Best Practice on Cost Estimation and Priority with Use Case Point (UCP) for Renewable Energy System

2016. 1. 19.

Bokyung Park
Hongik Univ. Selab
Advisor: R. Young Chul Kim
I. Research Motivation

II. Why use UCP, But not FP?

III. SW Effort Estimation based on UCP

IV. Case Study

V. Contribution

VI. Contribution & Future Works
1. Research Motivation

- As an alternative solution for recent energy problems in the world, most countries focus on renewable energy.
  - Renewable Energy have Unique Properties per each resource, and variously produce Electric Power depended on weather change.
  - So, Need to install a monitoring system to manage the renewable energy.

- The Problems of The Existing Monitoring Systems
  ① Their systems are structurally Heterogeneous
  ② Difficult to interoperate data at each device, and to integrate Real-time Information

So, need to develop an Integrated monitoring system to control it.

- For Developing a successful monitoring system,
  requires to estimate cost and effort spent for system development.
1. Research Motivation

Previous Research

- Most cases, they used Function Point for SW Project effort estimation
- Extracted and verified the priority of requirements based on UCP
  
  [So Young Moon, “Verification of Requirements Extraction and Prioritization using Use Case Points”]
  
  - Problems:
    1. This method can not make ‘effort estimation’ results
    2. difficult to make a systematic system planning

Our idea

- Our idea uses the use case point (UCP) to the effort estimation of SW for the renewable energy monitoring system
2. Why use UCP, but not FP?

- **FP Definition**
  - A function point is a "unit of measurement" to express the amount of business functionality an information system (as a product) provides to a user.
  - Function points measure software size.
  - The cost (in dollars or hours) of a single unit is calculated from past projects.

- **UCP Definition**
  - Use Case Points (UCP) is a software estimation technique used to forecast the software size for software development projects.
  - The concept of UCP is based on the requirements for the system being written using use cases, which is part of the UML set of modeling techniques.
  - The software size (UCP) is calculated based on elements of the system use cases with factoring to account for technical and environmental considerations.
  - The UCP for a project can then be used to calculate the estimated effort for a project.
2. Why use UCP, but not FP?

- With FP, They had used the previous system which are developed with the procedural language.

- But now, in most of systems, we are developed by object-oriented language.

- So, we used UCP for renewable monitoring system to measure SW effort (estimation).

⇒ Which mechanisms are more important to measure SW cost estimation?
3. SW Effort Estimation based on UCP

- **Use Case Point**
  - Developed by Gustav Karner
  - Actors and use cases in a use case diagram are used to measure the number of use cases, sizes and complexity.

- **The Problem of his Use Case Point**
  ① The UCP does not indicate the structure of a specific use case or how to write it.
  => So, vary Use case model and specification per each user(developer)
  ② The UCP does not allow for “Include” and “Extends” relations between use cases.

- **Our SW Effort Estimation based on Use Case Point(UCP)**
  ① Subdivide the types and weights of actors and use cases.
  ② Just add a weight of 0.25 to the use case of “Include,” “Extends” relations based on Periyasamy’s method
3. Our UCP Process for SW Effort Estimation

SW Effort Estimation based on UCP Process

Step 1: Actor Weight Calculation
Step 2: Use Case Weight Calculation
Step 3: Unadjusted Use Case Point Calculation
Step 4: Technical Complexity Factor
Step 5: Environment Factor
Step 6: The Priority based on UCP
Step 7: SW Effort Estimation
3. SW Effort Estimation based on UCP

- **Step 1 : Actor Weight Calculation**
  - We improve the existing actor weight values.
  - Actor Weights is classified as follows
    
    => Very Simple(0.5), Simple(1), Average(2), Complex(2.5), Very Complex(3)

- **Step 2 : Use Case Weight Calculation**
  - Use Case Weight is classified as follows
    
    => Very Simple(transaction ≥ 2: 0.5), Simple(transaction = 3: 1), Average(3<transaction≤6: 2), Complex(transaction ≥ 7: 3)

  - Use Case Weight is subdivided based on the numbers of transactions, that is, reflected as a size.
  - Make Prior Use Cases based on weight’s value

- **Step 3 : Unadjusted Use Case Point(UUCP) Calculation**
  - UUCP = Actor Weight + Use Case Weight
3. SW Effort Estimation based on UCP

- **Step 4**: Technical Complexity Factor (TCF) Calculation
  - A weight between 0 (no effect) and 5 (large effects) is applied to each component.

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

- **Step 5**: Environment Factor (EF) Calculation
  - The EF is calculated by applying a weight between 0 and 5.

<table>
<thead>
<tr>
<th>Environment Factor</th>
<th>Factor Description</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>Familiarity with UML</td>
<td>1.5</td>
</tr>
<tr>
<td>E2</td>
<td>Part-Time Workers</td>
<td>-1</td>
</tr>
<tr>
<td>E3</td>
<td>Analyst Capability</td>
<td>0.5</td>
</tr>
<tr>
<td>E4</td>
<td>Application Experience</td>
<td>0.5</td>
</tr>
<tr>
<td>E5</td>
<td>Object Oriented Experience</td>
<td>1</td>
</tr>
<tr>
<td>E6</td>
<td>Motivation</td>
<td>1</td>
</tr>
<tr>
<td>E7</td>
<td>Difficult Programming Language</td>
<td>-1</td>
</tr>
<tr>
<td>E8</td>
<td>Stable Requirements</td>
<td>2</td>
</tr>
</tbody>
</table>
3. SW Effort Estimation based on UCP

- **Step 6 : The Priority based on UCP**
  - $UCP = UUCP \times TCF \times EF$
  - Priority: Determined based on the extracted UCP values.

- **Step 7 : SW Effort Estimation**
  - SW Effort = The estimated development effort(hours) * A developer’s mean cost per hour
  - A method suggested by Karner: 20 hours/UCP
4. Case Study – Our target Domain:

- The Existing Renewable Energy Monitoring System
  - is limited to a particular domain.
  - Each company develops a different monitoring system.

- To provide an efficient monitoring system,
  - Need each interface for diverse renewable energy property information
  So, need to standardize interface, and also Integrated management.
  Then, easily interoperable with other existing renewable energy system.
4. Case Study

- Renewable Monitoring System Use Case Diagram

**Results**
- The number of Use Cases: 16
- The number of Actors: 2
- Include: 4
4. How to calculate UCP?

**Calculated UAW and UUCW**

<table>
<thead>
<tr>
<th>No</th>
<th>Use Case</th>
<th>Unadjusted Use Case Weight(UUCW)</th>
<th>UUCP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(Use) Actor Weight (Manager) Actor Weight</td>
<td>Actor Weight</td>
</tr>
<tr>
<td>1</td>
<td>Login</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Power Generation Trend</td>
<td>1.5</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Power Generation</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Detailed Measurements</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>5</td>
<td>User Management</td>
<td>No Use</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Member Register</td>
<td>No Use</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>Communication Status</td>
<td>No Use</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>Inverter Condition</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>9</td>
<td>Connector Condition</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>10</td>
<td>Equipment Management</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>11</td>
<td>Evaluation Result</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>12</td>
<td>Sensor Management</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**UCP = Actor weight + Use Case Weight**

**Actor Weight = User Weight + Manager Weight**

- **UC3** Both User and manager
- **UC9** Only the Manager
- Complex: Transaction ≥ 7 => Use Case Weight: 3

- **Actor Weight**
  - Actor: User, Manager
  - Actor Weight: Actor weights are calculated in use cases.
  - User Management(UC9): Only the manager has an actor weight.
  - Power Generation(UC3): Both User and Manager have a actor weight.
4. How to calculate UCP, Priority, Total Estimation?

Calculated UCP, Priority and Total Estimate

<table>
<thead>
<tr>
<th>No</th>
<th>Use Case</th>
<th>TCF1</th>
<th>TCF2</th>
<th>TCF3</th>
<th>TCF4</th>
<th>TCF7</th>
<th>TCF9</th>
<th>TCF10</th>
<th>TCF11</th>
<th>TCF12</th>
<th>TCF13</th>
<th>TCF Value</th>
<th>EF1</th>
<th>EF3</th>
<th>EF4</th>
<th>EF5</th>
<th>EF7</th>
<th>EF8</th>
<th>EF Value</th>
<th>UCP</th>
<th>Priority</th>
<th>Total Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>UC1</td>
<td>Login</td>
<td>2</td>
<td>1</td>
<td>1.5</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>37.5</td>
<td>15</td>
<td>750</td>
</tr>
<tr>
<td>UC2</td>
<td>Power Generation Trend</td>
<td>1</td>
<td>1.5</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>14</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>346.5</td>
<td>3</td>
<td>6930</td>
</tr>
<tr>
<td>UC3</td>
<td>Power Generation</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>17</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>340</td>
<td>4</td>
<td>6800</td>
</tr>
<tr>
<td>UC4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>202.5</td>
<td>5</td>
<td>1012.5</td>
</tr>
<tr>
<td>UC5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>202.5</td>
<td>5</td>
<td>1012.5</td>
</tr>
<tr>
<td>UC6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>202.5</td>
<td>5</td>
<td>1012.5</td>
</tr>
<tr>
<td>UC7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>202.5</td>
<td>5</td>
<td>1012.5</td>
</tr>
<tr>
<td>UC8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>202.5</td>
<td>5</td>
<td>1012.5</td>
</tr>
<tr>
<td>UC9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>202.5</td>
<td>5</td>
<td>1012.5</td>
</tr>
<tr>
<td>UC10</td>
<td>Member Register</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>68.75</td>
<td>12</td>
<td>1375</td>
</tr>
<tr>
<td>UC11</td>
<td>Communication Status</td>
<td>1</td>
<td>2</td>
<td>0.5</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>13.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>135</td>
<td>13</td>
<td>1350</td>
<td></td>
</tr>
<tr>
<td>UC12</td>
<td>Inverter Condition</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>13.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>135</td>
<td>13</td>
<td>1350</td>
<td></td>
</tr>
<tr>
<td>UC13</td>
<td>Connector Condition</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9.5</td>
<td>9.5</td>
<td>9.5</td>
<td>9.5</td>
<td></td>
</tr>
<tr>
<td>UC14</td>
<td>Equipment Management</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9.5</td>
<td>9.5</td>
<td>9.5</td>
<td>9.5</td>
<td></td>
</tr>
<tr>
<td>UC15</td>
<td>Evaluation Result</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9.5</td>
<td>9.5</td>
<td>9.5</td>
<td>9.5</td>
<td></td>
</tr>
<tr>
<td>UC16</td>
<td>Sensor Management</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9.5</td>
<td>9.5</td>
<td>9.5</td>
<td>9.5</td>
<td></td>
</tr>
</tbody>
</table>

- TCF: TCF5, TCF6, TCF8 measure 0 => Exception
- EF: EF2, EF6 measure 0 => Exception
- The Total Estimation 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: Login(UC1) UCP = 38, Total Estimation: 20 => SW Effort = 37.5 * 20 = 750

TCF Value = TCF2(1)*1+TCF3(1)*1.5+TCF7(0.5)*1+TCF11(1)*1+TCF13(1)*1=1+1.5+0.5+1+1=5

EF Value = EF1(1.5)*1+EF4(0.5)*1+EF7(-1)*1+EF8(2)*1=1.5+0.5-1+2=3

UCP = UUCP*TCF*EF
Login UC = 2.5*5*3 = 37.5

Total Estimation = UCP*20hours/UCP = 37.5*20 = 750hours/UCP
5. The Contribution of this paper

- With Priority Extraction
  - We got the prioritization of all use case, which means we decides to develop system based on the priority of use cases

- With UCP Extracted,
  - We can recognize which use cases are more complex.

- With Estimation Extracted,
  - We can estimated cost of development.
6. Conclusion & Future Works

✓ Conclusion

- The present paper estimates 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. [Verification of Requirements Extraction and Prioritization using Use Case Point, 2012]

- The Improved Use Case Point
  - Classify the weights into Actor and Use Case Weights

=> The present study enables a UCP-based use case priority and SW effort estimation.

✓ Future Works

- The proposed method will be applied to renewable energy monitoring system development in future studies.

- We should compare to mechanism: FP and UCP
Q&A

Thank You