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A NOVEL INFORMATION MODEL FOR DISTRIBUTION ENERGY PRODUCTION

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Abstract: Modeling of information processes provides an advantageous basis for information management and the production of services. By means of modeling the information needs of the process to be described can be easily and explicitly defined in the various phases of the system's life cycle. This paper describes a novel modeling method based on adjacency relations, providing a review of some utilization models of it. By means of adjacency relations the data constructs are defined to support the smooth refinement of data for the various needs of the process. The method can also be used for the management of business related information between organizations. The most important advantages of the method is that the information is user-originated, archivable, retrievable, traceable, accurate and maintainable. In addition, the method provides excellent means for reuse of information. The method clarifies the boundary surfaces between applications and discloses the needs for information interchange. The study is based on solutions related to distributed production of energy, a business field currently under heavy and dynamic development. The aim of the study was to increase the profitability of small-scale power production means by developing and implementing adjacency relation modeling on a life-cycle scale information management commitment. The method renders a total life-cycle view of the information chart of distributed power production and sets out a way to boost profitability. The described method points the way to a business-oriented assessment and improvement of the system solutions of the distributed energy production. This method boosts processes and enhances the information value chain. This will create new opportunities for concrete beneficial technological solutions and service functions.

Key-Words: Information modeling, Distributed energy, Cogeneration, Adjacency relations, Semistructured data

1 Introduction

Modeling of information processes provides an advantageous basis for information management and the production of services. By means of modeling the information needs of the process to be described can be easily and explicitly defined in the various phases of the system's life cycle. This paper describes a novel modeling method based on adjacency relations, providing a review of some utilization models of it.

The paper is organised as follows. In Chapter 2 the key concept of our paper, Adjacency Relation System, is defined shortly. Chapter 3 presents step by step the new method for information modelling. Chapter 4 gives an example of the modelling process in the case of bio energy systems. The final chapter is for discussion.

2 Adjacency Relations

We will first describe shortly the concept of Adjacency Relation Systems (ARS), the key concept of our paper.

The *adjacency relation system* (ARS) is a pair (A, R), where $A = \{A_1, A_2, \ldots, A_n\}$, $n \geq 1$, is a set containing pairwise disjoint finite nonempty sets and $R = \{R_{ij} \mid i, j \in \{1,2,\ldots,n\}\}$ is a set of relations, where each R_{ij} is a relation on $A_i \times A_j$.

If $(x, y_1), (x, y_2), \ldots, (x, y_m) \in R_{ij}$ are all the pairs of relation R_{ij} having x as the first component, then each element y_k $(k = 1,2,\ldots,m)$ is said to be *adjacent* to the element x.
We assume that the elements of each set A_i, $i = 1,2,\ldots,n$, represent entities of a certain type

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T_i. The adjacency between elements can also be defined with the help of the so-called adjacency defining sets (see [1]).

In the theory of adjacency relation systems the adjacency defining sets and so called unique and valid adjacency systems are the basic concepts. The definitions are omitted here (see [1], [2], [3]). Roughly speaking, if a system can be described by an adjacency relation system, then it allows basically all kind of data querying.

The following small example illustrates the above definition. Let

$$R = \{R_{11}, R_{12}, R_{13}, R_{21}, R_{22}, R_{23}, R_{13}, R_{23}, R_{33}\},$$

where

$$R_{11} = \{(x_1, x_2), (x_2, x_1)\},$$
$$R_{12} = \{(x_1, y_2), (y_2, x_1), (x_2, y_2), (y_2, x_2)\},$$
$$R_{13} = \{(x_2, z_1), (z_1, x_2), (x_2, z_2), (z_2, x_2)\},$$
$$R_{33} = \{(z_1, z_2), (z_2, z_1)\},$$
$$R_{21} = R_{22} = R_{23} = R_{31} = R_{32} = \phi.$$

This ARS can be illustrated by the graph of Fig.1.

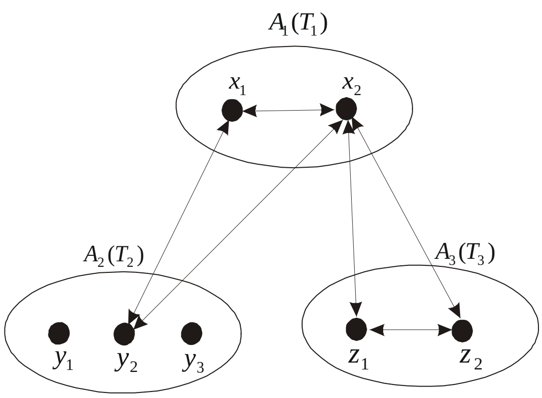

Fig.1 Adjacency relation system.

3 Information Modeling

This chapter presents step by step the new method for information modelling.

3.1 Data Collecting

The goal of this stage is to collect information as much as possible (Fig.2). It is also necessary to find out how information moves between different stakeholder groups and what information each group needs. Special attention is paid to the life cycle of a power plant. The aim is to keep facilities in good condition over their life time. Hence different information is needed in different phases of power plant's life cycle. In this case the life cycle is divided in four phases which are: Planning (1), Building (2), Operating (3) and Closing (4).

In Fig.1 letters state the type of the data. Subscript is used to index data, in other words different subscript means different data of same type. E.g. z_1, z_2, z_3 and z_4 refer to the elements or data of type z. The type of the data means the face of data. For example all documents created in power plant's life cycle are of the same type. However, in this case the concept of data type differs from the concept used in different programming languages.

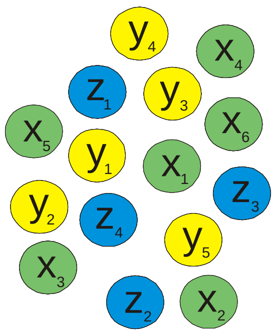

Fig.2 Information mass.

3.2 Data Grouping

In grouping stage we have to define the emergence point of data. All information pieces that has emerged at the same time are placed into the same group. In Fig.3 the information collected in the previous stage is grouped as shown below. In this case the emergence points are the four phases of power plant's life cycle. For example in Fig.3 x_1^1 describes data originating in the planning phase and which type is x. And respectively z_3^4 describes data of type *z* born in the closing phase.

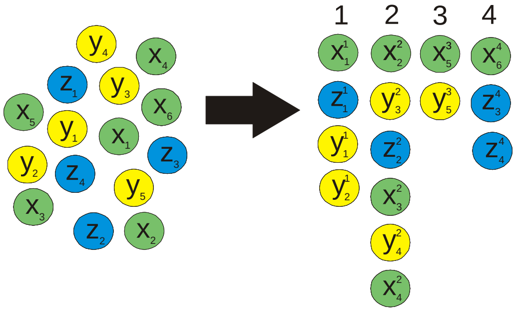

Fig.3 Grouping data.

3.3 Data Collections

After the data is grouped it is analysed. The goal is to find overlapping data. The data is divided between information producers, information users and emergence point. Same kind of information is put into the same data collection. Fig.4 is an example of data collections. In real examples a data collection can be for example a database or a single table of a database.

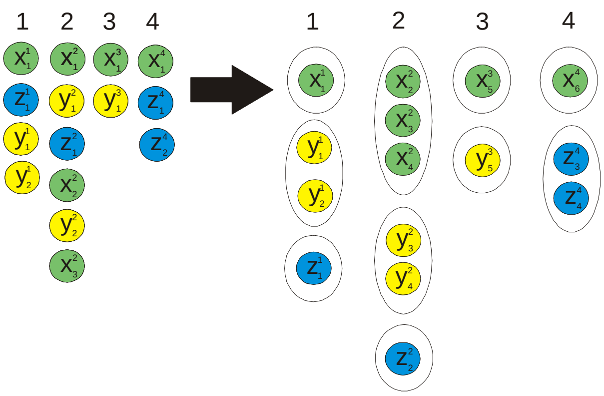

Fig.4 Data collections.

In this stage it is important to keep in mind the following view points: data modelling, data refining and data association.

3.4 Extending Data Collections

Extending of data collections consists of three steps (Fig.5). The first step is to define the top level (1st level) which at this case is the four phases of the life cycle. In the second step data collection, that is data type, becomes the second level of extended data collection. In the third step the hierarchy of levels are deepened so that data can be represented as atomic and single-valued. Atomicity means that data cannot be divided. Single-valued data has only one concurrent value. In other words the value cannot be table, list etc.

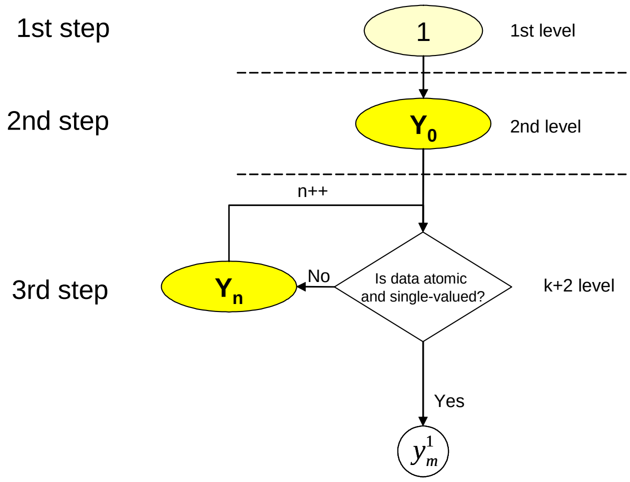

Fig.5 Steps of extending data collections.

The above steps of extending the data collections create paths that can be represented as follows:

$$1 \rightarrow Y_0 \rightarrow \ldots \rightarrow Y_n \rightarrow y_1^1$$
$$1 \rightarrow Y_0 \rightarrow \ldots \rightarrow Y_n \rightarrow y_2^1$$

The paths show how the extended data collection is made up. Paths also help us in finding associations and adjacencies between types and elements.

3.5 Data Structuring

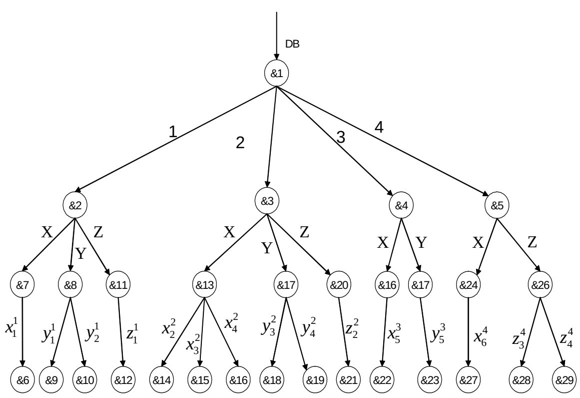

Fig.6 OEM graph.

In structuring stage we use extended data collections to help in forming an OEM graphs (Fig.6). OEM graphs are commonly used in presenting semistructured data (see [4], [5]). The graph is build up so that the levels become edges which connect nodes. In the lowest level of the graph data is atomic and single-valued.

4 Application

In this chapter we give an example of the information modelling process in bio energy systems. The process will be illustrated by examples. The modelling of bio energy begins with data collecting. In this stage the goal is to collect as much information as possible. One can use e.g. mind maps to help in the grouping of information. With the help of mind maps it is possible to find some associations between elements already at this stage.

In the second stage define the emergence points of the elements. Data will be grouped by its emergence point. In this case the emergence points are the four phases of power plant's life cycle which are: planning, building, using and closing. The next step is to analyse the data and the elements of the same type are placed into the same data collections (Fig.3)

Figs.7 and 8 illustrate the extending of the data collection. The extending consists of three steps. The first step is to define the top level, in this case the emergence point of the data. In the second step data collection, in other words data type, becomes the second level of extended data collection. In the third step the hierarchy of levels are deepened so that data can be represented as atomic and single-valued. Figures 8 and 9 show data collections which are extended to the atomic and single-valued level.

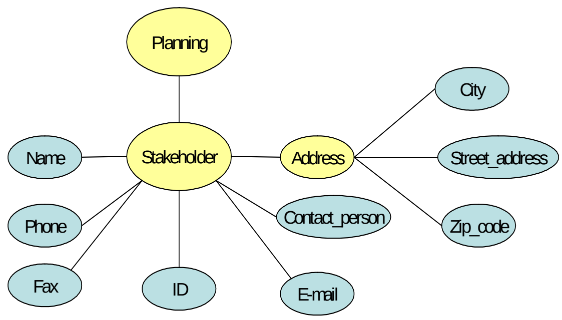

Fig.7 Planning phase data.

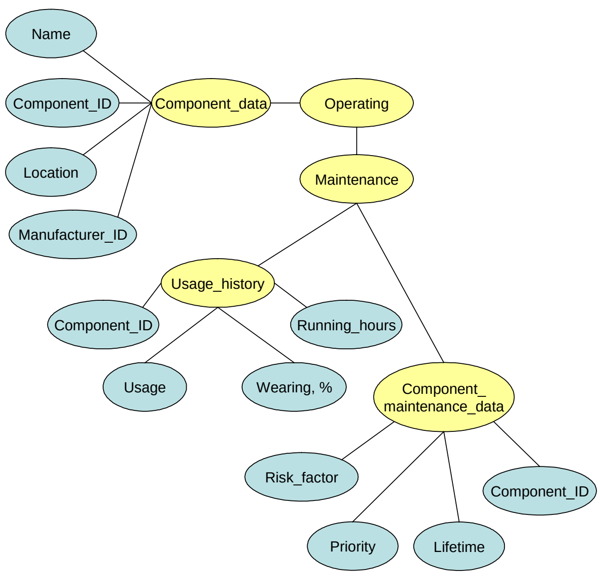

Fig.8 Operating phase data.

In the extension of the data collection (Fig.8) the following paths are created:

Planning → Stakeholder → Address → Zip_code
Planning → Stakeholder → Address → Street address
Planning → Stakeholder → Address → City
Planning → Stakeholder → ID
Planning → Stakeholder → Name
Planning → Stakeholder → Contact_person
Planning → Stakeholder → Phone
Planning → Stakeholder → Email
Planning → Stakeholder → Fax

In the structure phase the extended data collections are used to form OEM-graphs. Fig.9 shows an OEM-graph based on Fig.8 and in the same way Fig.10 shows an OEM-graph based on Fig.7. The graph is build up so that the levels become edges which connect nodes.

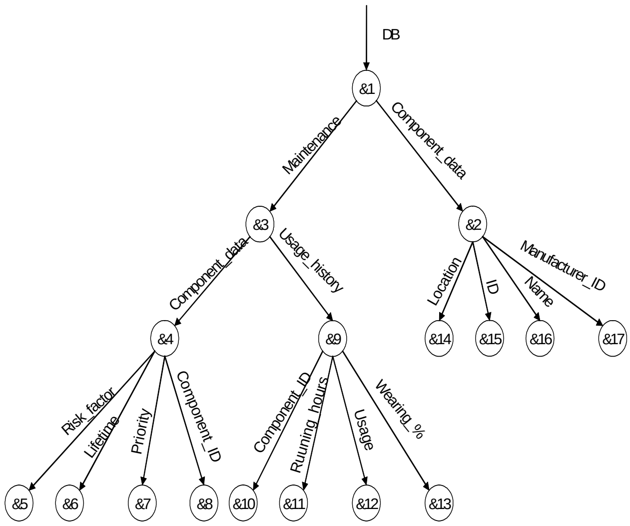

Fig.9 OEM-graph based on Fig.8.

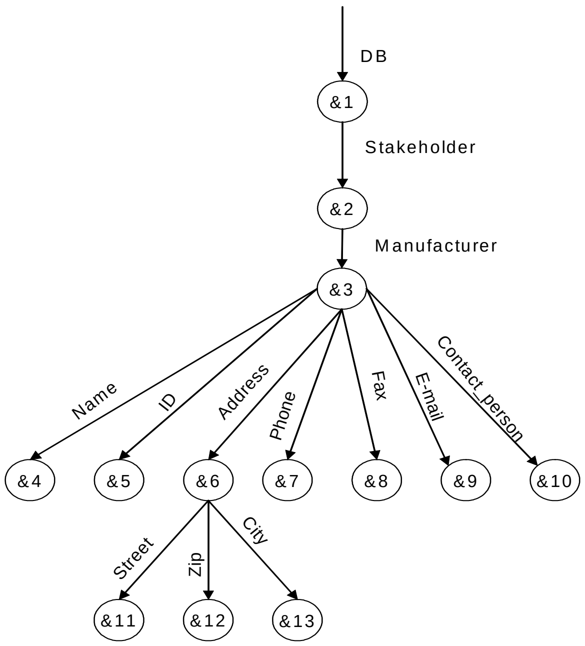

Fig.10 OEM-graph based on Fig.7.

The following example illustrates adjacency relation system based on Figs.9 and 10.

Let $(A,\Re)$ be a symmetric adjacency relation system (ARS),
where $A=\{A_1,A_2,A_3,A_4\}$, $A_1=\{x_1^3,x_2^3,x_3^3,x_4^3\}$,
$A_2=\{y_1^3,y_2^3,y_3^3,y_4^3\}$,
$A_3=\{v_1^1,v_2^1,v_3^1,v_4^1,v_5^1,v_6^1,v_7^1,v_8^1,v_9^1\}$,
$A_4=\{z_1^3,z_2^3,z_3^3,z_4^3\}$, and $\Re$ consist of the relations.

$$R_{12}=R_{21}=\{(x_1^3,y_1^3),(y_1^3,x_1^3)\}$$
$$R_{13}=R_{31}=\{(x_4^3,v_2^1),(v_2^1,x_4^3)\}$$
$$R_{14}=R_{41}=\{(x_1^3,z_1^3),(z_1^3,x_1^3)\}$$
$$R_{24}=R_{42}=\{(y_1^3,z_1^3),(z_1^3,y_1^3)\}$$
$$R_{33}=\{(v_2^1,\{v_3^1,v_4^1,v_5^1,\}),(v_3^1,v_2^1),(v_4^1,v_2^1),(v_5^1,v_2^1)\}$$

It can be illustrated by the undirected graph of Fig.11. The meaning of the sets and elements can be found from Table 1.

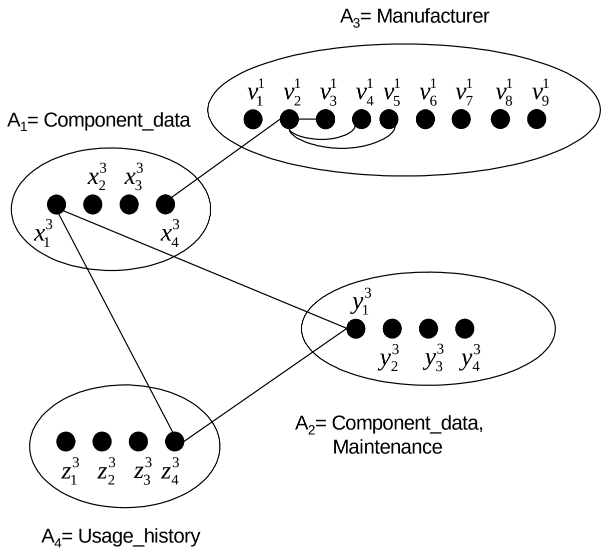

Fig.11 Symmetric ARS based on Figs 9 and 10.

Table 1 Sets and elements.

A_1 = Component_data
x_1^3 = Component_ID
x_2^3 = Name
x_3^3 = Location
x_4^3 = Manufacturer_ID
A_2 = Component_data, maintenance
y_1^3 = Component_ID
y_2^3 = Lifetime
y_3^3 = Priority
y_4^3 = Risk_factor

A_3 = Stakeholder_data, corporation
v_1^1 = Name
v_2^1 = ID
v_3^1 = Street address
v_4^1 = Zip code
v_5^1 = P.O Box
v_6^1 = Phone
v_7^1 = Fax
v_8^1 = E-mail
v_9^1 = Contact_person
A_4 = Usage_history
z_1^3 = Component_ID
z_2^3 = Running_hours
z_3^3 = Usage
z_4^3 = Wearing- %

5 Conclusion

The modeling process presented in this paper has been successfully applied to information modeling in different areas related to distributed energy. Especially, the developed modeling process helps in structuring of large information masses. In the future the idea will be developed so that it can be used as a basis for modeling tool. Since the method is exact it is also possible to build modeling software based on the theory of this paper.

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