Object relation data model of heat distribution network

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Abstract: - This paper shows object-relation model of heat distribution network as one part of information system. This model is based on object-relation features of Oracle database and is applied on three distribution networks in different locations. The basic structure of network is described by objects and data is stored in tables that use these objects. Furthermore, the structure is stored in metadata database that represents information about all objects in object database

Key-Words: object-relation model, heat distribution network, metadata, oracle

1 Introduction

This article describes object-relation model of heat distribution network as part of information system used in intelligent system of energetic control system of city agglomeration. This system is used for control of heat production (heating plant or combined heating and power plant), heat transport and heat distribution network with consumers. Distribution network is complex system containing thousands of different parts and cannot be described by mathematical formula and used in simulating program because of its deep complexity. Our solution uses simplification where real objects (pipes, water, heat consumers and others) are replaced by objects in Oracle database. Application programmed in java then uses basics of physical processes and heat exchange laws to simulate real heat distribution network.

2 Object Relational Features

This contribution shows one of many possible solutions that use object-relation features of Oracle 11g database which contains structure of heat distribution network, real measured data and also simulated data computed by java application.

The database data type that represents real-world object is the **object** data type. With this user defined data type we can model real-world entities such as customers, cars, products and others. In our case we model distribution network objects such as nodes, pipelines, pipeline sections, energy consumers, energy sources and others. Oracle introduces abstract layer built on Oracle database's relational technology. New object is based on any standard data type embedded in Oracle (FLOAT, NUMBER, DATE, etc.) or on another object or reference on object or reference on object collection. User defined metadata types are stored in schemes and are accessible through SQL, PL/SQL, Java or other supported interface. The data under the object layer is stored in columns and tables, but because of object approach we can use them as real-world entities. Using objects has following benefits:

- developers access data structures used in application directly without object-relational mapping (ORM)
- objects contain data and can have defined user operations (methods)
- using objects is more effective:
  - object types, methods and data are stored in database therefore developers don't have to create them in each application
  - related object are processed in one step. Single query on database returns also objects linked with searched object

Object types are composed of parts, called attributes and methods (illustrated in Fig. 1):

- **attribute** stores information about main features of object. The attribute is declared by data type (this can be another object)
- **method** is a procedure or function providing useful operation over attributes [1]

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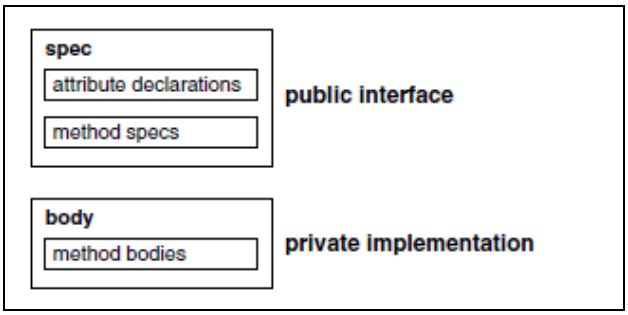

Fig. 1: Object attributes and methods

3 Design of objects, attributes and methods for heat distribution network model

This part shows definition of basic objects used in heat distribution network

- pipeline
- pipe section -
- node – the connection of two or more pipe sections
- consumer

Figure 2 shows relations among objects in distribution network. IN and BACK mean input and output places where heat transfer medium (liquid which supply or carry energy to consumer) enters and leaves particular part of network. [2]

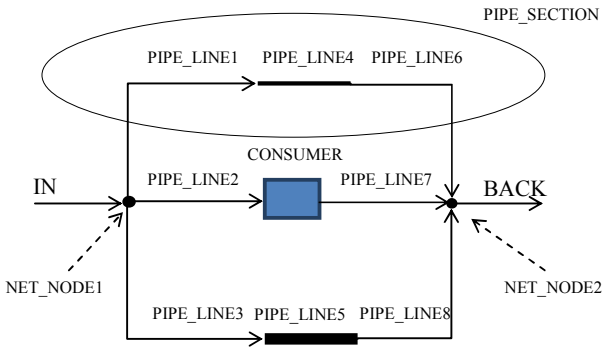

Fig. 2: Relations among objects

As an example, the Table 1 describes one object type – node type

Table 1

Object Type – node_type	
Attributes	**Methods**
- node identifier - node name - node coordinates - input state variables - output state variables - pressure difference - heat flow loss - mass flow loss	- input state variables determination - output state variables determination - pressure difference computation - thermal energy loss computation - mass flow loss computation

As can be seen, the node coordinates attribute data type is user defined data type – **coordinate_type** object (see Table 2)

Table 2

Object Type – coordinate_node	
Attributes	**Methods**
- x coordinate - y coordinate - z coordinate	- distance from previous node computation

4 Metadata database

We used metadata in designing of database structure. This metadata is structured data about data. Values stored in metadata represent information about objects, attributes methods and relations among objects. Basic principle of metadata transformation to object database containing real data is presented in Fig. 3.

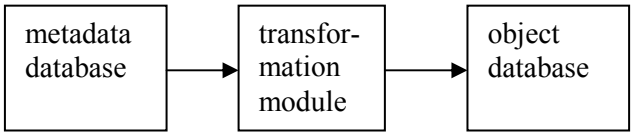

Fig. 3: Transformation of metadata database to object database

Metadata database consists from tables and methods designed in order to describe complete object database structure. We present to use tables described in Table 3.

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Table 3

Table	Description
Objects	Information about objects in object database
Attributes	Information about attributes in object database
Methods	Contains bodies of methods of particular objects
Relations	Relations among objects
Code tables	Data describing code tables
Columns of code tables	Data describing columns of code tables

4.1 Transformation module

Transformation module is based on methods on metadata database and that ensure the creation of object database structure according to the information stored in metadata. The goal of transformation model is to create new objects, add attributes, methods, code tables and also edit and remove existing objects.

4.2 Conversion module

This module is used for importing data from heating plant operation database or distribution network database into our object database. Each heating plant and distribution network has own database, but this databases vary from company to company. Also data is in different structure and with different data types. Conversion module is versatile and flexible tool that map data from these heterogeneous data sources into target database. This module is used repeatedly whenever new data is available. Mapping describes the location of source data in operation database and target location in object database.

Table 4

Table	Description
SourceDatabase	Defines source database
SourceTable	Defines source tables
SourceColumn	Defines source columns
SourceTarget	Pairing table of source columns and target attributes

Table 5 List of methods used in conversion

Method	Description
CompareSourceTarget	Method finds columns defined in metadata that are not available in source database
Import	Imports particular table defined by parameter @TableID (all tables are imported if parameter is not given)
Convert	Procedure used to data types conversion to other data types

In case of adding new measured parameter in source (operation) database we can easily edit appropriate metadata of conversion module and object database is automatically filled with new data. Edition of metadata means adding column or table into SourceTable or SourceColumn and pairing them with corresponding attribute of object in SourceTarget.

5 Conclusion

We presented in this contribution the advantages when object-relation features of Oracle database are used for description of real-world objects. We used these features in heat distribution network model shown examples.

Chapter four describes out approach in building database structure that uses metadata. This metadata stores all information about structure, relations and data stored in object database. Transformation and conversion modules were designed and programmed as a support in creating object database from metadata database and in transferring data from source databases into objects in object database.

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