OLAP Personalizaton with User-describing Profiles

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Abstract. In this paper we have highlighted five existing approaches for introducing personalization in OLAP: preference constructors, dynamic personalization, visual OLAP, recommendations with user session analysis and recommendations with user profile analysis and have analyzed research papers within these directions. We have pointed out applicability of personalization to OLAP schema elements in these approaches. The comparative analysis has been made in order to highlight a certain personalization approach. A new method has been proposed, which provides exhaustive description of interaction between user and data warehouse, using the concept of Zachman Framework [1, 2], according to which a set of user-describing profiles (user, preference, temporal, spatial, preferential and recommendational) has been developed. Methods of profile data gathering and processing are described in this paper.

Keywords: OLAP personalization, user preferences, profiles.

1 Introduction and Related Work

The OLAP applications are built to perform analytical tasks within large amount of multidimensional data. During working sessions with OLAP applications the working patterns can be various. Due to the large volumes of data the typical OLAP queries performed via OLAP operations by users may return too much information that sometimes makes further data exploration burdening or even impossible.

A query personalization method that takes user likes and dislikes into consideration exists in traditional databases [3]. Similar ideas seem attractive also for research in the data warehousing field and the topicality of this issue is demonstrated in the recent works of many authors on data warehouse personalization.

There are various aspects of data warehouse personalization.

Data warehouse can be personalized at the schema level [4]. As a result, a data warehouse user is able to work with a personalized OLAP schema

Users may express their preferences on OLAP queries [5]. In this case, the problem of performing time-consuming OLAP operations to find the necessary data can be significantly improved.

One of the methods of personalizing OLAP systems is to provide query recommendations to data warehouse users. OLAP recommendation techniques are proposed in [6] and [7]. In [6] former sessions of the same data warehouse user are being investigated. User profiles that contain user preferences are taken into consideration in [7], while generating query recommendations.

Other aspect of OLAP personalization is visual representation of data. [8, 9] introduce multiple layouts and visualization techniques that might be interactively used for different analysis tasks.

Our experience in using standard applications for producing and managing data warehouse reports in the University of Latvia as well as participation in scientific projects and development of our own data warehouse reporting tool [10] served as a motivation for further studies in the field of OLAP personalization. We consider a reporting tool, developed in the University of Latvia, as an experimental environment for introducing OLAP personalization. All models presented in this paper currently are not used in practice, however, it is planned to put it to use after proper evaluation that will follow.

As stated in [5], OLAP preferences deserve more attention by researchers.

The rest of the paper is organized as follows: section 2 introduces a review of existing OLAP personalization approaches; section 3 introduces the concept of user-describing profiles; section 4 presents a method for user-describing profile construction; section 5 concludes the paper.

2 OLAP Personalization Approaches

In this section various types of personalization – OLAP schema personalization, personalization during runtime, visual personalization of query results, etc. – are briefly described.

The first approach to be considered is OLAP schema personalization with *Preference Constructors (PC)*. An algebra that allows formulating of preferences on attributes, measures and hierarchies is defined in [5]. An important feature of proposed algebra is an opportunity to express preferences for hierarchy attributes of group-by sets, which consequently leads to expressing preferences for facts. Rollup function is used to outspread preferences applied to attributes along the whole hierarchy. Preferences can be defined on both attributes and measures, i.e. on categorical or numerical attributes.

The next approach is *Dynamic Personalization (DP)*. The time and method of creation of an adapted OLAP cube define the type of personalization – static or dynamic. Static OLAP personalization means that for different users of the data warehouse diverse OLAP cubes are created during design time. Dynamic OLAP personalization means that an adapted OLAP cube is created during the execution time according to the needs and performed actions of the user. Authors [4] cover dynamic OLAP personalization, because it is a more complicated task as it involves explicit or implicit interaction with user. Based on ECA-rules (*Event-Condition-Action*, see [11]), PRML (*Personalization Rules Modeling Language*, described in [12]) is used in [4] for specification of OLAP personalization rules.

Visual personalization of OLAP cube – *Visual OLAP (VO)* – may also be considered as a personalization action. The concept of Visual OLAP is disburdening the user from composing queries in "raw" database syntax (SQL, MDX), whereas events like clicking and dragging are transformed into valid queries and executed [9]. In [7, 8, and 13] authors present a user interface for OLAP, where user is explicitly involved. In [8] users are able to navigate in dimensional hierarchies using a schema-based data browser, whereas in [7, 13] users are provided with an interface for formulating queries by means of manipulation with graphical OLAP schema and rules.

The last two approaches for personalization in OLAP to be considered are based on providing query recommendations to the user by means of *User Session Analysis (RUSA)* and *User Preference Analysis (RUPA)*.

The idea of *RUSA* is described in [6], where users' previous data analysis patterns using OLAP server query log during sessions are taken into consideration. Cube measure values are being compared and a significant unexpected difference in the data is being detected. The emphasis is not on recommending queries from sessions that are prior to the current session, but on recommending queries from all sessions, where user found the same unexpected data as in current session. In this approach user preferences are not taken into consideration.

RUPA approach is presented in [7], where a context-based method for providing users with recommendations for further exploration is proposed. An analysis context includes two disjoint set elements (i.e. a set of OLAP schema elements – cubes, measures, dimensions, attributes, etc. and a set of its values).

Both types of user preferences – schema- and content-level preferences – are stated in the user profile and ranked with relevance score (a real number in the range [0; 1]). The idea of ranking preferences is also mentioned in [13]. User preferences later on are used in generating recommendations, filtering a recommendation with the highest overall score and displaying it to the user. Preferences in user profiles are also used for comparing queries and personalizing query result visualization in [14].

We have provided an evaluation in order to point out i) personalization options, described in these approaches, and its applicability to OLAP schema elements, aggregate functions, OLAP operations, ii) the type of constraints (hard, soft or other), used in each approach, iii) the methods for obtaining user preferences and collecting user information. Detailed comparison of observed personalization approaches is a subject of a separate paper [15].

3 The Concept of User-describing Profiles

In order to cover different aspects of personalization, we proposed a model for each profile that describes the user. The basic idea of development of user-describing profiles is inherited from Zachman Framework concept [1, 2]. Zachman Framework is an ontology that allows describing an arbitrary object from different viewpoints (temporary, spatial, etc. aspects). We used Zachman Framework concept to give a detailed characteristics of data warehouse user interaction with the system environment. To identify and develop profile, the following questions were used: *who*, *what*, *how*, *when*, *where* and *why*. Similar method has been applied in the field of data warehouses by [16, 17]. A detailed representation of used-describing profiles is provided in Table 1.

Table 1. User-describing profile diversity

Question	Description	Profile Type
What is the user expecting to get as a result?	User preferences data	*Preferential*
Who is the user?	Basic user data (personal data, session, activity, rights, etc.)	*User*
Where is the user located?	User physical location data & geolocation, according to user IP-address	*Spatial*
When does the user interact with the system?	Time characteristics of user activities	*Temporal*
How does the user & system interaction happen?	Characteristics of user device (i.e. PC, laptop, mobile phone, etc.), which is used for signing in as well as user software (e.g. web browser) characteristics	*Interaction*
Why the user is interested in this particular system?	User preferences are being gathered and analyzed. Recommendations are generated, according to user characteristics and preferences.	*Recommendational*

Proposed profiles describe user environment, i.e. different aspects of data warehouse user interaction with the system. User, spatial, temporal, interaction and preferential profiles altogether compose a versatile description of the data warehouse user. The limitations of user-describing profiles, e.g. incomplete or contradictory profile information, evolution of profiles, profile attribute updates, etc., are not discussed in this paper and are a subject for future work.

4 The Method for Profile Construction

User, interaction, temporal and spatial profiles consist of attributes that describe the user. To construct sets of attributes for each of mentioned profiles, the certain method has been applied.

Table 2. Information sources of the user profile attributes (fragment)

User Profile Attributes	**Information Sources**
Salutation, FirstName, LastName	[18, 19, 21]
InformalGreetingName, FormalGreetingName, Suffix, Ethnicity	[18]
Gender	[19, 21]
Username, Citizenship, BirthDate, MaritalStatus	[19]
Residence, AgeGroup	[23]
...	...

The method for profile construction includes studying of data warehouse literature (e.g., [18, 19, 20], etc.), CWM standard (*Common Warehouse Metamodel*, see [21]), scientific and technical articles (e.g., [22, 23], etc.), as well as practical experience in data warehouse field and working with data warehouse tools (e.g., Oracle Warehouse Builder) and web-services (e.g., [24, 25, 26], etc.). User-describing profiles have been built by means of collecting various attributes from different information sources (see Table 2).

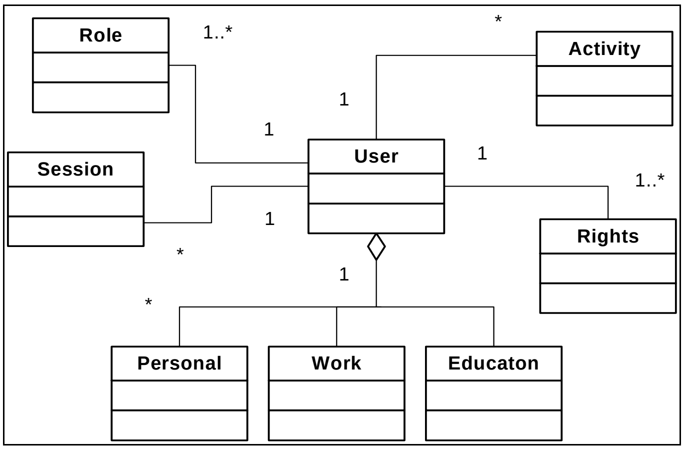

Fig. 1. User profile class diagram

An attribute set of each profile has been logically split into classes in order to compose user-describing profile class diagram. User profile class diagram is depicted in Fig. 1. However, attributes of user profile classes are omitted and other profile class diagrams are not presented in this paper due to limitations of space. A short description of user-describing profile classes will follow.

User profile classes:

- *Role* – contains the user system role attribute,
- *Personal* – contains 28 user personal information attributes (e.g. first name, last name, gender, ethnicity, marital status, age group, current passport nr., etc.),
- *Work* – contains 25 attributes, describing user work (e.g. position, company name, total years of experience, business tip day count per year, etc.),
- *Education* – contains 11 attributes, describing user education (e.g. currently student, educational institution, year of graduation, diploma nr., honors, etc.),
- *Session* – contains 9 attributes, describing user session characteristics (e.g. session start, session length, success status, session type, session context, etc.),
- *Activity* – contains 4 attributes, indicating user activity (e.g. hit count & spent time) on a certain webpage in a certain period of time (e.g. full date),
- *Rights* – contains 7 attributed, describing user rights for certain objects (i.e. table, column, etc.) of reporting tool (e.g. can read, can edit, can delete, condition, etc.).

Temporal profile classes:

- *StandardCalendar* – contains 22 standard calendar attributes (e.g. day number in month, month abbreviated, month number in year, etc.),
- *FiscalCalendar* – contains 12 fiscal calendar attributes (e.g. fiscal convention, fiscal week, fiscal year start date, fiscal quarter, etc.),
- *Time* – contains 7 non-calendar attributes and attributes that represent date as a number (e.g. hour, SQL date stamp, seconds since midnight, Julian date, etc.),
- *TimeStatus* – contains 12 attributes of yes/no type (e.g. holiday, weekend, last year in month, peak period, etc.),
- *DomainSpecific* – contains 13 attributes, specific for one or another domain (e.g. time-characterizing attributes of educational domain are semester, acad. year, etc.),
- *SpecialPeriod* – contains 7 attributes that describe certain planned or spontaneous global or local events (e.g. selling season, local special event – for instance, short-term strike, or global special event – for instance, earthquake or volcano eruption).

Spatial profile classes:

- *PhysicalLocation* – contains 22 attributes, describing person's physical address (e.g. street name, street direction, suite, countryside, city, country, etc.),
- *LocationByIP* – contains 14 attributes, derivable from user IP-address by means of web-services (e.g., postal code, time zone, continent, latitude, longitude, etc.).

Interaction profile classes:

- *WebAccess* – contains 15 attributes, describing operating system, web-browser and Internet connection properties (e.g., connection speed),
- *Functional* – contains 26 attributes, describing web-browser functional properties and supported applications (e.g. AdobeAcrobat, Quicktime, RealPlayer, etc.),
- *VisualLayout* – contains 12 attributes, describing visual layout properties in web-browser (e.g., color depth, browser dimensions, font smoothing, font sizing, etc.)

We claim that each class may be complemented with more attributes, if necessary.

Preferential and recommendational profiles' construction method differs from previously described.

While stating preferences, the user is able to select attributes from user, interaction, temporal and spatial profiles. Multiple scenarios, which describe user preference types, have been considered, while constructing preferential profile.

Recommendational profile contains sets of preferences that belong to different users. In this paper the idea of recommendation development algorithm has been proposed.

User-describing Profile Connections and Data Sources

One user may have more than one spatial, temporal, interactional, preferential and recommendational profile. User-describing profile connections are depicted in Fig. 2. For instance, signing in to system using PC or palmtop leads to construction of two separate interaction profiles belonging to one certain user that contain different data about the device screen resolution. Thus, the diversity of user-describing profiles gives an opportunity to apply personalization, adjusting the report structure, its visual layout and its contents, according to data in user-describing profiles.

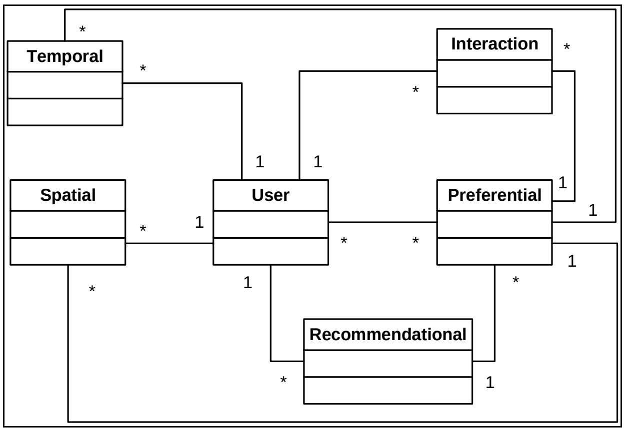

Fig. 2. User-describing profile connections

Preferential profile is connected with temporal, spatial, user and interaction profiles, because the user may state his/her preferences on attributes of mentioned profiles.

Recommendational profile contains sets of user preferences, which may be useful when the user is not determined about the way the report should be personalized. In this case he is offered to choose from other user preference sets. In this paper each of such user preference sets is considered as a recommendation.

A single profile may contain many attributes with values assigned. However, there may be multiple data sources to collect the profile attributes from (Fig. 3.). Let's consider the following data sources.

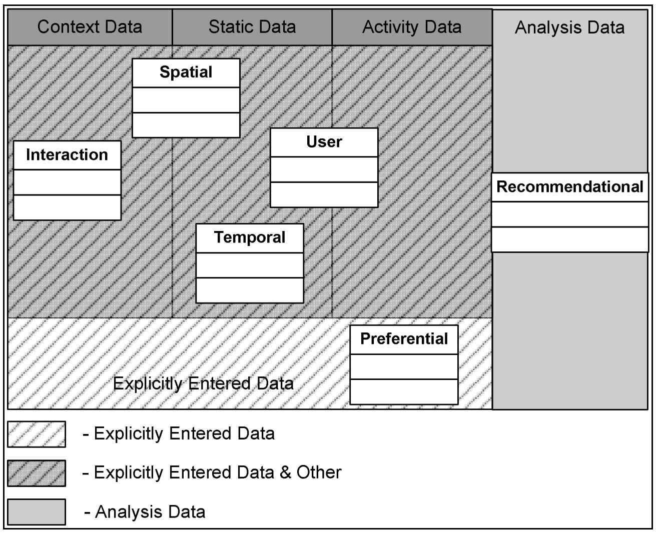

Fig. 3. User-describing profile data sources

Context data (i.e. data about the device used, operating system, IP-address, web-browser, etc.) describes the environment, in which reporting tool is being used. Context data are gathered automatically by means of web-services [24, 25, 26]. All the interaction profile attribute values are context data, as well as part of the spatial profile attributes (i.e. geolocation by IP-address).

Static data are gathered from data warehouse dimension attribute values. All the temporal profile attributes' values and part of spatial and user profile attribute values are static.

Activity data is derivable from data warehouse log-tables. In user profile, activity data indicates the intensity of usage of the reporting tool, defined by user hit count and spent time.

Analysis data refers to recommendational profile as recommendations are generated after analyzing of user preference profile.

Explicitly entered data is data, entered by user manually. All the preferential profile values, which indicate the importance of one or another user preference (i.e. degree of interest, weight or priority), are gathered from the user explicitly. It is shown in Fig. 3. that explicitly entered data is acceptable in interaction, spatial, temporal and user profiles, because the user can enter and/or edit attribute values of mentioned profiles.

User Preference Modeling Scenarios

Before developing user preference metamodel, it was important to classify user preferences for reports. To reach this goal, various user preference modeling scenarios have been considered, which later have been divided into two groups:

- Preferences for the contents and structure of reports (OLAP preferences),
- Visual layout preferences.

Although, user preference metamodel contains two distinct classes of preferences – OLAP and Visual layout (Fig. 4.) – in this paper we will describe in detail only OLAP preferences. However, preferences for visual layout of reports will be covered in separate paper.

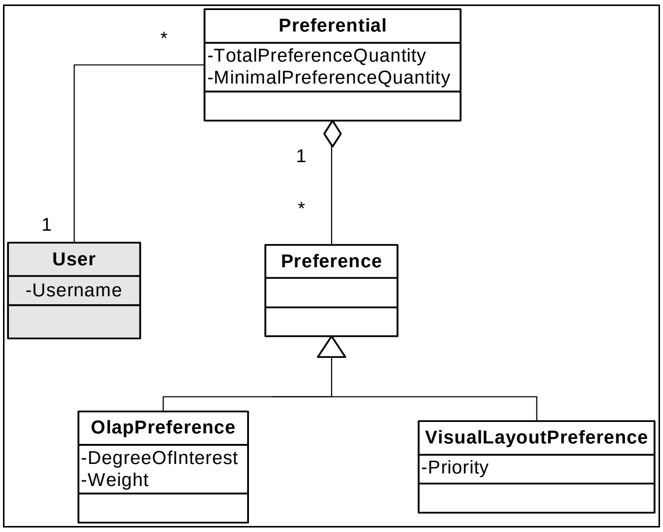

Fig. 4. Preferential profile metamodel (fragment)

Consider that the user may set preferences for OLAP schema elements (i.e. dimensions, dimension attributes, fact tables, measures, hierarchies and hierarchy levels) and aggregate functions, used for grouping of data. OLAP preference may apply to OLAP schema element (or aggregate function), which appears in single or multiple reports, or doesn't appear at all. Moreover, it is possible to set restrictions on data in one or several reports. We suggest the following user preference modeling scenarios in order to motivate and illustrate the preferential profile metamodel (demonstrated with preference examples):

ScenarioA.
User preference contains an OLAP schema element or aggregate function.

User preference refers to OLAP schema element or aggregate function, regardless of the report in which the given OLAP schema element or aggregate function is used (if it appears in any report at all).

Example A. The user is interested in Program dimension, which contains descriptive attributes of study program. The appearance of this dimension in one or several reports is not an indispensable condition, meaning that if in the given period of time there are no reports where Program dimension is involved, the preference still exists and may be applied later, when at least one report that contains Program dimension is created.

Scenario B.
User preference contains an OLAP schema element or aggregate function in the context of a certain set of reports.

Apart from OLAP schema element or aggregate function, user states in his/her preference a certain workbook that may contain the given OLAP schema element or aggregate function. In the reporting tool each workbook contains one on more worksheets, and each worksheet represents a single report.

Example B. StudentGrades workbook contains multiple worksheets with reports about student exam grades, grouped by faculties, courses, years and semesters. Besides, each report is of different level of data granularity. There are two hierarchies – Faculty hierarchy: Faculty –> Course, and Time hierarchy: Year –> Semester. The user is interested in reports that represent yearly summary information about average student grade in each course. Thus, user preferences are:

i) Acceptable aggregate function is average (AVG),

ii) Faculty hierarchy level is Course,

iii) Time hierarchy level is Year.

Scenario C.
User preference contains an OLAP schema element or aggregate function in the context of a certain report.

One and the same dimension attributes may be grouped in several hierarchies. Thus, in terms of a single report, more than one hierarchy may be defined. In this scenario the user is going to choose, which hierarchy or hierarchy levels are of more interest.

Example C. Consider a report on student activity in a course management system. There are two distinct hierarchies in this report – Time1 hierarchy: Year –> Month –> Date, and Time2 hierarchy: Week –> Date. The user states in his preference that he is more interested in hierarchy Time1.

Scenario D.
User preference contains restrictions on data in a several reports.

Preference refers to multiple reports that contain the given OLAP schema element and a certain value. In this scenario the user sets a restriction on data in scope of a workbook.

Example D. The user is interested in data on student registration to courses during the last semester. So, the following preference for StudentRegistrations workbook will be set: Semester attribute value is equal to “Autumn-2010”.

Scenario E.
User preference contains restrictions on data in single report.

Preference refers to one report that contains the given OLAP schema element and a certain value.

Example E. GraduatedStudents worksheet reflects yearly data on total number of students that graduated in each study program. Thus, user-defined preferences are:

i) StudyProgram attribute name is equal to “Masters of Computing”,

ii) User is highly interested in last year data, i.e. Year attribute is equal to “2010”.

OLAP Preferences Metamodel

A metamodel that describes OLAP schema preferences is depicted in Fig. 5. OlapPreference class has two attributes – user’s degree of interest (DegreeOfInterest, *doi* [3]) and preference weight (Weight). For instance, DegreeOfInterest attribute values may be the following: very low, low, medium, high, very high. Weight attribute value is a real number from the interval [0; 1]. Preference weight is a numeric equivalent of user’s degree of interest (which may be corrected if necessary). For example, medium degree of interest corresponds to weight value 0.5, low degree of interest – to weight value 0.2, etc.

OlapPreference is an abstract class, which splits into two classes – Schema-Specific and Report-Specific preferences.

Schema-Specific preference does not have a context (see Scenario A), meaning that it does not refer to a specific set of reports (i.e. workbook) or a single report (i.e. worksheet). However, Schema-Specific preference refers to OLAP schema as a whole. Preference of that kind contains degree of interest, weight and type of preference element. PreferenceElementType class describes the type of preference element, which may be either OLAP schema element (e.g. dimension, fact table, attribute, etc.) or an aggregate function.

One may consider one or several workbooks (see Scenario B and D) or one or several worksheets (see Scenario C and E). Attributes of classes Worksheet and Workbook are described in [27]. In Report-Specific preferences one or more preference type elements may be included (see Scenarios B-E), and vice versa, a single preference element type may be used in multiple user preferences.

Report-Specific preferences also include restrictions on report data. Each Report-Specific preference may contain a set of conditions (ConditionSet). A Condition class is devided into two subclasses: SimpleCondition and ComplexCondition. ComplexCondition consists of two or more simple conditions (SimpleCondition), joined with a logical operator (AND, OR). SimpleCondition consists of two expressions (Expression) and a comparison operator (Comparison). Typically, one of expressions is a preference element type and the other one is a constant value (ConstantValue), which is either a string of symbols or a numeric value. It is allowed to apply the following comparison operators: =, >=, <=, >, <, !=, IN, NOT IN, IS NULL, IS NOT NULL, LIKE, NOT LIKE, BETWEEN, NOT BETWEEN, EXISTS, NOT EXISTS.

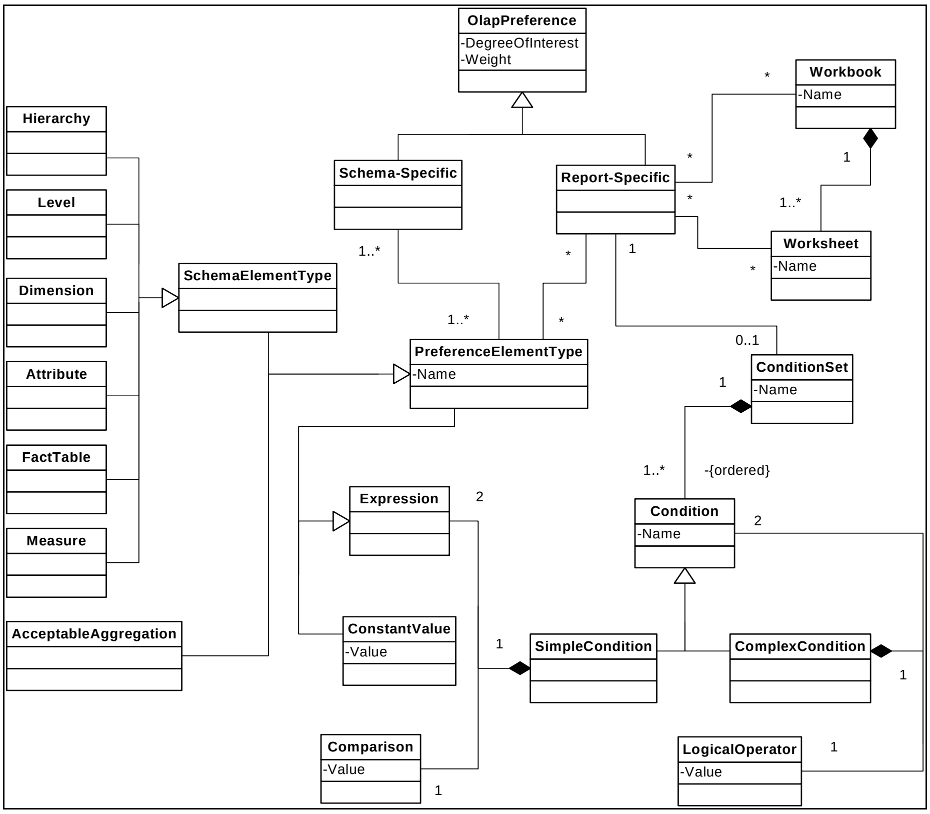

Fig. 5. OLAP preferences metamodel

Concept of Recommendational Profile Development

Sometimes a user has no idea about what kind of data he is able to find in data warehouse reports. Let's consider that data warehouse user has not created his preferential profile. In this case he/she may use preferences, which are set by other users that have something in common with the specific user. Such approach is common for recommender systems. There are several filtering methods for providing recommendations to users in recommender systems: content-based [28], collaborative [28], rule-based [28, 29], demographic [30, 31] and hybrid (i.e. a combination of all mentioned methods) [32]. In our approach we make use hybrid filtering method.

Let's consider any attribute value that is shared by a group of users from user-describing profiles as a possible common trait. For instance, EducationalInstitution = "University of Latvia", Faculty = "Computing", AgeGroup = "20-25", WebBrowser = "Mozilla Firefox", etc.

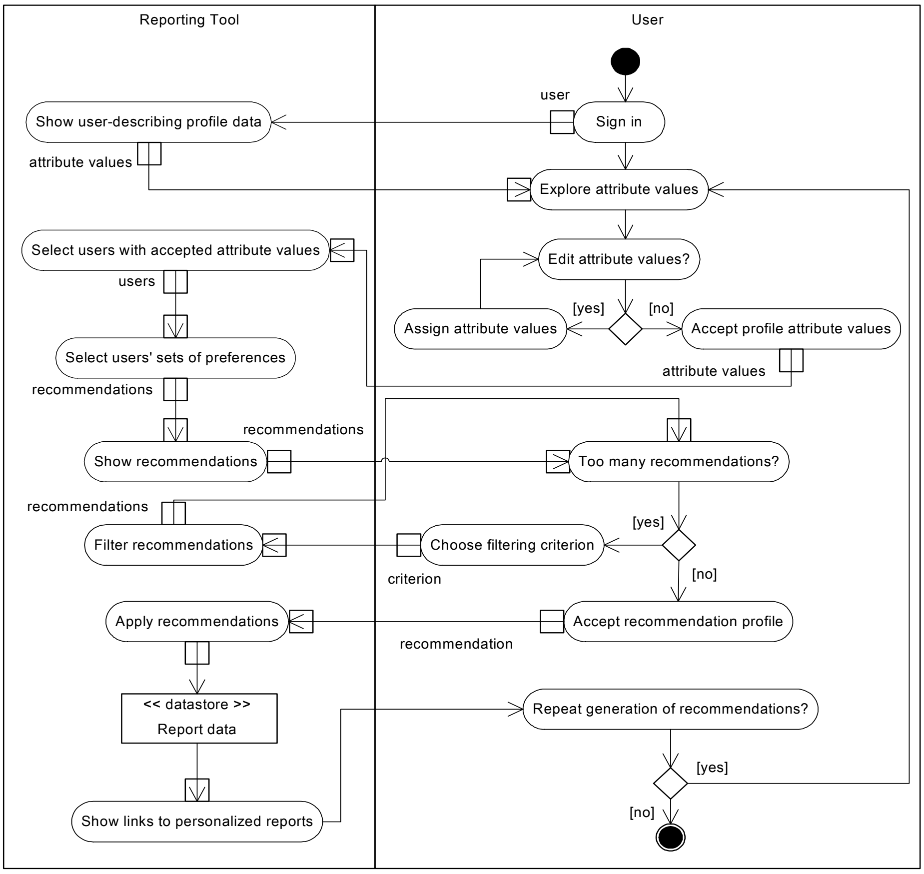

Fig. 6. Activity diagram for recommendational profile

Recommendation development algorithm is depicted as UML activity diagram in Fig. 6. Let's designate an arbitrary user of data warehouse reporting tool as user *U*. When user *U* signs in, the user-describing profiles (i.e. temporal, spatial, interaction, user, preferential) are being displayed. Each profile contains attributes with values, which are captured from data warehouse static, activity or context data sources (see Fig. 3). User *U* may look through and edit the proposed attribute values manually (if it is necessary). According to similarity of attribute values in profiles of user *U* and attributes values in other users' profiles, a set of users is selected.

Each user may own multiple OLAP and/or visual layout preferences. In this paper a recommendation is a set of preferences, belonging to a certain user. Thus, recommendation is a proposed way of personalizing data warehouse reports.

User *U* is being acquainted with recommendations of the set of selected users. If there are too many recommendations, a user is able to reduce its number by applying some filtering criterion. For instance, some of the filtering criteria may be:

- select *n* most active user recommendations,
- select *n* recommendations, ordered by the total weight of a set of user preferences (i.e. a recommendation) – Top-*n*, Bottom-*n*, Random-*n*,
- select *n* most recent recommendations, ordered by the time of its creation,
- etc., where *n* is a user-defined arbitrary numeric value.

When recommendations are filtered and user *U* has accepted the recommendation, then the observed recommendation (i.e. a set of user preferences) is applied in the reporting tool. As a result the user receives links to one ore more personalized reports.

5 Conclusions and Future Work

In this paper a new method has been proposed, which provides exhaustive description of interaction between user and data warehouse, using the concept of Zachman Framework [1, 2], according to which a set of user-describing profiles (user, preference, temporal, spatial, preferential and recommendational) have been developed.

The method, suggested in this paper, consists of the following steps:

1. Stating questions (what…? who…? how…? etc.) to enable the description of data warehouse user/system interaction;
2. Identifying the user describing profiles;
3. Collecting possible user-describing profiles' attributes from various sources of information (see Table 2, Section 4);
4. Generating user characteristics via profile attributes after signing in the reporting tool;
5. Suggesting possible recommendations for new and existing users of reporting tool, based on report preferences for the contents and structure of reports (OLAP preferences) and visual layout preferences;
6. Report personalization: applying selected recommendations to a report.

A model that reflects connections among user-describing profiles and a diagram that characterizes profile data sources has been proposed. To construct sets of attributes of user, interaction, temporal, spatial profiles, a method that includes studies of such sources of information as data warehouse literature, CWM standard, scientific and technical articles web-services data warehouse of the University of Latvia, and Oracle Warehouse Builder (13 different sources of information altogether). As a result class diagrams for user, interaction, temporal and spatial profiles have been developed. Several scenarios have been provided to describe possible ways of OLAP user preference modeling, and followed by a metamodel, which formulates user preferences for OLAP schema elements and aggregate functions and can be compatible with report metamodel [27]. Recommendational profile contains preference sets, belonging to different users. In this paper an idea of recommendation development for a report tool user has been proposed.

In one of our future papers a detailed description of visual layout user preferences will be presented. This paper will include scenarios visual layout preference modeling scenarios, followed by a visual layout metamodel and instance diagrams.

The goal of our future work is to integrate personalization into the reporting tool, using the method, described in this paper. It is important to research the recommendation generation algorithms and recommendation filtering criteria in existing recommender systems of different domains (e.g. CRM, e-commerce, entertainment, etc.). Recommendation filtering criteria will be gathered and evaluated in order to find more suitable criteria for recommendation processing in reporting tool.

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