



# XML Data Services

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## ABSTRACT

*In this paper, we address the question, "In the brave new world of Web services and service-oriented architectures (SOA), how does data fit in?" We bring data modeling concepts to bear on the world of services, yielding an approach in which enterprise data access is handled by a collection of interrelated data services. We show how the approach can be realized on a foundation of XML standards, namely XML Schema, Web services, and XQuery. We show that this approach provides a uniform and declarative framework for integrating enterprise data assets that are drawn from disparate underlying sources, including both queryable and non-queryable data sources as well as data that is encapsulated by Web services. We also explain how the approach yields data services that are easily and efficiently reusable.*

*Keywords:* data management; data modeling; declarative programming; information integration; service-oriented architecture; Web services; XML; XQuery

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## INTRODUCTION

Since the dawn of the information age, data has been at the center of enterprise applications. As a result, data modeling has played a central role in the design and development of new applications (Hull & King, 1987), and the resulting conceptual schemas have played a key role in the ongoing maintenance and evolution of those applications. In the past, the development of a new enterprise application usually began by identifying the entities (busi-

ness objects) of interest along with the relationships between these entities (Chen, 1976). These formed the conceptual schema and were then mapped into the data model of the database management system (DBMS), usually a relational DBMS, which was chosen to manage the application's data. Detailed design and implementation of the application code would then follow, as would the design and tuning of the physical design for the application's database.

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In the course of the past decade or so, businesses realized that developing all of their information technology (IT) applications in house, and from scratch, is an expensive and inefficient proposition. As a result, most enterprises then turned to purchasing packaged applications for large areas of commonly required functionality, such as enterprise resource management (ERP) or customer relationship management (CRM), giving birth to what has become a large and profitable packaged application market. Typical packaged applications are data-centric in nature and make heavy internal use of a DBMS. They are usually customizable to some degree, and it is common for packaged applications to encapsulate their data, allowing data access from outside only through the screens and/or the APIs of the application.

Fast-forward to the present day, and another shift is taking place — a shift toward the development of new applications through composition or orchestration. Enterprise IT departments are still being called upon to build new applications in support of their businesses, but they must do so in the world produced by the aforementioned trends. Today they have many existing applications, some homegrown, some packaged applications, some Web-accessible services provided by suppliers and other partners, and so on. They would like to utilize their existing applications in building new composite applications. This shift toward building applications by composing other application components was predicted over a decade ago and was referred to at the time as megaprogramming (Wiederhold, Wegner, & Ceri, 1992). The megaprogramming vision is becoming a reality today under the moniker of service-oriented computing (Huhns & Singh, 2005). This approach views the world as a set of services, usually Web services (Alonso, Casati, Kuno, & Machiraju, 2004), each offering a set of service calls. An enterprise architecture based on this approach is called a service-oriented architecture (SOA).

So here we are, halfway through the first decade of the new millennium, and the new rage in IT is SOA. In the days of old, when IT de-

partments built applications from scratch, data and data modeling were central to the process. Now what? Is data still central, where has the data gone, and how should data-centric applications be approached in the new world of SOA? The answers to these questions are the focus of the rest of this paper. The second section answers them at a high level, introducing the notion of data services and describing their role in SOA-based architectures. The section on modeling services proposes a more formal definition of a data service and describes a modeling methodology that can be used to model a set of data services. The section on declarative services makes the case for taking a declarative approach to the design and implementation of data services, explaining the benefits and describing how current XML technologies can be leveraged to declaratively build data services. The second-to-last section relates our data services approach to prior work. The last section concludes the paper.

## SERVICES, DATA, AND SOA

Data relevant to today's enterprise applications lives in a variety of information sources, including relational databases, packaged applications, various homegrown applications, external Web services, and files (Carey, Florescu, & Mangtani, 2003). An application developer who wishes to integrate or even just access data in such a wide range of sources must cope with three kinds of heterogeneity. First, each source has its own associated data model or data format (tables, WSDL with XML Schema, XML documents, files, and so on); this is *model heterogeneity*. Second, each type of source has its own programming interface (JDBC/SQL, SOAP, file I/O calls, RPC, and custom APIs like BAPI for SAP); this is *API heterogeneity*. Finally, a given piece of information such as a name or an address may be represented differently in different sources; this is *schema heterogeneity*.

Web services (Alonso et al., 2004) and the adoption of SOA relieve the application developer from having to directly cope with the first two forms of heterogeneity. In the Web services world, all sources are described using

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