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A Context-based Prototype for decision making in database administration

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Abstract

Decision Support Systems (DSS) have a great role in assisting decision makers in many organizations to identify and solve problems in order to make decisions. In the area of database management, many approaches have been used to automate procedures set for complex activities such as performance and database recovery. However, procedures need to be contextualized in order to take into account the permanent changing of technical and social contextual elements added in DBA (Database Administrator) practices. This paper presents a context-based prototype for decision making to support experts in database management and administration. The prototype uses a software-modeling tool called Contextual Graphs (CxG).

Keywords: *Contextual Elements, Contextual Graphs, Database Administration, DBA, Decision Support System, Intelligent Assistant System, Practices, Procedures, Prototype for decision making.*

1. Introduction

Today with the fast evolution of new technologies as big data, social networks, cloud computing and mobile systems, the decision-making in organizations is becoming more and more complex. As a result, decision makers have been obliged to make the best decisions in the shortest possible time. In the area of database administration, support is needed for DBAs (Database Administrators) to make decisions about complex activities such as tuning problems and managing the continuous changes to databases. DBMS vendors continue to provide standard procedures for solving most of the incidents that have been well known for a long time (bad memory configuration, buffer caches, database crashes, and security bugs, among others). In addition, organizations have also established, from their perspectives, their own internal procedures for incident solving based on the basis of their experience. However, each DBA develops his own practice to solve an incident, and one observes almost as many practices as DBAs for a given procedure because each DBA tailors the procedure in order to take into account the current proceduralized context, which is particular and specific. In many working processes human beings can be observed to develop accurate procedures to reach the efficiency that decision makers intended when designing the task.

In parallel, DBAs prefer to plan again their action in real time rather than to rely on these procedures based on company's experience. This is due to two main reasons. Firstly, the selected procedure is not always perfectly adapted to the situation at hand and can lead to improper actions or sub-optimal incident resolution strategies. Secondly, if the DBA relies on a procedure, he can miss some important facts and notice them too late to adequately solve the incident. DBAs choose generally to plan again their action continuously according to the situation. Procedures are then used as frames to build and create a genuine strategy tailored to the specificity of a given situation. Such practices are based on operational knowledge and are shared by actors. In many different domain areas (i.e. medicine, technical process regulation, nuclear power, etc.…), the distinction between procedure and practice in the one hand, and the notion of context in the other hand is very important. Practices can appear as a contextualized expression of procedures.

The modeling of DBAs' reasoning is a difficult task because each DBA can use a number of contextual elements, and also because procedures for solving complex incidents do not always offer a great flexibility and degree of freedom. Their reasoning stems from some chunks of implicit knowledge, which are imposed on the DBA because they correspond to mandatory procedures. Procedure are established from DBA's experience during similar incidents and fixed by the company.

This paper presents a prototype for designing a context-based intelligent assistant system to support experts in database management and administration activities. The prototype uses a software-modeling tool called Contextual Graphs (CxG), which is well adapted to represent user procedures and practices. First, some of the related approaches will be discussed. Then we present a description of the context-based prototype for decision making including the Contextual Graphs formalism,

prototype architecture and a case study. Finally, we conclude our work.

2. Related work

Intelligent assistance is one of the important active research fields within Artificial Intelligence (AI). This section reviews some of the important approaches for intelligent assistance in database management over the years. Many expert systems have been introduced to help in simplifying the process of database design and development like the Generalized Expert System for Database Design (GESDD) developed by [6]. Such experts systems are mainly targeted for experts in database design, but not for novice designers with little experience because they do not provide adequate facilities for novice database designers to use the system. Another limit of expert systems for database management is that they didn't adopt a user-centered approach and they did not consider context explicitly. Decision support systems (DSS) have also been used in database management. Palvia [11] presented an interactive DSS tool, which supports the database designer in this task by providing several heuristic optimization procedures to enable the generation of many good designs. In addition, Spiegler and Widder [13] proposed a conceptual model based on a decision support system (DSS) that focuses mainly on the later stages of the system design, when the system is being mapped into the structure of the database management system (DBMS) selected for application. One of the main problems with such DSSs is that they didn't always consider, detect and process the users' context, preferences and new unexpected situations (i.e. DBA is new to the database administration tool). Other related approaches are Intelligent Tutoring Systems (ITS) for learning database management. These ITSs focus on teaching database domains such as Structured Query Language (SQL) and Database Design. One of the ITS is SQL LightweightTutoring Module (SQL-LTM) [7] which is a system that can provide semantic feedback on SQL statements, pointing out their logic flows, even if they are syntactically correct. Another work is that presented by Risco and Reye [12] about an evaluation of the Personal Access Tutor (PAT), an Intelligent Tutoring System (ITS) for Learning Rapid Application Development (RAD) in a database environment. Many other research efforts have already been made towards a best automatic database management and administration using multi-agent systems such as AutonomousDB tool proposed by Moraes et al. [9] to support the task of schema evolution in heterogeneous multi-database environments where there are replicated schemas. Other two famous multi-agent systems are Intelligent Agent Assistant (IAA) by Elfayoumy and Patel [8] and Grid Control Agent [10] to help DBAs in performance monitoring tasks and the automation of resolution actions.

In this section we have cited different approaches to intelligent assistance for supporting database management including database administration. Most of these approaches consider only technical sensors as contextual parameters and there is a little research dealing with context in the area of database and data administration from a user-centered perspective (i.e. DBA viewpoint). In information retrieval systems, Bouramoul et al. [1] proposed an approach based on the context to evaluate the performance of the search tool and the relevance of results compared to an executed query and the user's judgments. Another interesting approach is to explore system-level provenance to improve the mental models, and troubleshooting process for system administrators as in [5]. Nevertheless, context is rarely considered explicitly in procedures and policies used by many database administration tools. In addition, most policies rely on technical sensors, location and history. Contextual information does not include user's individual and interaction context (skills, experience, age, etc.…) with the system and other actors, and which could be of a great importance in efficiently performing complex DBA activities.

We can summarize the limitations of these approaches by saying that the developed tools are:

- Unable to automatically detect, diagnose and repair efficiently failures in unexpected new situations (context is evolved) ;
- Context-Aware Administration (i.e. only physical parameters and sensors are considered);
- Not Human-Centered Context (i.e. Social Context: DBA Profile, experience, Knowledge, Conflict with Developers, degree of collaboration between DBA and other shareholders…).
- Not suitable for the efficient sharing of context (i.e. Context is implicit).

3. Prototype for decision-making

This section presents a brief presentation of the Contextual Graph formalism followed by the architecture of the prototype for decision-making and a case study in the area of database administration.

3.1 Contextual Graphs formalism

The proposed context-based prototype for decision making uses a Contextual Graph formalism to represent the different ways to solve a problem. Each path corresponds to a practice, a way to fix the problem. It is a directed graph, acyclic with one input and one output and a general structure of spindle. Fig. 1 shows the elements in a Contextual Graph. This formalism and its implementation are well explained in [3]. Elements of a Contextual Graph are: actions, contextual elements, activities and temporal branching. Brézillon and Pomerol [4] consider that context is "what constrains something without intervening in it explicitly."

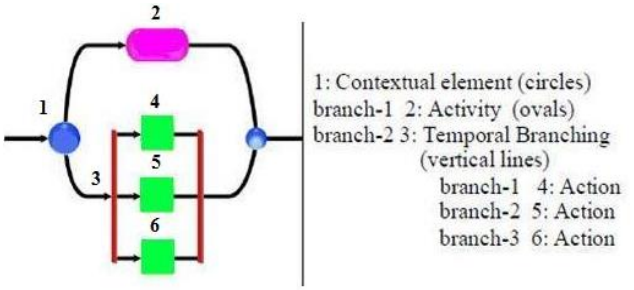

Fig. 1 Contextual Graph Elements

According to Brezillon [2], an Intelligent Assistant System (IAS) must present different properties like:

- Providing users with a first approximation of environmental trends and events;
- Pointing out useful information implicit in large volumes of data to alert users to sudden changes;
- Developing multiple scenarios and perspectives on a given line of action;
- Attracting user attention to existing and emerging strategic issues;
- Supporting users in sharing and communicating their views and perspectives;
- Guiding user attention to specific data and its interpretation in relation to particular issues;

The design of a Context-Based Intelligent Assistant System uses Contextual Graphs formalism to respond to the main requirements in the field of database administration such as:

- Assisting DBA in executing and managing efficiently their daily activities as well as resolving incidents;
- Improving collaboration between actors by sharing the context in which the DBA is confronted when dealing with complex database administration activities;
- Analyzing practices and the different strategies used by different actors when dealing with the same or similar situations and contexts.

Contextual Graphs represent the set of known practices (strategies) in order to solve a given problem. They also allow incremental acquisition of practices and provide an understandable way to model context-based reasoning. A practice is the path from the input to the output of a Contextual Graph. The problem solving process is guided throw a specific path by the evolution of context over time. Adopting a given practice or strategy among the others is dictated by the values of the different contextual elements forming the situation. However, it is not always obvious for a user to select one of these values.
User practices may differ from each other because of their contexts that are slightly different where users used different actions at a step of the problem solving. The process of practice acquisition by the CxG system concerns the new action to integrate and the contextual element that discriminates that action with the previous one. The integration of the new practice requires either adding a new branch on an existing contextual node, or introducing a new contextual node to distinguish the alternatives. The phase of incremental acquisition of practices relies on interaction between the CxG system and the users in order to acquire their expertise, which consists of a context-based strategy and its evolution along the process of the problem solving. We can distinguish two types of practices: (1) Practices created by experts (Design mode) (2) Practices executed by users (Running mode).

3.2 Prototype Architecture

As shown in Fig. 2, our proposed prototype for decision making integrates the following components:
CxG Editor: This component helps authorized users to manage their corresponding Contextual Graphs representing the main procedures and the significant changes added by them (i.e. practices).

CxG Reader: This component enables reading a desired Contextual Graph to execute one or more practices already created by different experts to perform a given activity.
CxG Analyzer: This component supports users in adopting the best strategies and practices when performing complex tasks to reach a desired goal.
CxG Manager: The CxG Manager controls and communicates with the different components of the Contextual Graphs Platform and with users.
Operational experience database: The CxG Manager uses this component to record and store users' practices.
Archive database: This component manages copies of executed Contextual Graphs.

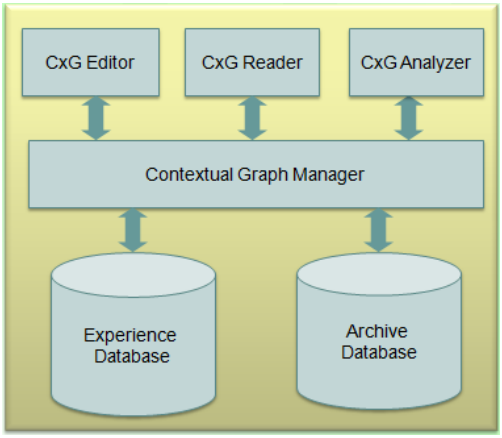

Fig. 2 Architecture of the proposed context-based prototype for decision making

3.3 A case study

In this case study, we have used the Contextual Graph representing a part of a DBA procedure for database performance troubleshooting as in [14] and [15]. To solve a serious performance problem within a given critical situation and context, a DBA may have different options when asking this question: what causes the slow response time of the system? Is it a network problem? Is it a bad database configuration? Is it a bad query in the application programs? Etc.
The Contextual Graph in Fig. 3 is composed of the following:

- Three contextual elements C1, C2 and C3 representing respectively nodes numbered 3, 7 and 11 with the set of values: Val (C1)= {C1.0, C1.1, C1.2}, Val (C2)= {C2.0, C2.1, C2.2}, Val (C3)= {C3.0, C3.1, C3.2, C3.3}.
- Set of Actions A= {A1, A2, A4, A5, A6, A7, A8, A9, A10, A12, A13, A14, A15}.

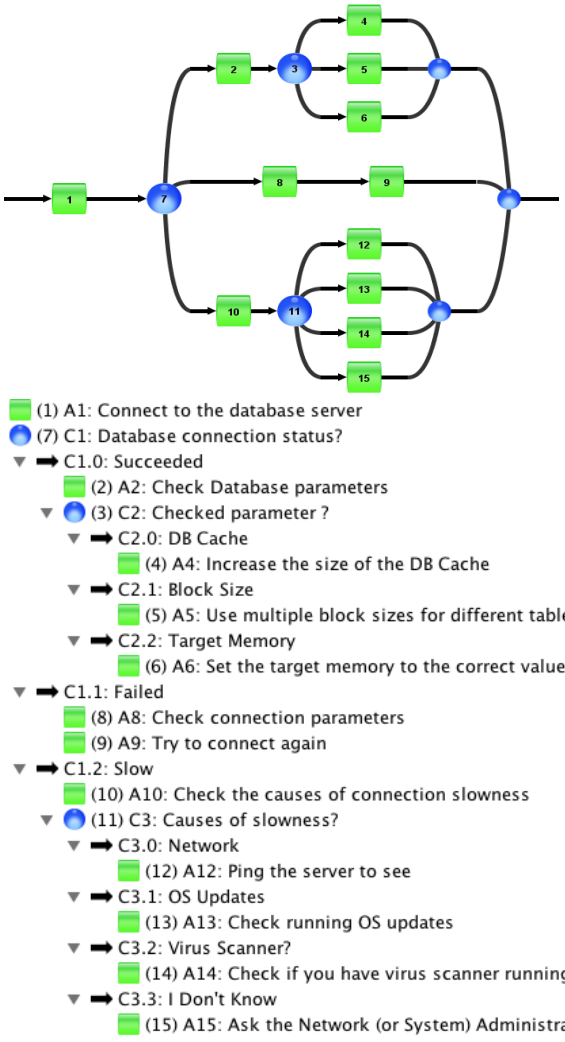

Fig. 3 Contextual Graph representing a part of a DBA performance procedure.

The DBA may be interested in the statistics about the path he selected, the number of errors generated when following that path but also the most used path for solving a critical problem within a context similar to that of his current situation. Many indicators can be used to assist the users of Contextual Graphs (i.e. the average evaluation of a selected contextual element branch, profile of user, number of executions, total time of task execution, etc.). Table 1 shows an example of the indicators about a selected branch of a contextual element.

Table 1: Contextual Elements Indicators

Contextual Element (CE)	*CE values*	*User Profile*	*Evaluation (%)*
Database connection status?	Succeeded	DBA	90
	Failed	DEVELOPER	60
	Slow	DBA	30
Checked parameter?	DB Cache	DBA	50
	Block Size	DBA	20
	Target Memory	SYSTEM ADMIN	10
		DBA	40
Causes of Slowness?	Network	DBA	10
		SYSTEM ADMIN	30
	OS Updates	SYSTEM ADMIN	40
	Virus Scanner	SYSTEM ADMIN	30
	I Don't Know	DBA	15

4. Conclusion

This paper has presented a context-based prototype for decision making to support database administrators (DBAs) in their complex activities such as resolving performance problems to ensure high availability of information systems. We have used the Contextual Graphs formalism to design the prototype. The objective is to build a context-based intelligent assistant system that can be used in different domains. Detailed architecture and evaluation of the described prototype will be explained in our future publications. We will also discuss how Data Marts can be used with Contextual Graphs to help in the process of analysis in decision making both in individual and collaborative activities.

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