Interactive PMCube Explorer

Documentation and User Manual

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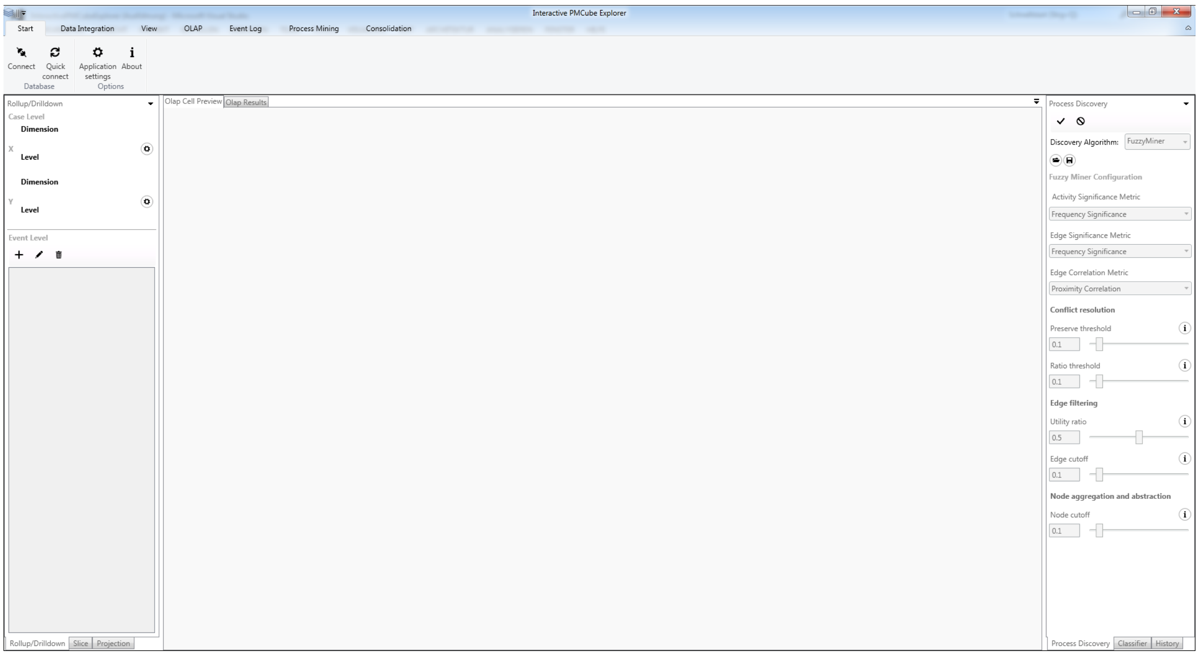
Contents

1 Introduction

The Interactive PMCube Explorer is a tool for multidimensional process mining (MPM). This manual gives a brief introduction of its usage and the necessary preparation of event data. For a general introduction of MPM and the concept of the PMCube approach, we refer to [VA16]. For this document, we assume that the reader is familiar with process mining.

2 Application Overview

Figure 2.1 shows the application's main window after start-up. In general it consists of four parts: the ribbon menu at the top, the content area at the center, and two sidebars left-hand and right-hand of the content area.



Process Discovery

Discovery Algorithm: FuzzyMiner

Fuzzy Miner Configuration

Activity Significance Metric: Frequency Significance

Edge Significance Metric: Frequency Significance

Edge Correlation Metric: Proximity Correlation

Conflict resolution

Preserve threshold: 0.1

Ratio threshold: 0.1

Edge filtering

Utility ratio: 0.5

Edge cutoff: 0.1

Node aggregation and abstraction

Node cutoff: 0.1

Figure 2.1: Main window after start-up

The ribbon menu provides access to most of the features of the application which are grouped in different tabs by their semantic. The six main tabs are:

Start This tab offers general features like connecting the application to the database (see Chapter 5) and customizing the application settings (see Chapter 4).

Data Integration This tab provides tools that support the integration of data into the data cube like the editor for meta-data files (see Section 3.2).

View On this tab, you can change the view of the application, e.g., turn on/off the process model matrix view or hide/show particular tabs.

OLAP This tab provides all OLAP-related features like loading the cube and its data from the data warehouse.

Event Log On this tab, you find all features to manipulate (e.g. filter) the event logs that were loaded from the data warehouse.

Process Mining This tab offers advanced process mining techniques like process enhancement and conformance checking.

Consolidation This tab provides access to the consolidation of process models.

Tip: You can hide/collapse the ribbon bar by clicking the icon on the right side (below the window close button) or double-clicking one of the tabs.

The sidebar on the left side of the main window comprises all configuration options for the OLAP query. Grouped by different tabs, you can roll-up/drill-down or slice the data cube. Furthermore, you can also omit unnecessary attributes from the query results.

In the sidebar on the right side of the main window, you find the selection and configuration of the process discovery algorithm, the selection of the classifier, and the operation history where you can undo/redo the analysis steps.

The content area in the center of the window uses a tab system to present the analysis results. The *Olap Cell Preview* tab shows a preview of the currently set OLAP query while the *Olap Results tab* presents an overview of the results of the last executed OLAP query.

Tip: The main window is based on a docking framework. Therefore, you can customize it according to your needs, e.g., by changing the size of or rearranging the different parts of the window.

3 Data Preparation

The Interactive PMCube Explorermanages the event data required for process mining in a multidimensional data cube that is stored in a relational data warehouse. Currently, the following database management systems (DBMS) are supported:

- Microsoft SQL Server (recommended)
- Oracle DB
- PostgreSQL
- MySQL

However, it is recommended to use Microsoft SQL Server which was primarily used for testing and application so far. Before analyzing processes with Interactive PMCube Explorer, the event data has to be integrated into the data warehouse. Section 3.1 explains its expected database schema.

3.1 Data Warehouse Schema

In Interactive PMCube Explorer, there are two different ways to model the case and event attributes.

Dimension A dimension represents an axis of the data cube that can be used to partition the event data into sublogs. Each dimension consist of a set of pair-wise distinct values. Furthermore, Interactive PMCube Explorerallows the user to define dimension hierarchies in a tree-like structure. Dimensions should be the preferred way of modeling the attributes. However, they may not be appropriate in case of many rare attribute values as can this result in sparse data cubes and missing representativeness of of the process models. To avoid such problems, sets of different attribute values may be grouped into artificial categories, e.g. representing intervals of values. If this is not meaningful, the attributes can also be stored as simple attributes.

Simple attribute This way of modeling directly attaches an attribute to its case or event. In contrast to dimensions, simple attributes are very limited in their usage (e.g., they cannot be used for roll-up and drill-down). Therefore, it is only recommended to use simple attributes for avoiding the loss of data if the attribute cannot be meaningfully mapped to a dimension.

Column Name(s)	Type	Cardinality	Description
id	arbitrary	1	id of cell, must be unique
dim_1 ... dim_s	arbitrary	$1 \ldots *$	foreign key to table of most fine-grained dimension level

Table 3.1: Columns of Fact table

The database schema manages case and event attributes on different levels. This is not only reflected in the definition of OLAP operations, but also by the database schema that stores cases and events in different tables. Figure 3.1 shows the generic database schema of the data warehouse which is an extension of the traditional snowflake schema commonly used for relational data warehouses.

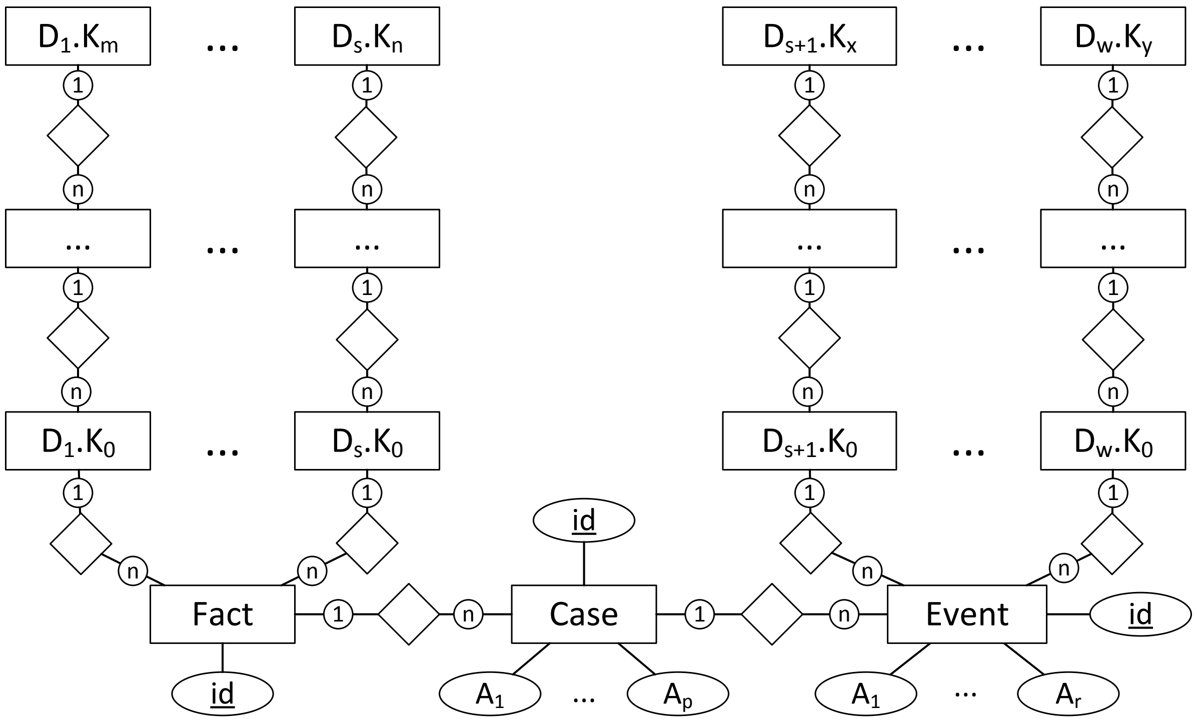


Figure 3.1: Entity-relationship model of generic database schema

Similar to the snowflake schema, there is one table for each level of a dimension hierarchy and the tables of a dimension are connected by a 1:n foreign key relationship according to the hierarchy (e.g., tables $D_1.K_0, \ldots, D_1.K_m$). The **Fact** table references case dimension (i.e., each dimension representing a case attribute) by a foreign key reference to the table of its most fine-grained dimension level. Additionally, it also stores a unique id for the easy identification of cell of the data cube. Table 3.1 gives an overview of the columns of the Fact table.

Using a foreign key, the cell id of the Fact table is referenced by the **Case** table which stores each single case as a row. Each tuple requires a mandatory unique id to identify

Column Name(s)	Type	Cardinality	Description
id	arbitrary	1	id of case, must be unique
cell_id	arbitrary	1	foreign key reference to id column of Fact table
A_1 ... A_p	arbitrary	0 ... ∗	columns for storing simple case attributes

Table 3.2: Columns of Case table

Column Name(s)	Type	Cardinality	Description
id	arbitrary	1	id of event, must be unique
case_id	arbitrary	1	foreign key reference to id column of Case table
dim_1 ... dim_w	arbitrary	1 ... ∗	foreign key to table of most fine-grained dimension level
A_1 ... A_p	arbitrary	0 ... ∗	columns for storing simple event attributes

Table 3.3: Columns of Event table

the cases. Additionally, the Case table can also have an arbitrary number of additional attributes ($A_1, \dots, A_p$) to store the simple case attributes (i.e., all case attributes that are modeled as simple attributes). The simple attribute columns of the Case table may have arbitrary types. Table 3.2 gives an overview of the columns of the Case table.

The **Event** table stores one event per row. Similar to the Case table, it references the tables of the most fine-grained dimension levels of all event dimensions (i.e., event attributes that are modeled as dimensions). The simple event attributes (i.e., event attributes modeled as simple attributes) are represented by an additional table column for each simple attribute (similar to Case table). The Event table also has a unique id and a foreign key reference to the id of the case that own the event. Table 3.3 summarizes the columns of the Event table.

The structure of a dimension level table depends on whether the dimension level is the highest (i.e., most coarse-grained) level of the dimension. If it is not the highest dimension level, the table has a unique *id* column (used for referencing), a *value* column (holding a representation of the attribute's value), a *description* column (providing a more verbose textual description of the value), and a *parent_id* column holding a foreign key reference to the id of the parent dimension level value. The latter can be omitted for the highest level of a dimension, because this does not have a parent. Table 3.4 gives an overview of the columns of a dimension level table.

Column Name(s)	Type	Cardinality	Description
id	arbitrary	1	id of dimension value, must be unique
value	arbitrary	1	representation of dimension level value
description	varchar/varchar2	1	textual description of the dimension level vale
parent_id	arbitrary	0 . . . 1	foreign key reference to the table of parent dimension level, can be omitted if no parent exists

Table 3.4: Columns of Event table

3.2 Creating a Meta-data File

To be able to load the event data from the database, Interactive PMCube Explorerrequires some meta-data on the database schema which is provided by an XML-based meta-data file. To create this file, Interactive PMCube Explorerprovides a meta-data editor that can be opened from the data integration tab (see Figure 3.2).

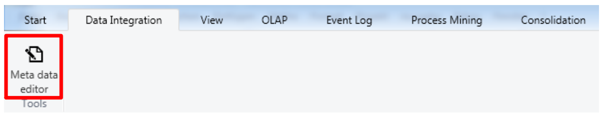


Figure 3.2: Meta-data editor icon

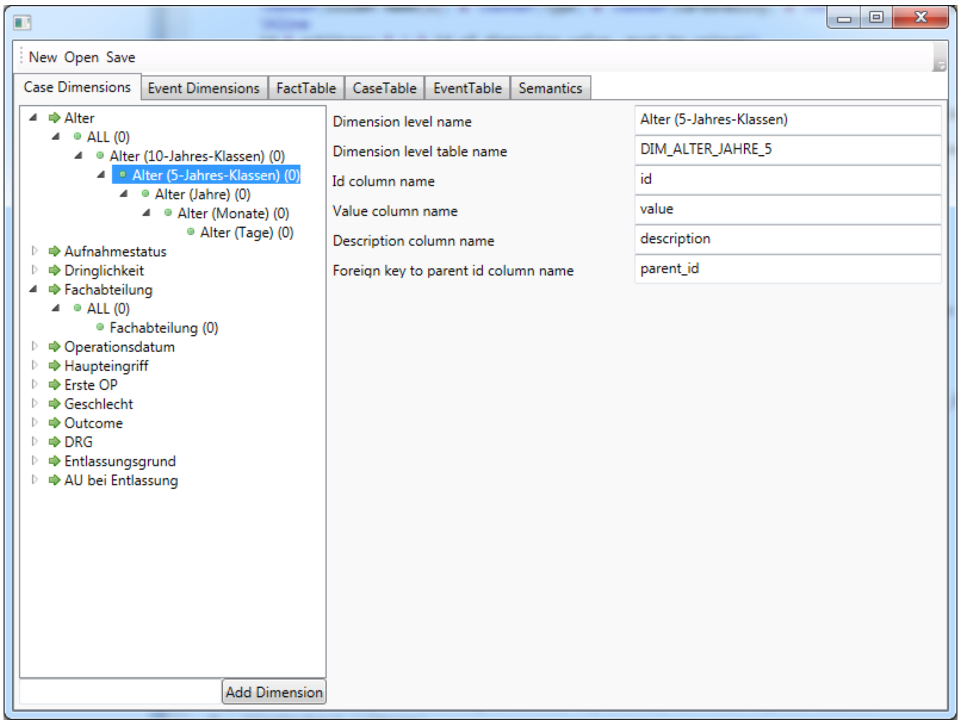
The editor window provides a number of different tabs to edit the meta-data file which are explained in the following in more detail.

3.2.1 Case Dimensions

On the Case Dimensions tab (see Figure 3.3), all dimension levels and their relationships need to be defined. Dimensions can be added by typing the dimension's name into the text input field on the left bottom and clicking on add dimension. The dimension and its logical root (ALL) are added to the tree-view on the left. After selecting the dimension node, one can change its name and its data type (default is string).

Selecting the ALL node and a right-clicking on it opens a pop-up menu that allows to add a new dimension level as a child of the selected node. After selecting a dimension level in the tree, one need to define the properties as specified in Table 3.5.

Note: To create a dimension hierarchy, the dimension levels must be specified from top to bottom (starting with the most coarse-grained dimension level).



- Alter
  - ALL (0)
    - Alter (10-Jahres-Klassen) (0)
      - Alter (5-Jahres-Klassen) (0)
        - Alter (Jahre) (0)
          - Alter (Monate) (0)
            - Alter (Tage) (0)
- Aufnahmestatus
- Dringlichkeit
- Fachabteilung
  - ALL (0)
    - Fachabteilung (0)
- Operationsdatum
- Haupteingriff
- Erste OP
- Geschlecht
- Outcome
- DRG
- Entlassungsgrund
- AU bei Entlassung

Dimension level name	Alter (5-Jahres-Klassen)
Dimension level table name	DIM_ALTER_JAHRE_5
Id column name	id
Value column name	value
Description column name	description
Foreiqn key to parent id column name	parent_id

Figure 3.3: Meta-data editor (Case dimensions)

Property	**What to enter**
Dimension level name	Name of the dimension level (as it should be displayed in the tool)
Dimension level table name	Name of the database table representing the dimension level
Id column name	Name of the column holding the id
Value column name	Name of the column holding the value
Description column name	Name of the column holding the description
Foreign key to parent id column name	Name of the column holding the foreign key to the parent table (can be left empty if no parent table exists)

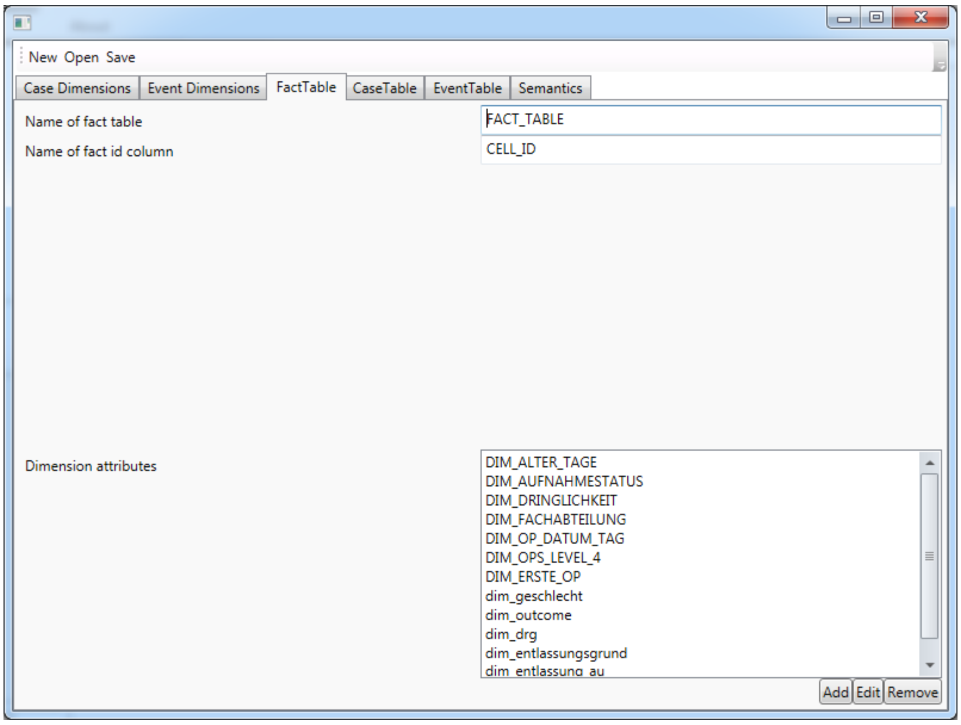
Table 3.5: Properties of dimension level

3.2.2 Event Dimensions

On the Event Dimensions tab, one needs to specify the event dimensions and their dimension levels. The workflow and the properties are similar to the Case Dimensions tab (see Section 3.2.1).

3.2.3 FactTable

On the FactTable tab, one has to specify the table name of the Fact table and the name of the column that holds the cell id (cf. Figure 3.4). Furthermore, one needs to specify the foreign key relationships of the Fact table to the tables representing the dimension levels. Clicking the *Add* button opens a new dialog to create this mapping (cf. Figure 3.5).



Name of fact table FACT_TABLE
Name of fact id column CELL_ID

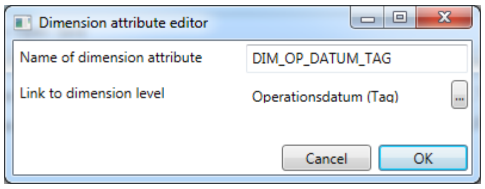
Dimension attributes
DIM_ALTER_TAGE
DIM_AUFNAHMESTATUS
DIM_DRINGLICHKEIT
DIM_FACHABTEILUNG
DIM_OP_DATUM_TAG
DIM_OPS_LEVEL_4
DIM_ERSTE_OP
dim_geschlecht
dim_outcome
dim_drg
dim_entlassungsgrund
dim_entlassung_au

Figure 3.4: Meta-data editor (FactTable)

In the first field, one needs to enter the name of the column holding the foreign key to the dimension level table. For the second filed, click on the right-hand button and select the dimension level that is referenced by the foreign key from the dialog. Confirm the mapping by clicking *OK*.

3.2.4 CaseTable

On the CaseTable tab (Figure 3.6), you need to specify the structure of the Case table by entering the following information:

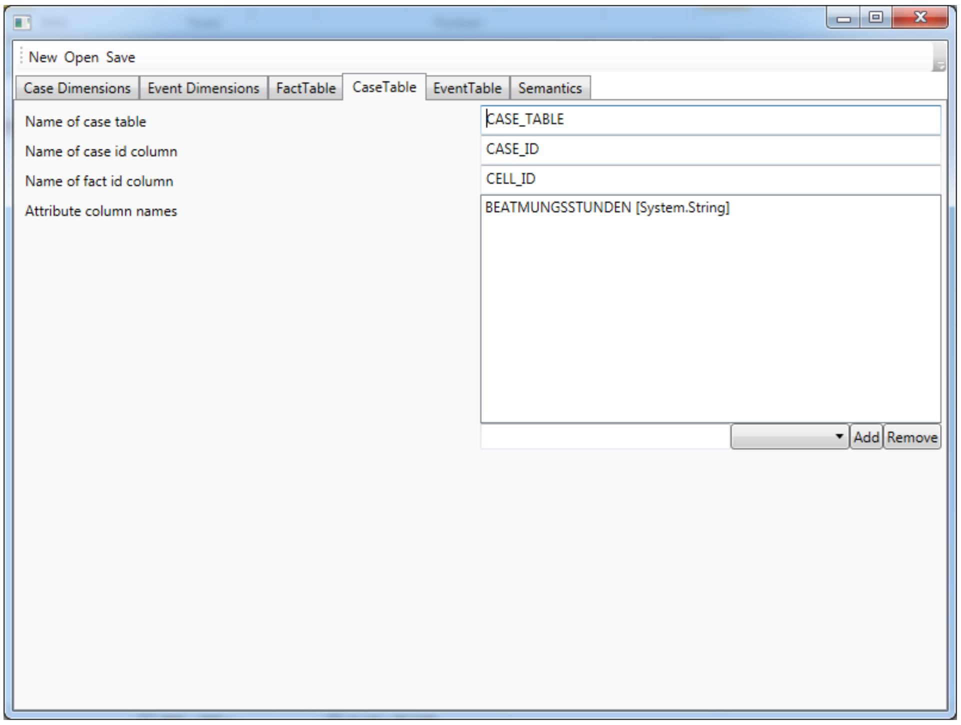


Dimension attribute editor

Name of dimension attribute: DIM_OP_DATUM_TAG

Link to dimension level: Operationsdatum (Tag)

Figure 3.5: Meta-data editor (attribute editor)



Name of case table: CASE_TABLE

Name of case id column: CASE_ID

Name of fact id column: CELL_ID

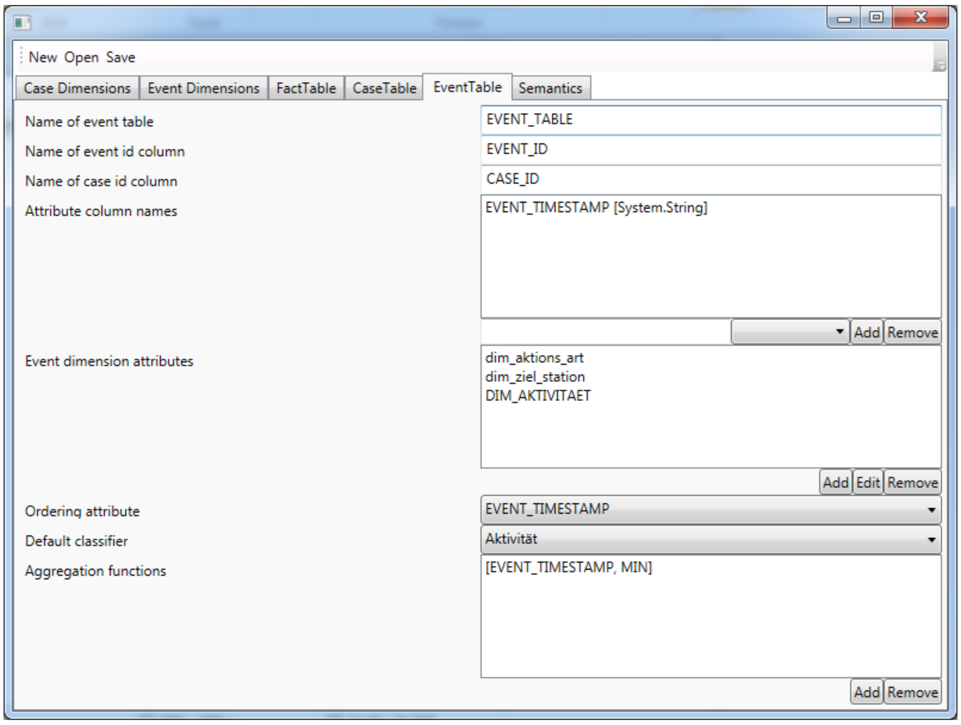
Attribute column names: BEATMUNGSSTUNDEN [System.String]

Figure 3.6: Meta-data editor (Case table)

1. The table name of the Case table
2. The name of the column that holds the case id (primary key)
3. the name of the column that holds the cell id (foreign key to Fact table)
4. For each simple case attribute stored in the Case table, enter the column name and data type of the attribute and press *Add*

3.2.5 EventTable

On the EventTable tab (Figure 3.7), you must specify the structure of the Event table. Enter the following information:



Name of event table	EVENT_TABLE
Name of event id column	EVENT_ID
Name of case id column	CASE_ID
Attribute column names	EVENT_TIMESTAMP [System.String]
Event dimension attributes	dim_aktions_art dim_ziel_station DIM_AKTIVITAET
Ordering attribute	EVENT_TIMESTAMP
Default classifier	Aktivität
Aggregation functions	[EVENT_TIMESTAMP, MIN]

Figure 3.7: Meta-data editor (Event table)

1. The table name of the Event table
2. The name of the column that holds the event id (primary key)
3. The name of the column that holds the case id (foreign key to Event table)
4. For each simple event attribute stored in the Event table, enter the column name and data type of the attribute and press *Add*

5. For each event dimension, create a mapping between a dimension and the corresponding foreign key column in the Event table

6. Select the attribute that should be used to order the events (usually the timestamp)

7. Select the attribute that should be used as the default classifier (usually the activity)

8. For each simple event attribute stored in the Event table, specify the aggregation function that should be used for event aggregation

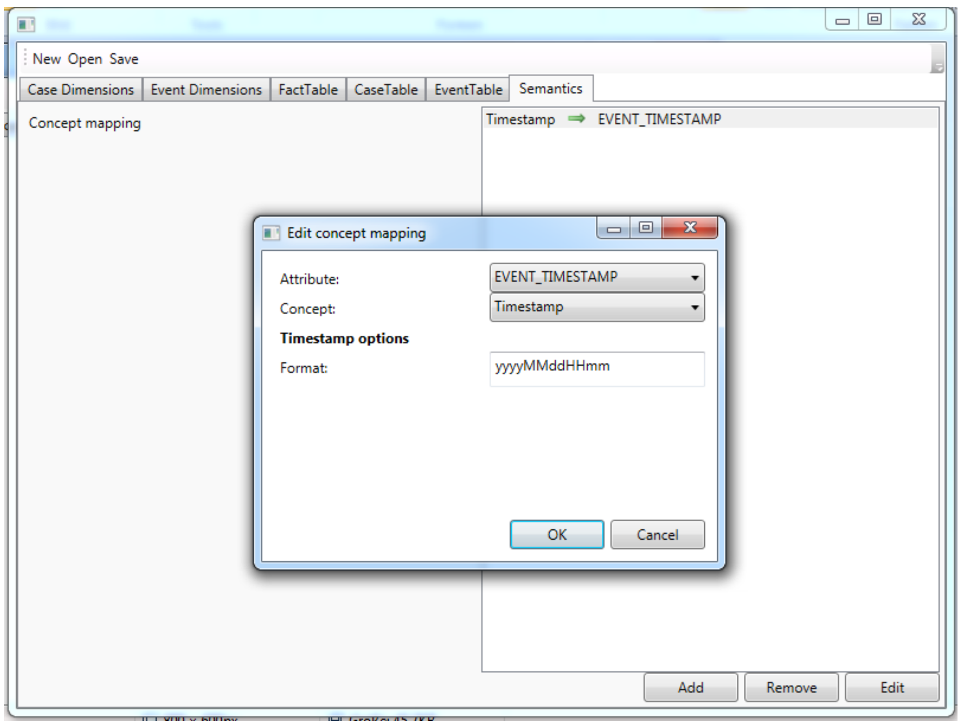
3.2.6 Semantics

On the Semantics tab (Figure 3.8), you must specify the semantics of particular attributes (similar to a concept in XES) – especially for the time-stamp. Click *Add* and enter the following information in the dialog:

1. The attribute that should have the semantic

2. The concept the selected attribute should have

For the time-stamp, enter a format string required for parsing the time-stamp which describes the time-stamp format of the attribute in the database. The format string must be defined according to the C# time format specification (`https://msdn.microsoft.com/de-de/library/8kb3ddd4(v=vs.110).aspx`)



Timestamp ⇒ EVENT_TIMESTAMP

Attribute: EVENT_TIMESTAMP

Concept: Timestamp

Timestamp options

Format: yyyyMMddHHmm

Figure 3.8: Meta-data editor (Semantics)

4 Application settings

Before starting the first analysis, it is recommended to configure the tool. To customize the application settings, click on the *Application settings* button in the start tab. The application settings dialog showing up provides multiple settings on different pages. The following sections will give a brief overview of the available configuration options.

Note: Changes of some particular settings will only take effect after a restart of the application.

4.1 General Settings

On this page, you can select the configuration file for the logger. Interactive PMCube Exploreruses the Apache log4net library[1] (a .NET port of the log4j library). To enable the logging, create a configuration file (see log4net documentation for details) and select it in the application settings.

Additionally, you can also set maximum tree depth of XML documents handled by the serializer. However, the default value should be fine in most cases.

4.2 Paths

On the *Paths* page, you can configure the default paths for the import and export files (e.g., process models, images), a default folder for storing meta-data files, and the default folder for the setting files of process mining algorithms. Furthermore, you have to specify the file that will store your database connection information.

4.3 Visualization

On this page, you can customize the appearance of the process model visualization (e.g., node size, distances between nodes etc.). Most of the settings are specific for a particular process model type. To edit the appearance of a specific view model, you can select the corresponding process model notation from the drop-down list.

[1]https://logging.apache.org/log4net/

4.4 Process Model Diff

On this page, you can select the algorithm that should be used to create difference models.

4.5 Process Discovery

Here, you can select the default process discovery algorithm. This algorithm will be automatically selected on application start-up. Optionally, you can also select a configuration file to provide customized default settings to the selected default algorithm.

4.6 Plugins

The *Plugins* page gives you an overview of all plug-ins that have been loaded at the start-up of the application. To search for a particular plug-in, the text field on the top of the page allows you to filter the plug-in list.

Tip: By default, the tool provides multiple plug-ins. Therefore, an empty plug-in list indicates that the path to the plug-in folder is not correctly set. To fix this issue, you can select the plug-in directory and confirm it by clicking the *Okay* button. Now, the plug-ins should be loaded when restarting the application.

5 Connect to Database

At the beginning of your analysis, you need to select the connection to your database. To open the connection dialog (Figure 5.1), click on the *Connect* button of the Start tab.

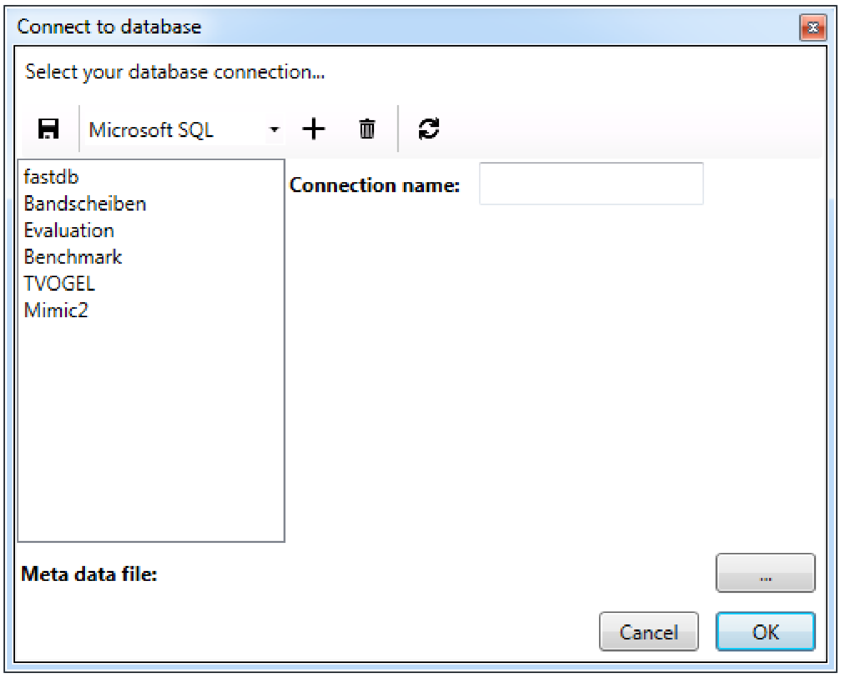


Figure 5.1: Connection Dialog

To create a new database connection, select the used database management system from the drop-down list and click on the plus icon. After that, enter the required parameters in the dialog. Table 3.2.1 explains the parameters in more detail.

For connections to Microsoft SQL Server databases, there is also the option to use the automatic authentication of the Windows operating system. You can check the checkbox to enable this option. User and password field can be left empty when Windows authentication is used. You can save the settings using the *Save* icon in the toolbar on top of the dialog.

Property	**Description**
Connection name	The user-defined name of the connection which is used in the connection list on the left. Should be unique.
Database	The name of the target database
Server	The URL or IP address of the target database server
Port	The port of the target database service
User	The name of the database user
Password	The password of the database user

Table 5.1: Parameters of the connection dialog

Note: The database configurations are saved in a file (for selecting this file, see Section 4.2) which is encrypted using the Windows user account. Consequently, the connection file can only be read from the user account you created it. Sharing connection information between different user accounts or machines is not possible.

Finally, you need to select the meta-data file that describes the structure of the selected database. To connect to the database, select the desired connection from the list and click on *OK*. Now the application initializes the dimension values from the database. Depending on the size of the data and your connection speed, this may take some time.

Tip: The application automatically saves the last used database connection and meta-data file. To reconnect quickly, you can click on the *Quick connect* button in the Start tab.

Bibliography

[VA16] Thomas Vogelgesang and Hans-Jürgen Appelrath. *PMCube: A Data-Warehouse-Based Approach for Multidimensional Process Mining*, pages 167–178. Springer International Publishing, Cham, 2016.