BIM Perspective Definition Metadata for interworking Facility Management Data
- 2016.5.24

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Ph.D, Hyun sang, Choi, Research Fellow, KICT

Interests – BIM, GIS, Vision, Interoperability

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This research was supported by a grant from the Strategic Research Project (Development of Integrated Operation Technology on Construction Information & Spatial Information based on BIM/GIS Interoperation Platform in 2016) funded by KICT and (11 High-tech G11) Architecture & Urban Development Research Program funded by Ministry of Land, Infrastructure and Transport of Korean government.
Introduce

Name - Tae Wook, Kang  
Ph.D, Senior Research, ICT Lab, Korea Institute of Construction Institute (Current)  
https://sites.google.com/site/bimprinciple/

Specialty – Civil Engineering, Software Engineering

Experiences
• Writing book  
  IFMA, BIM for FACILITY MANAGERS, Translator (2014.5)  
  Architectural collaborative design, Author (2014.2)  
  Civil BIM, Author (2013.11)  
  BIM interoperability and platform, Author (2013.1)  
  BIM principle, Author (2011.6)

• Research  
  BIM on GIS (Part 1 and 2) Research, KICT (Current)  
  Point cloud-based architectural MEP object reverse engineering research, KICT(Current)  
  BIM-based railway system planning project, MLIT (2013)  
  VDC support system development planning Project, KICT (2013)  
  World best software BIM modeler and check development, Ministry of Knowledge Economy (2012)

• Career  
  BIM division head manager, Hangil IT (2011)  
  Adjunct Professor, Chung-Ang University (2010)
CONTENTS

1 Background

2 BPD

3 Conclusion
Background
# BIM on GIS platform project overview

-B2GM is related to BIM on GIS platform research project
-Developing BIM on GIS platform which has interoperability, application including various use-cases, standard/policy platform. Fund 8 M $ for 5 years (2012 – 2016). KICT with private sector (GAIA 3D, Seokyoung Systems…)

## Commercialization and Standardization

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Application</strong></td>
<td>Use-cases and scenario ex – O&amp;M</td>
<td>Develop it ex – FM, BEMS …</td>
<td>Validate it</td>
<td>Improve it</td>
</tr>
<tr>
<td><strong>SW Platform</strong></td>
<td>Interoperability Support Platform Design between BIM and GIS</td>
<td>Develop it Open API. Linkage. Mapping Rule</td>
<td>Validate it using the pilot project</td>
<td>Improve it</td>
</tr>
<tr>
<td><strong>Standard File</strong></td>
<td>IFC4 analyze and Infra-BIM IFC design</td>
<td>Infra IFC draft version, Converting Tool</td>
<td>Infra-BIM IFC completion</td>
<td>Infra-BIM IFC Standardization</td>
</tr>
<tr>
<td><strong>Policy system</strong></td>
<td>IPDish design</td>
<td>IPD guideline development</td>
<td>IPDish validation</td>
<td>Collaboration System like IPD Suggestions for Public Sector</td>
</tr>
</tbody>
</table>

## Research and Development

Survey the technology and the solution

## R&D Results Validation and Feedback

KICT
BIM on GIS platform issue

GIS-BIM Object Visualization
- BIM Modeling
- IFC Parsing / Converter
- LandXML converter
- CityGML converter
- LOD generator
- Spatial Indexing

GIS-BIM Data Integration
- Integrated query Language
- Object Mapping Ruleset
- LOD Mapping
- Data View Definition
- Coordination Mapping
- Topology Linkage
- CityGML-BIM Extension
- Sensor / Actuator Node Management
- Open API with Security

GIS-BIM Data Mining
- Data Analysis (ex – Trend, Decision Tree, Classification etc)
  - BIM Cube (Data Mining Method based on BIM-GIS)
  - Data Quality Validation
  - Data Mining Language

Context-based Application
- Smart city service
  - Semantic Query and Analysis
  - Model View Definition for Application - MBP Layers (Model + Business Logic + Presentation Layer)
  - Context-based Presentation

Smart city service
- Sensor / Actuator Node Management
- Open API with Security
Objective

BIM Perspective Definition for defining the view related to specific use-case from heterogeneous dataset such as BIM, GIS and external data

Which spaces and users of those spaces exceed the specific reference amount of annual energy usage

SELECT SpaceObject(*) FROM Alignment, Building WHERE Buffer(Alignment, Building, '1km') AND Building.Pset('EM').EnergyUsage < '500 kWh'
2 BPD
### Use-cases

<table>
<thead>
<tr>
<th>No</th>
<th>Requester</th>
<th>Usecase</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>User</td>
<td>Confirm defect</td>
<td>Confirm defect such as a structural crack, facility damage, etc.</td>
</tr>
<tr>
<td>2</td>
<td>User</td>
<td>Maintenance request</td>
<td>Request facility maintenance</td>
</tr>
<tr>
<td>3</td>
<td>Facility manager</td>
<td>Verify defect</td>
<td>Verify the defect by visiting the worksite</td>
</tr>
<tr>
<td>4</td>
<td>Facility manager</td>
<td>Check construction/maintenance history</td>
<td>Check defect-related construction/maintenance history and information on the companies who had performed it</td>
</tr>
<tr>
<td>5</td>
<td>Facility manager</td>
<td>Check location/structure/history of the construction/maintenance (using blueprints)</td>
<td>Check the facility-related information to assess causes and alternatives</td>
</tr>
</tbody>
</table>
Legacy system-based FM use-case scenario in KICT

1. Defect Confirmed
2. Request Maintenance
3. Verify defect (2)
4. Check construction/maintenance history (3)
5. Request site operation commencement approval
6. Draft work plans
7. Request cost estimation
8. Perform site verification of the company (2)
9. Request site operation related data (2)
10. Deliver relevant data (2)
11. Deliver cost estimation
12. Examine cost estimation
13. Request operation commencement approval
14. Send approval
15. Request company-contracted work
16. Perform maintenance
17. Check status before and after maintenance
18. Submit product and results before and after maintenance
19. Confirm the results of maintenance on site
20. Renew blueprints, documents, and historical records
21. Request payment
22. Request expense sanction
23. Approve payment and register the historical record
24. Send notification of maintenance result
25. Authorize payment
26. Send notification of maintenance result

Place / System
Actor
Request
Self-execution

Data Acquisition Repetitive Work (Minimum Repetitive Number)
BIM-based FM scenario

1. Defect Confirmed
2. Request Maintenance
3. Verify defect
4. Check construction/maintenance history using BIM-based FM system
5. Check location/structure/history of the construction/maintenance
6. Draft work plans
7. Request cost estimation
8. Perform site verification of the company
9. Request site operation related data
10. Deliver relevant data
11. Deliver cost estimation
12. Examine cost estimation
13. Request operation commencement approval
14. Send approval
15. Request company-contracted work
16. Perform maintenance
17. Check status before and after maintenance
18. Submit product and results before and after maintenance
19. Confirm the results of maintenance on site
20. Renew blueprints, documents, and historical records
21. Request payment
22. Request expense sanction
23. Approve payment and register the historical record
24. Send notification of maintenance result
25. Authorize payment

Underlined tasks which can be replaced as BIM-based FM work to improve the effectiveness

Facility Manager
FM DB
FM DBMS
BIM-based FM
MIS (Management Information System)
Administrative Manager
Worker
FM Subcontractors
User

Place / System Actor Request Self-execution
Repetitive work calculation

<table>
<thead>
<tr>
<th>Data acquisition work item</th>
<th>Minimum Repetitive</th>
<th>Maximum Repetitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.3</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>No.4</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>No.5</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>No.8</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>No.9</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>No.10</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>TOTAL</td>
<td>28 = 15 + (5 x 2) + 3</td>
<td>43 = 15 + (4 x 3) + 8 + 5 + 3</td>
</tr>
</tbody>
</table>

BIM-based FM work scenario

| Improvement                | 25%                      | 205%                    |
## Perspective Information

<table>
<thead>
<tr>
<th>No</th>
<th>User Perspective</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>User</td>
<td>Manager, space/ no-space area</td>
</tr>
<tr>
<td>2</td>
<td>Facility Manager</td>
<td>Story, classification, space name, date, space area, space perimeter, space volume, space height</td>
</tr>
</tbody>
</table>
| 3  | Subcontractor    | Floor maintenance record is floor finish, partial repair, repair rate, and date.  
Wall maintenance record is wall finish, partial repair, repair rate, and date.  
Ceiling maintenance record is ceiling finish, partial repair, repair rate, and date. |
BPD metadata architecture concept

The interface to query the BIM-based FM data using BPD
From BIM-based FM Database
## BPD grammar

<table>
<thead>
<tr>
<th>No</th>
<th>BPD Grammar Element</th>
<th>Description</th>
</tr>
</thead>
</table>
| 1  | BPD = \{Arg_{BPD}, LogicView, DataView, StyleView\}  
Arg_{BPD} = \{role\}  
role= Name of role to define the perspective of the data representation including the external data transform, data view schema definition, the style for user interface. | The BPD has three components depending on the role, such as the facility manager, the FM engineer, the subcontractor, and the user. |
| 2  | LogicView = \{Mod_{ETL}\}  
Mod_{ETL} = \{Path_{ETL} \ast\}  
Path_{ETL} = string | [;]  
| = OR operation  
[; ] = ETL execution path terminal character | The LogicView supports data transformation methods to translate FM external data to our data view schema for the FM database system to designate the paths of the ETL execution program. |
# BPDxml Grammar

<table>
<thead>
<tr>
<th>No</th>
<th>BPD Grammar Element</th>
<th>XML Tag</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S&lt;sub&gt;Conn&lt;/sub&gt;</td>
<td>“ConnectString” of the DataView tag</td>
</tr>
<tr>
<td>2</td>
<td>N&lt;sub&gt;Cat&lt;/sub&gt;</td>
<td>“name” of the Category</td>
</tr>
<tr>
<td>3</td>
<td>T</td>
<td>“Table” of the Object</td>
</tr>
<tr>
<td>4</td>
<td>N&lt;sub&gt;T&lt;/sub&gt;</td>
<td>“name” of the Object</td>
</tr>
<tr>
<td>5</td>
<td>K</td>
<td>“ObjectKey” of the Object</td>
</tr>
<tr>
<td>6</td>
<td>G</td>
<td>“Group” of the Object</td>
</tr>
<tr>
<td>7</td>
<td>N&lt;sub&gt;G&lt;/sub&gt;</td>
<td>“name” of the Group</td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>“field” of the Object Property</td>
</tr>
<tr>
<td>9</td>
<td>N&lt;sub&gt;TF&lt;/sub&gt;</td>
<td>“name” of the Object Property</td>
</tr>
<tr>
<td>10</td>
<td>N&lt;sub&gt;SVC&lt;/sub&gt;</td>
<td>“Category”</td>
</tr>
<tr>
<td>11</td>
<td>N&lt;sub&gt;SV&lt;/sub&gt;</td>
<td>“name” of the StyleView Property tag</td>
</tr>
<tr>
<td>12</td>
<td>F&lt;sub&gt;SV&lt;/sub&gt;</td>
<td>“format” of the StyleView Property tag</td>
</tr>
<tr>
<td>13</td>
<td>Script&lt;sub&gt;SV&lt;/sub&gt;</td>
<td>TEXT of the StyleView Property tag</td>
</tr>
</tbody>
</table>
BPD example

**Perspective Style View**
Information takeoff and representation from the user perspective definition using BPD

- User A: Code = 12.3.4
- User B: Area = 300 m²
- User C: Building = A
  - Floor = 3F
  - Zone = 4
  - Area = 11811 inch²

**Perspective Data View**

<table>
<thead>
<tr>
<th>BIM database objects</th>
<th>FM database records</th>
</tr>
</thead>
<tbody>
<tr>
<td>GUID</td>
<td>NAME</td>
</tr>
<tr>
<td>3A999</td>
<td>S101</td>
</tr>
</tbody>
</table>

**Logic View**
Extract the external data

Translate and load the external data to FM database

- c:\ETL\ExtractAndTransform.jar

**External Data sources**
Such as the external excel, text, doc and database etc.
BPD approach example

The heterogeneous FM data from the external legacy system

Subcontractor Perspective

View and Use the data

Query the perspective data

Facility = B199
Storey = S05
Code = B199.S05
Name = Main research building

Floor finish history =
- At 2005.3.2, Tile#024 replacement, 0.5 year
- At 2006.7.5, Tile#024 replacement, 0.5 year
- At 2006.10.9, Tile#099 replacement, 0.5 year
- At 2007.12.5, Tile#099 replacement, 0.5 year
**BPD and BIMcube**

---

**SELECT * FROM Building, Pipe WHERE Overlap(Pipe, Building, ‘1m’) AND Building.Pset(‘FM’).Owner = ‘LH’**

---

**SELECT * FROM Alignment, Building WHERE Buffer(Alignment, Building, ‘1km’) AND Building.Pset(‘FM’).PCI < ‘50%’ ORDER BY Building.Pset(‘FM’).PCI**

---

**User**

**BIMcube**

**KPI**

---

**GIS**

**BIM**

**I-DB**

---

**External Data**

---

**BPD**

---

**KPI**

---

**CityGML**

- Civil Engineering Oriented Format
- LOD Features
- Detailed Building Information?
- City engineering objects
- GIS Topology Element?
- Detailed object information network civil engineering
- ex: superposition

**LandXML**

- Civil Engineering Oriented Format
- LOD Features
- Detailed Building Information?
- GIS Topology Element?
- Detailed object information network civil engineering
- ex: superposition

---

**IFC2x3**

- Building Oriented Format
- LOD Features
- Detailed Building Information?
- GIS Topology Element?
- Detailed object information network civil engineering
- ex: superposition

---

**External Dataset**

---

**User**

**BIMcube**

**KPI**

---

**GIS**

**BIM**

**I-DB**

---

**External Data**

---

**BPD**

---

**KPI**

---

**CityGML**

- Civil Engineering Oriented Format
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**LandXML**

- Civil Engineering Oriented Format
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**IFC2x3**

- Building Oriented Format
- LOD Features
- Detailed Building Information?
- GIS Topology Element?
- Detailed object information network civil engineering
- ex: superposition

---

**External Dataset**

---

**User**

**BIMcube**

**KPI**
Case study
BPD demo
BPD demo
BPD demo
Case study

Owner Perspective

Launch BIM Viewer

Object Property Window

Select BIM Object

Facility Manager Perspective

Modeler Perspective

User Perspective

Facility Subcontractor Perspective
## Existing FM Activity Cost Analysis

<table>
<thead>
<tr>
<th>Difficulty Level</th>
<th>Average Cases Quantity/Annual</th>
<th>Minimum Days/Case</th>
<th>Total Days</th>
<th>Case Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50</td>
<td>5</td>
<td>250</td>
<td>Ceiling deflection, Window damage, Door damage, Floor tile damage, etc.</td>
</tr>
<tr>
<td>2</td>
<td>35</td>
<td>10</td>
<td>350</td>
<td>New Facility installation, Crack, Water leak, System window damage, etc.</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>14</td>
<td>140</td>
<td>Space remodeling (electrical wire and switch, communication line installation, finishing work, etc.), partition replacement, etc.</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>90</td>
<td>450</td>
<td>Curtain wall replacement, Structural reinforcement which needs administrative office permission, etc.</td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
<td>29</td>
<td>1,190</td>
<td>-</td>
</tr>
</tbody>
</table>
### Annual cost savings considering BIM-based FM with a BPD

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Work Months (= 30 days)</th>
<th>Saving Factor</th>
<th>Monthly Salary [$]</th>
<th>Documentation Activity Factor</th>
<th>Annual Cost [$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing FM Scenario</td>
<td>40 = 1,190/30</td>
<td>1.0</td>
<td>40</td>
<td>2,600</td>
<td>374,400</td>
</tr>
<tr>
<td>BIM-based FM with BPD Scenario</td>
<td>40 = 1,190/30</td>
<td>0.25</td>
<td>30</td>
<td>2,600</td>
<td>280,800</td>
</tr>
<tr>
<td>CostSavings</td>
<td></td>
<td></td>
<td>10</td>
<td></td>
<td>93,600</td>
</tr>
</tbody>
</table>

**RoI** = 145,600 / 93,600 = 1.56 year

### Investment Cost Estimation of BIM-based FM with a BPD

<table>
<thead>
<tr>
<th>No</th>
<th>Cost Item</th>
<th>Cost [$]</th>
<th>Cost %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Initial BIM Modeling Cost</td>
<td>95,000</td>
<td>65%</td>
</tr>
<tr>
<td>2</td>
<td>FM Database Development</td>
<td>19,000</td>
<td>13%</td>
</tr>
<tr>
<td>3</td>
<td>Software License Cost including DBMS</td>
<td>6,800</td>
<td>5%</td>
</tr>
<tr>
<td>4</td>
<td>PDF Conversion Cost</td>
<td>4,800</td>
<td>3%</td>
</tr>
<tr>
<td>5</td>
<td>Server (H/W)</td>
<td>9,500</td>
<td>7%</td>
</tr>
<tr>
<td>6</td>
<td>Client PC (H/W)</td>
<td>9,500</td>
<td>7%</td>
</tr>
<tr>
<td>7</td>
<td>Education Fee</td>
<td>1,000</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>145,600</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

**RoI** = 145,600 / 93,600 = 1.56 year
## Interview items about the effects of BPD usage

<table>
<thead>
<tr>
<th>Item</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA (Data Accessibility)</td>
<td>Is it easy to search and access the needed data for facility management?</td>
</tr>
<tr>
<td>MPS (Multiple Perspective Support)</td>
<td>Can multiple users access and use the FM data under their roles?</td>
</tr>
<tr>
<td>DVC (Data View Customization)</td>
<td>Is it easy to make and manage the property and data schema of the new facilities by operating the FM system systematically?</td>
</tr>
<tr>
<td>DV (Data Validation)</td>
<td>Can it reduce data errors such as data input errors, data formatting errors?</td>
</tr>
<tr>
<td>DI (Data Integration)</td>
<td>Is it easy to extract and reuse the data from external heterogeneous FM systems such as Excel-based FM tools and CMMS as the viewpoint of the data integration?</td>
</tr>
</tbody>
</table>
Post analysis results of a BPD case study

BPD benefits showed a significant difference between pre and post groups in p-values of 0.05.
BIM in CITY – INTEROPERABILITY BETWEEN BIM-GIS
Conclusion
Conclusion & Future research

Conclusion

• Redemption period considering the return on investment was about 1.56 year.

• BPD benefits showed a significant difference between pre and post groups in p-values of 0.05

Future research

• For supporting decision making by realizing BIM-based machine learning

• Big data processing from IoT

• Terabytes BIM data support
Thanks for your interest

Ph.D, Tae Wook, Kang (www.facebook.com/laputa999)
Blog - https://sites.google.com/site/bimprinciple/

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Pre and post difference analysis results chart from a BPD case study
BPD metadata architecture

- **BPD**
  - `name: string`
  - `Load(BPD_FileName: string): bool`

- **BPD_Library**
  - `ETL_ModuleURL: string`
  - `Find(PerspectiveName: string, BPD_FileName: string): BPD`

- **DataView**
  - `DataMappingAndNormalize(): bool`

- **ViewStyle**
  - `RenderDataFormat(category: string, property: string): string`

- **PropertyStyle**
  - `category: string`
  - `property: string`
  - `format: string`
  - `StyleFormattingLogic: string`

- **Object**
  - `Object_GUID: string`

- **Category**
  - `name: string`
  - `description: string`

- **Property**
  - `name: string`
  - `value: string`
  - `type: enum Type = {integer, real, string}`
### BPD grammar

The DataView supports the data view schema design how to view the structured data from the database which was transformed by the LogicView.

The definitions of the terms on the left are listed below.

**Arg<sub>DV</sub>:** The arguments of the data view.

**Cat<sub>DV</sub>:** The category of the data view to classify the data.

**Obj:** The object definition including the linkage method to combine the BIM object with the database record, the object property definition related to the data view field.

**Arg<sub>Obj</sub>:** The arguments of the object definition which has the database table name, the data view object name, and PK.

**G:** The property group can contain the properties.

**Arg<sub>G</sub>:** The arguments of the property group.

**P<sub>Obj</sub>:** The property definition of the object.

**Arg<sub>P</sub>:** The arguments of the object property to select the field and view the data from the database.

---

$$\text{DataView} = \{\text{Arg}_{DV} *, \text{Cat}_{DV} *\}$$

* = Same element list operation

$$\text{Arg}_{DV} = \{S_{\text{Conn}}\}$$

$$S_{\text{Conn}} = \text{Data source URL string}$$

$$\text{Cat}_{DV} = \{\text{Arg}_{\text{Cat}}, \text{Obj} *\}$$

$$\text{Arg}_{\text{Cat}} = \{\text{N}_{\text{Cat}}\}$$

$$\text{N}_{\text{Cat}} = \text{Data view category name}$$

$$\text{Obj} = \{\text{Arg}_{\text{Obj}} *, G *, | P_{\text{Obj}} *\}$$

$$\text{Arg}_{\text{Obj}} = \{T | N_{TF} | K\}$$

T= Database table name

$$N_{TF} = \text{Name of data view object depending on the table}$$

K= Primary key (PK) definition to link the FM data between BIM object and database record

G = \{Arg_{G} *, P_{Obj} *\}

$$\text{Arg}_{G} = \{N_{G}\}$$

$$N_{G} = \text{Group name of data view object}$$

$$P_{\text{Obj}} = \{\text{Arg}_{P} *\}$$

$$\text{Arg}_{P} = \{F \mid N_{DF}\}$$

F= Data table field

$$N_{TF} = \text{Data view name of the table field}$$
The StyleView supports the representation method as the viewpoint of the user interface.
The meaning of the left definitions is like below.

StyleView = \{Arg_{SV} *, P_{SV} *\}

\(P_{SV} = \{\text{Arg}_{P_{SV}}, \text{Script}_{SV}\}\)

\(\text{Arg}_{P_{SV}} = \{\text{Cat}_{SV} | N_{SV} | F_{SV}\}\)

\(N_{\text{SVC}} = \text{Name of style view category}\)

\(N_{SV} = N_{TF}\) of data view

\(F_{SV} = %[0-9][.][0-9][df] | \text{string}\)

Script_{SV} = \text{Script string}

\(F_{SV} : \text{The formatting string which is similar to the printf() function in ANSI C.}\)