Design and Implementation of TEMPO Fuzzy Triggers

Tarik Bouaziz*, Janne Karvonen, Antti Pesonen and Antoni Wolski

Technical Research Centre of Finland (VTT)
VTT Information Technology
P.O. Box 1201, FIN-02044 VTT, Finland

e-mail: <first name>.<last name>@vtt.fi
http://www.vtt.fi/tte/projects/tempo/

Abstract

Fuzzy triggers are database triggers incorporating fuzzy concepts. The approach leads to the application of approximate reasoning to trigger-based decision making. In C-fuzzy triggers, fuzzy rules may be specified in the trigger condition part. The C-fuzzy trigger model is presented, and an implementation thereof in the TEMPO Server—a prototype active database system—is described. The performance test results are included.

Keywords: Active databases, approximate reasoning, fuzzy triggers.

1 Introduction

In various application domains of information technology a phenomenon of data explosion may be observed. For example, in the field of industrial process management, the data explosion effect is caused by the improved data acquisition techniques: more and more process variables are reported at higher and higher frequencies. In a needs survey performed in 1993 [JP93] a peak acquisition rate required for a major power station installation was about 5 000 measurements per second, and the requirements have been growing since then. In the presence of data explosion one needs powerful means to extract useful information from the flooding data. In time-critical environments like manufacturing process management and control, the speed of data evaluation is also of great importance. As we see it, providing the right information at the right time becomes a new challenge of next generation database systems. The goal may be achieved by improving the active capabilities of database systems. In this paper, we present an implementation of a new type of database triggers using fuzzy inference in making the decisions. The results of this work are applicable to other environments suffering from data explosion—ranging from corporate databases to World Wide Web.

The work presented in this paper was originally driven by the requirements of an industrial application: a paper machine drive control system. A paper machine is equipped with tens of high-power electric motors. Process measurements data is stored in a database which is fed by sensors. There is a need to analyze the data and

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to provide useful information to the end user, in a timely and appropriate manner, in order to prevent failures of the drive system. To achieve this, in the TEMPO project, we have proposed a technique of fuzzy triggers [BW96]. In this paper, we focus on a concrete implementation of the concept.

To our best knowledge, no attention has been paid until now on integrating imprecision and/or uncertainty within database triggers. There are many approaches through which this integration can take place [BW96, BW97]. The TEMPO approach focuses on a seamless integration of fuzziness within database triggers. There are three design criteria which we strive to satisfy in TEMPO.

The first goal is to enhance the expressive power of triggers to capture the expert knowledge which is imprecise, incomplete or vague. This knowledge is more easily expressed using fuzzy rules which allow fuzziness in the antecedents and/or consequents [Zad84, Zad89]. Indeed, many experts have found that fuzzy rules provide a convenient way to express their domain knowledge. In industrial applications, linguistic terms such as low, medium, high, large, small, etc. are widely used since they convey more information than crisp values would do [Men95].

The second goal is to extend the (exact) reasoning inherent to triggers and to integrate it with the approximate reasoning more tightly. This makes fuzzy triggers a powerful mechanism to capture both approximate and exact reasoning characterizing real-world problems. Approximate reasoning deals with inference under imprecision and/or uncertainty in which the underlying logic is approximate rather than exact [Zad75, GKB+84]. It should be noted that in our daily life most of the information on which our decisions are based is linguistic rather than numerical in nature. In this perspective, approximate reasoning provides a natural framework for the characterization of human behavior and suitable for decision making.

The third goal, a practical one, is to find an easy way to add a fuzzy trigger capability to an existing active database system since we have previously developed such a system [WKP96]. Also, a possibility to use an existing fuzzy inference engine is highly recommended since it reduces the implementation effort.

This paper is organized as follows: Section 2 illustrates the main features of the model of implemented fuzzy triggers. Section 3 presents selected topics of the implementation of the TEMPO Server prototype. We show performance test results in Section 4. Then, we conclude in Section 5.

2 TEMPO Fuzzy Triggers

In this section we briefly describe a trigger model incorporating approximate reasoning (fuzzy inference) in the process of the evaluation of the condition part of an ECA trigger. We are calling such triggers C-fuzzy triggers (or Condition-fuzzy ECA triggers). For a more detailed presentation of this one and other fuzzy trigger models, see [BW96, BW97]. The C-fuzzy trigger model is based on the concepts of the linguistic variables, the corresponding terms and the rule set function.