Measuring Function Points from VDM-SL Specifications

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Introduction

- How can we realize highly dependable or highly reliable systems?
  - System modeling
    - VDM is one of the approach to reflect the requirement of users correctly and to realize highly dependable system.
  - Measuring the system size
    - Function Point Analysis (FPA, hereafter) is widely used method to measure software size.
Purpose of this research

- The purpose is to propose an efficient system development methodology by putting “modeling method” and “measuring size method” simultaneously.

- Concretely, to try to devise the method for measuring Function Point (FP, hereafter) from VDM-SL specifications.
Overview of FP Method

- One of the methods to measure the size of software

- It is a method to assign points to files and data processes in the software according to the complexity.
Five Components of FPs

1. External Input (EI)
2. External Output (EO)
3. External Inquiry (EQ)
4. Internal Logical File (ILF)
5. External Interface File (EIF)

Transaction Function
- The function realized by data process
- Assign Points based on complexity by DET & FTR

Data Function
- The function recognized as “file”
- Assign Points based on complexity in DET & RET

Data Element Type
File Type Reference
Record Element Type
Overview of VDM-SL

- VDM-SL: Vienna Development Method Specification Language
- We can analyze a specification described in VDM-SL easily with VDMTools.
  - Model checking
  - Test
- Cases
  - IC card system
  - Air traffic control system
Literature Survey

- Measuring FP from ER-DFD [Gramantieri et al. 1997]
  - Measure FP from visually described specifications
- Measuring FP from B Specifications [Diab et al. 2002]
  - Measure FP from Specification Language.
  - Judgment of Complexity is ambiguous in this method.
Seven steps for measuring FP

1. Find data function from type definition.
2. Measure DET & RET of data function.
3. Find transaction function from function definition and decide EI, EO, and EQ.
4. Determine ILF & EIF from data function.
5. Measure DET & FTR in transaction function.
6. Assign points based on complexity for each function.
7. Sum up all functions FP.

Unadjusted Function Point

UFP
The Structure of VDM-SL

- **Data Definition**
  - Block to abstract the data structure.
  - Data functions (ILF,EIF) are distinguished in this block.

- **Function Definition**
  - Block to abstract the algorithm.
  - Transaction functions (EI,EO,EQ) are distinguished in this block.

VDM-SL Specification

```plaintext
// 参加者に関する情報
Name = token; Email = token;
Telephone = token; Age = nat;
Address = token;

pInfo:
   email : Email
address : Address
telephone: Telephone
age     : Age;

// データを対応付ける、写像型定義
person = map Name to pInfo;

// 参加者登録
Add(name, pinfo, book) == book union {name |-> pinfo}
pre name not in set dom(book.person);
```
Data Definition Block

VDM-SL Specification

```
types

// 参加者に関する情報
Name = token; Email = token;
Telephone = token; Age = nat;
Address = token;

pinfo ::
  email  : Email
  address : Address
  telephone: Telephone
  age     : Age;

// データを対応付ける、写像型定義
person = map Name to pInfo;
```
Mapping Type

VDM-SL Specification

```plaintext
types

// 参加者に関する情報
Name = token; Email = token;
Telephone = token; Age = nat;
Address = token;

pInfo ::
  email : Email
  address : Address
  telephone : Telephone

// データを対応付ける、写像型定義
person = map Name to pInfo;
```

Mapping type

<table>
<thead>
<tr>
<th>Name</th>
<th>pInfo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ms. A</td>
<td>AUS</td>
</tr>
<tr>
<td>Mr. B</td>
<td>AUS</td>
</tr>
<tr>
<td>Ms. C</td>
<td>JPN</td>
</tr>
</tbody>
</table>

Find the data function from the mapping type which connects data logically.
**Function Definition Block**

```
VDM-SL Specification

functions

// 参加者登録
Add.Name * pInfo * person -> person
Add(name, pinfo, book) == book union {name |-> pinfo}
pre name not in set dom(book.person);
```
Determine the type of transaction function from the signature which shows the types of the function’s in/output.
Notation

- \( Z \): VDM-SL Specification of application whose FP is to be measured.
- \( B\text{types} \): the set of basic data types
  \[ \{ \text{nat, nat1, int, real, bool, char, token} \} \]
- \( \text{types}(Z) \): the set of types defined in \( Z \)
- \( \text{functions}(Z) \): the set of functions defined in \( Z \)
Notation - Element Functions

- **Element Functions**
  - \( S \) is product type and \( S = S_0 \times S \) (\( S_0 \) is not product type): \( \text{element}(S_0 \times S) = \text{element}(S_0) \cup \text{element}(S) \)
  - \( S \) is complex type: \( \text{element}(S) = \text{element}(T_1) \cup \cdots \cup \text{element}(T_n) \)
    - complex type: \( S :: e_1 : T_1 \\
      e_2 : T_2 \\
      \vdots \\
      e_n : T_n \)
  - \( S \) is another type: \( \text{element}(S) = \{S\} \)
Notation - Data Function

- **Data Function**
  
  \[ DF(S) = \{ m \mid m \in \text{types}(Z) \land (\exists T \in \text{types}(Z))(m = \text{map } S \text{ to } T) \} \]

- **Complexity**
  
  for \( S \in DF(Z) \),  
  
  \[ RET(S) = \{ U \mid U \in \text{types}(Z) \land (\exists T \in \text{types}(Z))(U = \text{map } S \text{ to } T) \} \]

  for \( S \in DF(Z) \),  
  
  \[ DET(S) = \text{element}(S) \cup \bigcup \{ \text{element}(T) \mid (U \in RET(S))(U = \text{map } S \text{ to } T) \} \]
Notation - In/Output Data Set

■ For function

For Signature \( F : X_1 \cdots X_m \rightarrow Y_1 \cdots Y_n \),

Input Data Set: \( \text{ids}_{\text{functions}}(F) = \text{element}(X_1) \cup \cdots \cup \text{element}(X_m) \)

Output Data Set: \( \text{ods}_{\text{functions}}(F) = \text{element}(Y_1) \cup \cdots \cup \text{element}(Y_n) \)

■ For mapping type

For mapping type \( M : \text{map } S \text{ to } T \),

Input Data Set: \( \text{ids}_{\text{types}}(F) = \text{element}(S) \)

Output Data Set: \( \text{ods}_{\text{types}}(F) = \text{element}(T) \)
Notation - Transaction Function

- **External Input**

\[
EI(Z) = \{ F \mid F \in \text{functions}(Z) \land (\exists S \in \text{types}(Z))(\exists U \in \text{RET}(S))
\]

\[
((\text{id} (U) \cup \text{ods} (U)) \cap \text{id} (F) \neq \emptyset \land \text{DF} (S) \cap \text{id} (F) \cup \text{ods} (F) \neq \emptyset)\}
\]

- **External Output**

\[
EO(Z) = \{ F \mid F \in \text{functions}(Z) \land \text{ods} (F) \cap \text{Btypes} \neq \emptyset\}
\]

- **External Inquiry**

\[
EQ(Z)
\]

\[
= \{ F \mid F \in \text{functions}(Z) \land (\exists S \in \text{DF}(Z))(\exists U \in \text{RET}(S))(\exists V \in \text{id} (U) \cup \text{ods} (U))
\]

\[
(U \in \text{id} (F) \land (\exists V \in \text{ods} (F) \lor \text{set(seq) of } V \in \text{ods} (F)))\}\}
\]
Notation - Transaction Function

- Complexity

\[ FTR(F) = \{ S \mid F \in functions(Z) \land (\exists U \in RET(S))(U \in ids(F))\} \]

\[ DET(F) = \{ T \mid F \in functions(Z) \land (\exists T \in types(Z) \cup Btypes)(T \in (ids(F) \cup ods(F)) \cap DET(S))\} \]
Measuring FP

- Count one data function for each set of mapping types which have a common domain.
- Count one transaction function for each function in the specification.

⇒ Assign points based on complexity and measure UFP

<table>
<thead>
<tr>
<th>Function</th>
<th>Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low</td>
</tr>
<tr>
<td>Internal Logical File (ILF)</td>
<td>7</td>
</tr>
<tr>
<td>External Interface File (EIF)</td>
<td>5</td>
</tr>
<tr>
<td>External Input (EI)</td>
<td>3</td>
</tr>
<tr>
<td>External Output (EO)</td>
<td>4</td>
</tr>
<tr>
<td>External Inquiry (EQ)</td>
<td>3</td>
</tr>
</tbody>
</table>
FP Calculation Tool for VDM-SL

- FP calculation tool reads a VDM-SL specification and measure FP automatically using the proposed method.

- As a result, calculated FPs for several specifications were correctly measured.
Case Study

- Target: “Asase Book Store Online Order System Project”
  - Online members can order books on the Web, and clerks can manage order and members’ information.

Asase Book Store System
The Process of Measuring

Requirement Definition

Table Definition

Screen Contents Definition

Documents

VDM-SL Specification

Measure from VDM-SL Specification

Measure directly

Compare

UFP
### Result (benchmark in parentheses)

<table>
<thead>
<tr>
<th>No.</th>
<th>Function Name</th>
<th>Type</th>
<th>DET</th>
<th>RET/FTR</th>
<th>Simplicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td>Login</td>
<td>EI(EI)</td>
<td>2</td>
<td>1 (1)</td>
<td>Simple(Simple)</td>
</tr>
<tr>
<td>2-1</td>
<td>Displaying Personal Information</td>
<td>EQ(EQ)</td>
<td>10</td>
<td>1 (1)</td>
<td>Simple(Simple)</td>
</tr>
<tr>
<td>2-2</td>
<td>Changing Password</td>
<td>EI(EI)</td>
<td>4</td>
<td>1 (1)</td>
<td>Simple(Simple)</td>
</tr>
<tr>
<td>3-1</td>
<td>Order</td>
<td>EI/EQ(EI)</td>
<td>13</td>
<td>4 (4)</td>
<td>Complex(Complex)</td>
</tr>
<tr>
<td>3-2</td>
<td>Displaying Personal Order</td>
<td>EO/EQ(EO)</td>
<td>14</td>
<td>4 (4)</td>
<td>Complex(Complex)</td>
</tr>
<tr>
<td>3-3</td>
<td>Displaying Personal Order (Detail)</td>
<td>EQ(EQ)</td>
<td>18</td>
<td>1 (1)</td>
<td>Simple(Simple)</td>
</tr>
<tr>
<td>3-4</td>
<td>Approving Order Progress</td>
<td>EI/EQ(EI)</td>
<td>18</td>
<td>1 (1)</td>
<td>Simple(Simple)</td>
</tr>
<tr>
<td>3-5</td>
<td>Canceling Order</td>
<td>EI/EQ(EI)</td>
<td>18</td>
<td>1 (1)</td>
<td>Simple(Simple)</td>
</tr>
<tr>
<td>3-6</td>
<td>Gift</td>
<td>EI/EQ(EI)</td>
<td>17</td>
<td>1 (1)</td>
<td>Simple(Simple)</td>
</tr>
<tr>
<td>3-7</td>
<td>Displaying Gifts' Information</td>
<td>EQ(EQ)</td>
<td>7</td>
<td>1 (1)</td>
<td>Simple(Simple)</td>
</tr>
<tr>
<td>3-8</td>
<td>Displaying Gifts' Information (Detail)</td>
<td>EQ(EQ)</td>
<td>12</td>
<td>5 (5)</td>
<td>Complex(Complex)</td>
</tr>
<tr>
<td>4-1</td>
<td>Searching Member</td>
<td>EQ(EQ)</td>
<td>11</td>
<td>1 (1)</td>
<td>Simple(Simple)</td>
</tr>
<tr>
<td>4-2</td>
<td>Displaying Members' information</td>
<td>EQ(EQ)</td>
<td>12</td>
<td>1 (1)</td>
<td>Simple(Simple)</td>
</tr>
<tr>
<td>4-3</td>
<td>Registering Member</td>
<td>EI(EI)</td>
<td>9</td>
<td>1 (1)</td>
<td>Simple(Simple)</td>
</tr>
<tr>
<td>4-4</td>
<td>Changing Members' information</td>
<td>EI(EI)</td>
<td>11</td>
<td>1 (1)</td>
<td>Simple(Simple)</td>
</tr>
<tr>
<td>4-5</td>
<td>Removing Members' information</td>
<td>EI(EI)</td>
<td>1</td>
<td>2 (2)</td>
<td>Simple(Simple)</td>
</tr>
<tr>
<td>5-1</td>
<td>Introducing Books</td>
<td>EQ(EQ)</td>
<td>4</td>
<td>2 (2)</td>
<td>Simple(Simple)</td>
</tr>
</tbody>
</table>

*Standard values are written in parentheses

**Functions which have two kinds**

**Different kind of function**
Reasons of different results from bench mark

- **Functions which have two kinds**
  - These specifications are written from the viewpoint of not users but system developers.
    - We have to chose proper type as users.

- **Different kind of function**
  - Details have not decided.
Advantages of this method

- We can measure FP without any document except specification.

- Complexity, especially RET & FTR, can be assigned clearly, though ambiguously in the methods of literature survey.
Conclusion

- A method to measure FP from VDM-SL Specifications is proposed.
  - The advantage of this method is its ability of measuring the degree of complexity of functions.

- The followings are achieved with this measuring method.
  - Development of calculation tool
  - Consideration of this method by case study
Future works

- Enhancement of measuring method
  - Apply the proposed method for other practical VDM-SL Specifications.

- Calculation tool for FP
  - Generation of FPA report
  - Connection with VDM-SL Tool
  - Visualization of ambiguities
Thank You for Your Attention.