



Ain Shams University

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# XML Databases Technology and Its Application in E-Learning

A Dissertation

Submitted to the Mathematics Department - Faculty of Science  
Ain Shams University

In Partial Fulfillment of the Requirements for the  
Degree of Doctor of Philosophy  
in  
Computer Science

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جامعة عين شمس

جمهورية مصر العربية - القاهرة

# تقنية قواعد بيانات XML وتطبيقاتها في التعليم الإلكتروني

رسالة مقدمة إلي قسم الرياضيات - كلية العلوم - جامعة عين شمس

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علوم الحاسب

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Dissertation : Ph. D.  
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# ABSTRACT OF THE DISSERTATION

## XML Databases Technology and Its Application in E-Learning

by

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XML (eXtensible Markup Language) has become a standard format in information exchange and integration on the Web. Much research has been conducted in recent years on XML technology, which has led to new developments in this field. One of these developments is XML Database, which is meant for efficient management of XML data. While it is possible to store XML data in traditional relational databases or object-oriented databases, we also desire high-performance native XML databases that are particularly tailored for XML data.

This dissertation introduces mainly three issues needed to support the XML databases:

[1] We introduce a novel approach for storage and retrieval of XML documents using relational databases. Our approach enables us to store XML documents using a fixed relational schema without any information about XML schema. For the processing of XML documents, we propose two algorithms, the first, for converting XML data to relational data, and the other for extracting data from database tables and create the XML document corresponding to it. Our approach doesn't assume any extension to the relational model, and no restriction should be imposed on the input XML documents.

[۲] We study the problem of how to extend the concepts of functional dependency (FD) and normalization in relational databases to include the XML model. We show that, like relational databases, XML documents may contain redundant information, and this redundancy may cause update anomalies. Furthermore, such problems are caused by certain functional dependencies among paths in the document. Our goal is to find a way for converting an arbitrary XML Schema to a well-designed one, that avoids these problems. We first introduce new definitions of FD and normal forms of XML Schema. We show that our normal forms are necessary and sufficient to ensure all conforming XML documents have no redundancies. Finally, we present the decomposition algorithm for converting any XML Schema into normalized one, that satisfies X-BCNF.

[۳] Based on the XML databases technology, and relational databases, we developed an easy to use web-based training and quizzes system. The system allows teachers to store, update, and delete questions from the database using the web, in a very easy and simplified manner. In addition, teachers can track the activities of their students and can guide them to reach the pre-determined objectives of the courses. Our system is used successfully in distance learning as well as in self-training. We have tested the system with different type of courses taught in the university. The feedbacks of both teachers and students were highly promising.

Based on the previous work, we introduce the Semantic Web-Based model for our e-learning system. In addition we introduce an approach for developing a Semantic Web-based e-learning system, which focus on the RDF data model and OWL ontology language.

**Keywords:** *XML, XML Documents, XML Schema, XML Data Conversion, XML Databases, Relational Databases, XML Databases Design, Functional Dependencies, Redundancy, XML Normalization, Normal Forms, Educational System, WBT, E-Learning, Distance Learning, Semantic Web, RDF, Ontology, OWL.*



# SUMMARY OF THE DISSERTATION

## Chapter 1: The XML Model

XML stands for eXtensible Markup Language is the new universal format for structured documents and data on the Web, currently being standardized by the World Wide Web Consortium (W<sup>3</sup>C). The XML is designed to improve the functionality of the Web by providing more flexible and adaptable information identification. It is called *extensible* because it is not a fixed format like HTML (HyperText Markup Language), which is a pre-defined markup language, developed for displaying data on Web. Instead, XML is rather a *meta-language* that can be used for defining other languages. That is, with XML as a tool, one can define his/her own customized markup languages for specific types of documents.

In this chapter, we briefly present an overview of XML model and its schema and query language .

## Chapter 2: XML Database Systems

There are two ways to manage XML data and documents. The first way uses the traditional database systems such as relational database or object-relational database, the other way uses a database system specially designed for handling XML documents.

In this chapter, we introduce a brief overview for the XML database types, and present some approaches used to store (and query) XML documents in relational databases. The comparison of these approaches with our DOM-Based approach is described in chapter 3.

## Chapter 3: Storage and Retrieval of XML Documents Using Relational Databases

In this chapter we introduce a novel approach for storage and retrieval of XML documents using relational databases. In this approach, an XML document is decomposed into nodes based on its tree structure, and stored into relational tables according to the nodes types.

Our approach enables us to store XML documents using a fixed relational schema without any information about XML schema. For the processing of XML documents, we propose two algorithms denoted by "*XtoR*" and "*RtoX*", where the first is used for converting XML data to relational data, and the other is used for extracting data from database tables and create the XML document corresponding to it. Our approach doesn't assume any extension to the relational model, and no restriction should be imposed on the input XML documents. We show the effectiveness of this approach through several experiments using different XML documents.

## Chapter 4: XML Databases Normalization

With the present of XML and its use as a database, dependency and normal form theory has attracted novel research interest.

In this chapter we study the problem of how to extend the concepts of functional dependency (FD) and normalization in relational databases to include the XML model. We show that, like relational databases, XML documents may contain redundant information, and this redundancy may cause update anomalies. Furthermore, such problems are caused by certain functional dependencies among paths in the document.

Our goal is to find a way for converting an arbitrary XML Schema to a well-designed one, that avoids these problems. First we introduce new definitions of FD and normal forms of XML Schema ( $X-1NF$ ,  $X-2NF$ ,  $X-3NF$ ,

and X-BCNF). We show that our normal forms are necessary and sufficient to ensure all conforming XML documents have no redundancies. Finally, based on our research works, we present the decomposition algorithm for converting any XML Schema into normalized one, that satisfies X-BCNF.

## Chapter 6: A Web-Based E-learning System Experiment

Research works in the field of electronic learning are represented by a broad spectrum of applications, ranged from virtual classrooms to remote courses or distance learning.

In this chapter, based on the XML databases technology and relational databases, we developed an easy to use web-based training and quizzes system, in which, teachers and trainers can conduct any type of courses and set different types of quizzes and exams.

The system allows potential users to store, update, and delete questions from the database using the web, in a very easy and simplified manner. In addition, teachers can track the activities of their students and can guide them to reach the pre-determined objectives of the courses. Our system is used successfully in distance learning as well as in self-training. We have tested the system with different type of courses taught in the university, ranged from basic to advanced namely: introduction to computer science, programming concepts using C++, and fundamentals of database systems. The feedbacks of both teachers and students were highly promising.

## Chapter 7: E-learning Model Based on Semantic Web Technology

Web-based courses offer obvious advantages for learners by making access to educational resource very fast, just-in-time and relevance, at any time or place.

In this chapter, based on our previous work (chapter 9), we introduce the Semantic Web-Based model for our e-learning system. In addition we introduce an approach for developing a Semantic Web-based e-learning system, which focus on the RDF data model and OWL ontology language.

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