

# Chapter 14

## Efficient Algorithm for Answering Fuzzy Medical Requests in Pervasive Healthcare Information Systems

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### ABSTRACT

*The progress in mobile devices and wireless networks technologies has considerably contributed to integrate pervasive computing expertise in many domains with the aim of improving the quality of services and users' mobility. However, in many situations, users may face difficult situations, needing faster decisions, where classical systems impose the submission of classic queries in which crisp conditions must be carefully fixed. This inconvenience limits the potential of pervasive applications accessed by users having few times to make the right decisions. To introduce the contributions of this paper, we choose the medical domain as example. We considered a pervasive healthcare application under which physicians haven't enough time to fix carefully their queries in some emergency cases. Therefore, they are allowed to flexibly express their preferences using conjunctive fuzzy queries and to quickly receive best answers anywhere and anytime while treating patients in the shortest time and consequently free resources for eventually other urgent requests. In this work, we consider, in general, the problem of efficiently finding the top-K answers for a conjunctive fuzzy query from the top-N conjunctive query rewritings of the query. In particular, we propose an efficient algorithm called the Top-N rewritings algorithm for finding the top-N query rewritings of a medical conjunctive fuzzy query using a set of conjunctive crisp views. At the best of our knowledge, this algorithm is the first to generate, without computing all possible rewritings, the N best ones ordered according to their satisfaction degrees and that are likely to return the best K-answers for the user fuzzy query. The relevance of a query rewriting is estimated using a second algorithm called the Query-satisfaction computing algorithm proposed to estimate, through the histograms maintained to approximate the distribution of set of values returned by the rewriting and to which fuzzy predicates are related, the pertinence of a conjunctive fuzzy query rewriting rather than accessing the database relations.*

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## INTRODUCTION

The integration of pervasive computing in healthcare has enabled patients to take profit from high quality health care services anytime and anywhere. For this reason, providing continuous remote monitoring especially for elderly patients into the comfort of their home will be certainly less expensive than the cost of in-clinic recovery and more efficient. Furthermore, the advancement in mobile devices and in context-aware technologies has contributed to enhance the quality of healthcare services and the users' mobility from one place to another.

Pervasive healthcare has the potential to reduce medical costs and improve quality of services; however it faces many technical difficulties related to the integration of the different medical information systems interoperating under the same healthcare application and maintaining periodically changeable schemas. In front of this challenging problem, middleware is gaining interest by insulating different systems from proprietary interfaces and providing layers of abstraction giving hence the illusion of using a homogeneous system. In many cases, physicians face problematic situations threatening patients' lives and needing fast and firm decisions; nonetheless classical medical middleware systems used to force physicians to submit traditional queries in which they must inflexibly precise their crisp conditions. This inconvenience limits the potential of the healthcare application used by physicians having few times to save patients' lives. In fact, they might have enough time to fix carefully their queries and can't wait any longer for needed answers. For this reason, we put forward a pervasive healthcare application based on an efficient virtual integration system in order to allow physicians to express freely their preferences using natural language and vague terms and consequently quickly to obtain their desirable answers anywhere and anytime while treating patients in the shortest time and therefore free medical resources for eventually other urgent requests.

In this paper, we propose the Top-N rewritings algorithm, a novel and efficient algorithm for generating ordered top-N query rewritings which are likely to return the top k-tuples fitting with user preferences. This algorithm is the first one to generate the N best rewritings without computing all possible ones while it discards useless rewritings from the query rewritings searching step and hence, generates only the best likely satisfactory ones ordered according to their satisfaction degrees of the user query. We discuss also two different solutions on how exploiting the output of the Top-N rewritings algorithm in order to recover the Top-K tuples considered as best answers. Finally, we envision an implicit query cache memory in the middleware to avoid useless query processing when it is already available in the cache.

In the next section, a brief summary about pervasive healthcare is presented. Section 3 shows the contribution of middleware to help integrating different medical information systems interoperating under the same healthcare application. In section 4, we define a fuzzy medical conjunctive query. Section 5 is devoted to describe the two proposed algorithms. This section describes also how to exploit the Top-N rewritings to determine the Top-K tuples. Section 6 explains when and how using the query memory cache. In section 7 we discuss the feasibility of the study and the final section concludes the paper.

## Pervasive Healthcare Applications

The progress in mobile devices over wireless networks and in context-aware technologies has considerably contributed to integrate pervasive computing in healthcare domain (Bardram, 2004; Bardram & Christensen & Olsen, 2004; Christensen & Bardram, 2002; Favela & Rodriguez & Preciado & Gonzalez, 2004; Varshney, 2003). In fact, by using wireless mobile devices, physicians become able to better com-

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