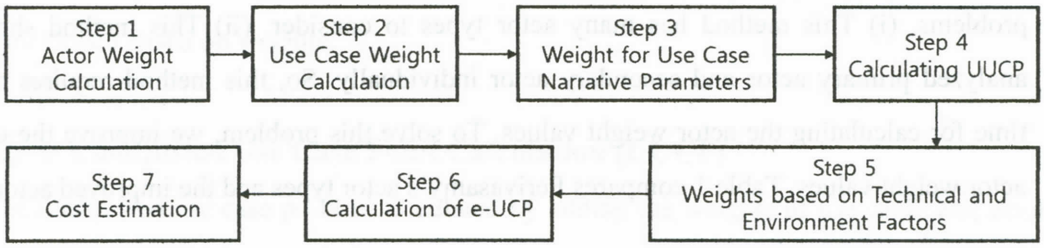

Fig. 2. The size estimation process of an extended Use Case Point (e-UCP)

The e-UCP method is to multiply of the UUCP, TCF and EF values as follows:

$$e - UCP = UUCP \times TCF \times EF \qquad (2.1)$$

Here, e-UCP is the number of use cases required to complete the software development project. In order to obtain a cost estimation, e-UCP value should be converted to the number of working hours. The e-UCP was applied Karner's method (20 man-hours). Therefore, Cost estimation is multiplied by the e-UCP value and 20. Also, it can be estimated man-hours required for a single project.

3. Software Effort Estimation based on Use Case Point (UCP)

Prior to developing the renewable energy monitoring system, we are to apply the estimation based on the use case point. The use case point (UCP) was originally developed by Gustav Karner [4]. In this method, actors and use cases in a use case diagram are used to measure the number of use cases, sizes and complexities [5]. However, the existing UCP has the following problems: (i) The UCP does not indicate the structure of a specific use case or how to write it. Therefore, use case models and specification can vary. (ii) The UCP does not allow for the Include and Extend relations of use cases. To address this problem, we subdivide the types and weights of actors and use cases. Also, if a use case involves *include* or *extend* relation, we added a weight of 0.25 to the use case, which is based on Periyasamy's method [6]. Figure 3 is use case point process for SW effort estimation.

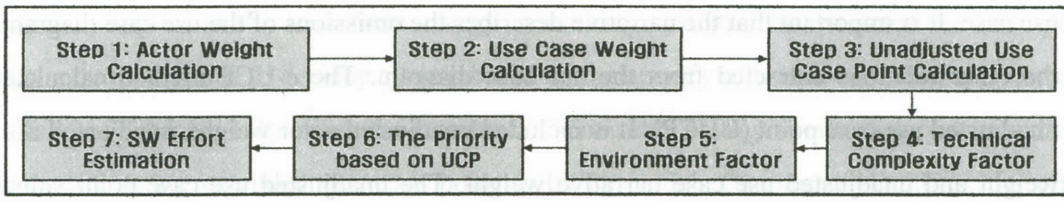

Fig. 3. SW Effort Estimation based on Use Case Point Process for SW effort estimation.

- Step 1: Actor Weight Calculation (UAW)

In Periyasamy's method, the actor weight is consists of seven types. This method has two problems. (i) This method has many actor types to consider. (ii) This method should be analyzed primary actor and secondary actor individually. So, this method requires a lot of time for calculating the actor weight values. To solve this problem, we improve the existing actor weight values. Table 1 compares Periyasamy's actor types and the improved actor types.

Table 1. Compares Periyasamy's actor types and the improved actor types

Periyasamy's Actor Weight			The Improved Actor Weight		
Actor Type	Classification of actors	Weight	Actor Type	Classification of actors	Weight
Very Simple	Specialized Primary/Secondary Actor	0.5	Very Simple	Specialized Actor	0.5
Simple	Primary actor with 1 < number of associations <= 3	1	Simple	Actor with 1 < number of associations <= 3	1
Less Average	Primary actor with 3 < number of associations <= 5	1.5			
Average	Primary actor with number of associations > 5	2.0	Average	Actor with 3 < number of associations <= 5	1.5
	Secondary actor with only One associations	2.0			
Complex	Secondary actor with 1 < number of associations <= 3	2.5	Complex	Actor with 5 < number of associations <= 8	2
Very Complex	Secondary actor with 3 < number of associations <= 5	3.0	Very Complex	Actor with number of associations > 8	2.5
Most Complex	Secondary actor with < number of associations > 5	3.5			

-Step 2: Use Case Weight Calculation (UUCW)

Use case weight is classified as follows: Simple (3<transaction), Average (4≤transaction≤7) and Complex (8≤transaction). Also, in the previous Karner's approach, use cases weight was defined as 5, 10, and 15. However, this method is a wide range of the number of transactions and a big difference between the weights. So, it is difficult to exactly measure the unadjusted use case weight(UUCW). In the use case point, the scale of a use case is determined based on the number of transaction. Therefore, in this method, use cases that have different numbers of

transactions are reflected as a size.

Table 2. Use Case Weight Classification based on the periyasamy's approach.

Use Case Type	Classification of Use Cases	Weight
Simple	Number of transactions <=2	0.5
Average	2 < Number of transactions <=4	1
Complex	4< Number of transactions <= 6	2
Very Complex	Number of transactions >6	3

Table 2 shows use case weight classification. In this paper, we apply the periyasamy's approach. This method subdivides the number of transactions. Also, each extracted use cases are prioritized based on weights.

-Step 3: Unadjusted Use Case Point Calculation (UUCP)

The unadjusted use case point is calculated by adding the weights of use cases and actors. Unadjusted use case point is calculated as follows:

$$\mathrm{UUCP} = \mathrm{UAW} + \mathrm{UUCW} \tag{3.1}$$

-Step 4: Technical Complexity Factor Calculation (TCF)

Technical Complexity Factor describes the size of technical complexity associated with the development and implementation of the system. TCF is calculated as follows:

$$\mathrm{TCF} = C_1 + C_2 \sum_{i}^{n} F_i (C_1 = 0.65, C_2 = 0.01) \tag{3.2}$$

Table 3. Factor Contributing to Complexity

Technical Factor	Factor Description	Weight
T1	Distributed System	2
T2	Response or Throughput Objectives	1
T3	End-User Efficiency	1
T4	Complex Internal Processing	1
T5	Code must be reusable	1
T6	Easy to install	1
T7	Easy to use	0.5
T8	Portable	2
T9	Easy to change	1
T10	Concurrent	1
T11	Includes special security features	1
T12	Provides direct access to third-party SW	1
T13	Special user Training facility is required	1

Table 3 is factor contributing to complexity. The technical complexity factor have 13 categories. The Fi is factor value from 0 to 5. A weight between 0 and 5 is applied to each component. 0 is no effect. Also, 5 is large effect.

- Step 5: Environment Factor Calculation (EF)

The environment factor is based on the experience of the project team members. This is the environment factor predicting projects efficiently. The environment factor is calculated by a weight between 0 and 5. This factor is the same format as the TCF. EF is calculated as follows:

$$\mathrm{EF} = C_1 + C_2 \sum_{i=1}^{8} F_i \times W_i (C_1 = 1.4, C_2 = -0.03) \quad (3.3)$$

Table 4. Factor Contributing to Efficiency

Environment Factor	Factor Description	Weight
E1	Familiarity with UML	1.5
E2	Part-Tome Workers	-1
E3	Analyst Capability	0.5
E4	Application Experience	0.5
E5	Object Oriented Experience	1
E6	Motivation	1
E7	Difficult Programming Language	-1
E8	Stable Requirements	2

Table 4 is factor contributing to efficiency. The environment factor has 8 categories. 0 is no experience, 5 is essential.

- Step 6: Unadjusted Use Case Point Calculation (UUCP)

Upon completion of all calculation from steps 1 to 5, UCP is calculated. UCP is the product of UUCP, TCF and EF. Then, the priority is determined based on the extracted UCP values.

$$\mathrm{UCP} = \mathrm{UUCP} \times \mathrm{TCF} \times \mathrm{EF} \quad (3.4)$$

-Step 7: SW Effort Estimation

SW effort estimation is the product of the estimated development effort (hours) and a developer's mean cost per hour. For the UCP-based SW effort estimation, the present paper applies a method suggested by Karner. (20 hours/UCP) That is, Effort Rate (ER) defined 20 hours/UCP. SW effort estimation calculated as follows:

$$\text{SW Effort Estimation} = \mathrm{ER} \times \mathrm{UCP} \quad (3.5)$$

4. Case Study

In this paper, we follow the steps 1 to 7 of the estimation to describe the effort estimation for the monitoring system. In this method, it is improved to extract and verify the requirements priority better than the existing methods of [3].

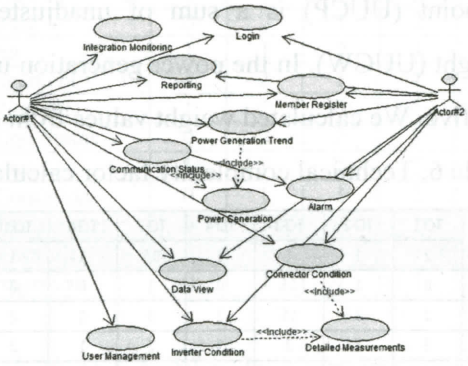

Fig. 4. Use case diagram of the renewable energy monitoring system

Figure 4 shows use case diagram of the renewable energy monitoring system. At the design time, we would get use case diagram such as 16 use cases, 2 actors and 4 'include' relations.

Table 5. Calculated unadjusted actor weight (UAW) and unadjusted use case weight (UUCW)

No	Use Case	Unadjusted Actor Weight(UAW)			Unadjusted UseCase Weight(UUCW)					UUCP
		(User) Actor Weight	(Manager) Actor Weight	Actor Weight	Basic Flow	Alternative Flow	Exceptional Flow	Total Transaction	Use Case Weight	
UC1	Login	1	1	2	1	0	1	2	0.5	3
UC2	Power Generation Trend	1.5	1	2.5	1	5	1	7	3	5.5
UC3	Power Generation	1	1	2	1	6	1	8	3	5
UC4	Detailed Measurements	1	1.5	2.5	1	3	0	4	2	4.5
UC5	Integration Monitoring	2	3	5	1	2	1	4	2	7
UC6	Data View	0.5	1	1.5	1	1	0	2	0.5	2
UC7	Reporting	0.5	1	1.5	1	1	0	2	0.5	2
UC8	Alarm	2	1	3	1	1	1	3	1	4
UC9	User Management	No Use	2	2	1	4	1	6	2	4
UC10	Member Register	No Use	2	2	1	1	0	2	0.5	2.5
UC11	Communication Status	No Use	2	2	1	7	2	10	3	5
UC12	Inverter Condition	0.5	0.5	1	1	0	0	1	0.5	1.5
UC13	Connector Condition	0.5	0.5	1	1	2	0	3	1	2
UC14	Equipment Management	0.5	0.5	1	1	0	0	1	0.5	1.5
UC15	Evaluation Result	0.5	0.5	1	1	0	0	1	0.5	1.5
UC16	Sensor Management	0.5	0.5	1	1	1	0	2	0.5	1.5

Table 5 is the results of unadjusted use case point (UUCP). In this paper, the actor weight are categorized into *users* and *managers*. Use case weight is based on use case specification. Table 5 shows the values of unadjusted actor weight (UAW) and unadjusted use case weight (UUCW). For the requirements priority, actor weights are calculated in use cases. For example, only the manager has an actor weight in the user management (UC9) where the manager is solely allowed to access. Power Generation (UC3) considers both user and manager actor weights simultaneously as both can access it. In 'power generation' use case, user actor weight are simply decided. That is, we assign number one. In 'manager actor' weight, it is the same as that. As a result. It is a sum of total actor weights of them. The total actor weight is two. Unadjusted use case weight (UUCW) is based on use case specification. In the use case specification of 'power generation' use case, this basic flow is one. Alternative flows are six, and exception flow is one. The total transactions are eight. If total transactions are more than seven, we marked three, that is, the 'power generation' use case weight is three. Unadjusted use case point (UUCP) is a sum of unadjusted actor weight (UAW) and unadjusted use case weight (UUCW). In the power generation use case, UAW is two. UUCW is three. So, we marked five. We calculated weight values from each use cases.

Table 6. Technical complexity factor calculation (TCF)

No	Use Case	TCF1	TCF2	TCF3	TCF4	TCF7	TCF9	TCF10	TCF11	TCF12	TCF13	TCF Value
		2	1	1	1	0.5	1	1	1	1	1	
UC1	Login	0	1	1.5	0	1	0	0	1	0	1	5
UC2	Power Generation Trend	1	3	1.5	2	3	1	2	0	0	1	14
UC3	Power Generation	2	3	2	3	2	1	2	0	0	1	17
UC4	Detailed Measurements	1	2	1	1	2	0	1	0	1	1	10
UC5	Integration Monitoring	3	3	2	1	3	1	1	0	1	1	17.5
UC6	Data View	0	2	3	0	2	0	0	0	0	0	6
UC7	Reporting	0	2	2	1	4	0	0	2	0	0	9
UC8	Alarm	0	4	1	0	3	1	1	0	2	0	10.5
UC9	User Management	0	1	2	0	2	0	0	0	0	0	4
UC10	Member Register	0	1	1	0	2	2	0	0	0	0	5
UC11	Communication Status	1	2	1	0.5	2	1	2	2	0	2	13.5
UC12	Inverter Condition	0	3	2	0	4	3	0	2	0	1	13
UC13	Connector Condition	0	2	3	0	2	1	0	1	0	1	9
UC14	Equipment Management	0	2	2	0	2	1	0	1	0	1	8
UC15	Evaluation Result	0	2	3	2	3	1	0	0	0	0	9.5
UC16	Sensor Management	1	2	3	2	3	1	0	0	0	0	11.5

Table 6 is the results of technical complexity factor calculation. In TCF, a weight between 0 and 5 is applied to each component. 0 is no effects and 5 is large effects. This is how the technical complexity factor is calculated. We should check all technical complexity factor on the each use case. Based on that definition, we are marked each use case. In 'Login' use case, *distributed system* (TCF1) decided zero. *Response or Throughput objectives* (TCF2) decided one. *End-user efficiency* (TCF3) assigned 1.5. *Complex internal processing* (TCF4) assigned zero. Easy to use (TCF7) is one. *Easy to change* (TCF9) is zero. *Concurrent* (TCF10) decided zero. *Includes special security features* (TCF11) decided one. *Provides direct access to third-party SW* (TCF12) assigned zero. *Special user training facility* is required (TCF13) assigned one. So, the TCF values of 'Login' use case calculated as follows:

$$\text{Total TCF (Login use case)} = 2 \times 0+1 \times 1+1 \times 1.5+1 \times 0+0.5 \times 1+1 \times 0+1 \times 0+1 \times 1+1 \times 0 +1 \times 1 = 0+1+1.5+0+0.5+0+0+1+0+1=5$$

Total EF Value is three. In EF, EF 2 and EF 6 measured 0. So, we remove them. Table 7 shows environment factor which is calculated by applying a weight between 0 and 5.

Table 7. Environment Factor (EF)

No	Use Case	EF1	EF3	EF4	EF5	EF7	EF8	EF Value
		1.5	0.5	0.5	1	-1	2	
UC1	Login	1	0	1	0	1	1	3
UC2	Power Generation Trend	0	1	2	3	2	1	5

UC3	Power Generation	0	2	2	2	2	1	4
UC4	Detailed Measurements	0	1	2	2	3	2	5
UC5	Integration Monitoring	1	3	3	3	4	2	8
UC6	Data View	0	1	1	2	1	2	6
UC7	Reporting	0	2	1	2	2	2	6
UC8	Alarm	1	1	2	3	3	2	7
UC9	User Management	1	2	1	4	0	1	9
UC10	Member Register	1	2	0	1	0	1	6
UC11	Communication Status	0	2	2	3	2	4	11
UC12	Inverter Condition	1	1	1	2	2	2	7
UC13	Connector Condition	0	1	1	2	2	2	5
UC14	Equipment Management	0	1	1	1	1	1	3
UC15	Evaluation Result	0	1	1	1	1	1	3
UC16	Sensor Management	0	1	1	1	1	1	3

UCP is the product of UUCP, TCF and EF. In Alarm use case (UC8), UUCP is 4. TCF is 10.5. EF is 7. The use case point (UCP) of alarm use case is 294. We should calculate all UCPs on the each use case. Then, the priority is determined on the extracted UCP values. That is, the higher a use case priority is, the higher a complexity. Also, the total estimate is the result of effort estimation extracted from the renewable energy monitoring system. These values indicate the effort estimation for each use case. For example, the UCP of Login (UC1) is 38. Here, the total estimate is 20. The effort estimate of Login UC is 750(37.5X20). As comparing with extracted use case point values, we decided the priority of each use case. So, the priority of Login use case is 15. Table 8 is the final results of use case point, priority and total estimation.

Table 8. Use case point, Priority and Total Estimation

No	Use Case	UCP	Priority	Total Estimate
UC1	Login	38	15	750
UC2	Power Generation Trend	347	3	6930
UC3	Power Generation	340	4	6800
UC4	Detailed Measurements	203	6	4050
UC5	Integration Monitoring	919	1	18375
UC6	Data View	72	11	1440
UC7	Reporting	99	9	1980
UC8	Alarm	294	5	5880
UC9	User Management	144	7	2880
UC10	Member Register	69	12	1375
UC11	Communication Status	743	2	14850
UC12	Inverter Condition	127	8	2535
UC13	Connector Condition	90	10	1800
UC14	Equipment Management	36	6	720
UC15	Evaluation Result	43	14	855
UC16	Sensor Management	52	13	1035

5. Conclusion

In this paper, we estimate the efforts needed to develop the renewable energy monitoring system using the improved use case point. This paper rectifies the existing studies to extract the values for SW effort estimation [3]. Also, we improved the problems of use case point.

The improved use case point id rectified to classify the weights into actor and use case weights. As a result, we enable a UCP-based use case priority and SW effort estimation. In future works, the proposed method will be applied to renewable energy monitoring system development. Also, we will compare the function point and use case point mechanism.

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References

[1] The Export-Import Bank of Korea, the First Quarter of 2014 Renewable Energy Trend. *Issue Briefing*, 2014-G-01, (2014).

[2] GyeJung Ahn, and NamYoung Lee., A Case Study on Applying Function Point Analysis Technique to Measure the Size of Software Systems based on UML. *The Journal of Korean Institute of CALS/EC*, 7 (2002).

[3] So Young Moon, Bo Kyung Park, and R. Young Chul Kim., Verification of Requirements Extraction and Prioritization using Use Case Points. *ITCS (Information Technology and Computer Science)*, ASTL13 (2013), 100-104.

[4] Karner, G., Resource Estimation for Objectory Projects. *Objective System SF AB (Copyright*

Owned by Rational Software), (1993).

[5] Bo Kyung Park, Hyoseok Yang, Kidu Kim, R. Young Chul Kim., Adapting the Analytic Hierarchy Process(AHP) Technique for Importance Analysis and Prioritization on Use Case. *SMA 2013 the 2nd International Conference on Smart Media and Applications*, 2 (2013), 294-298.

[6] Kasi Periyasamy, Aditi Ghode., Cost Estimation using extended Use Case Point(e-UCP) Model, *Computational Intelligence and Software Engineering, CISE (2009), 1-5*

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