

Interoperability of Information Systems

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INTRODUCTION

An information system is a multilevel system characterized by a “data” level, a “behavioral” level, and a “communication” level. The data level represents the data stored by the system. The behavioral level represents management and production processes carried out by the system. The processes can interact with the data level to extract, generate, and store data. The communication level relates to the network used to exchange data and activate processes between geographically distant users or machines.

Information system interoperation has emerged as a central design issue in Web-based information systems to allow data and service sharing among heterogeneous systems. Data heterogeneity stemming from the diversity of data formats or models used to represent and store information in the Web is a major obstacle to information systems interoperability. These data models range from the structured data models [network, relational, object oriented (OO)] found in traditional databases to flat files and emerging Web-oriented semistructured models. Information system interoperability aims at supporting the amalgamation of autonomous heterogeneous systems to create integrated virtual environments or architectures in which information from multiple disparate sources can be accessed in a transparent and efficient manner. As an example of such integrated virtual systems, consider an airline reservation system based on the integration of a group of airlines reservation and ticket sale information systems. The specific airline systems provide various types of fares and special discount trips that can be searched and compared to respond to user queries for finding the best available prices for specified flights.

BACKGROUND

Database interoperability issues have been extensively studied in the past. Several approaches, including database translation, distributed systems, federations, lan-

guage-based multidatabase, ontology, and mediation, have been proposed to bridge the semantic gaps among heterogeneous information systems.

The database translation approach is a point-to-point solution based on direct data mappings between pairs of information systems. The mappings are used to resolve data discrepancies among the systems (Yan & Ling, 1992). The database translation approach is most appropriate for a small-scale information-processing environment with a reduced number of participants. The number of translators grows with the square of the number of components in the integrated system. For example, consider two information systems IS1 and IS2 in the travel agency example above. The corresponding translators must be placed between the information systems as shown in Figure 1. Information in IS1 is represented by vertical lines, while the information in IS2 is shown as horizontal lines.

In the standardization approach (Figure 2), the information sources use the same model or standard for data representation and communication. The standard model can be a comprehensive metamodel capable of integrating the requirements of the models of the different components (Atzeni & Torlone, 1997). The use of a standard metamodel reduces the number of translators (this number grows linearly with the number of components) to resolve semantic differences. However, the construction of a comprehensive metamodel is difficult; the manipulation of high-level languages is complex; and there are no unified database interfaces. In our example, the travel agencies must define a common model to export their data. A centralized information system can be built to replace the original information systems (IS1, IS2). The global centralized schema is a combination of the data (horizontal and vertical lines) contained in IS1 and IS2.

Federated systems (Figure 3) consist of a set of heterogeneous databases in which federation users can access and manipulate data transparently without knowledge of the data location (Sheth & Larson, 1990). Each federation database includes a federated schema that incorporates the data exported by one or more remote

Figure 1. Database translation approach

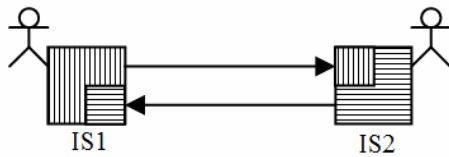


Figure 2. Standardization approach

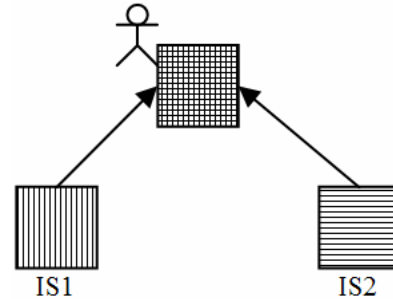


Figure 3. Federated systems

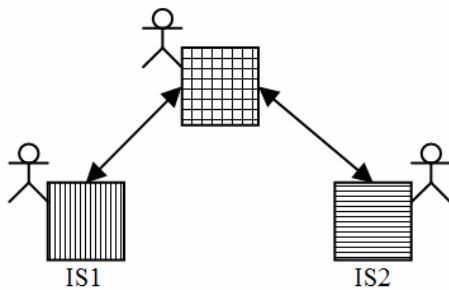


Figure 4. Multibase systems

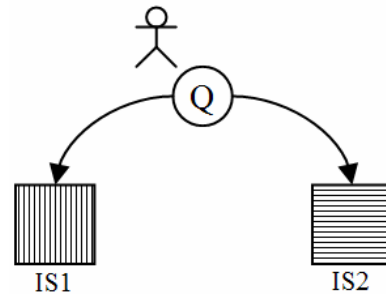


Figure 5. Ontology approach

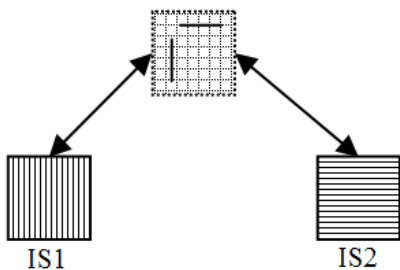
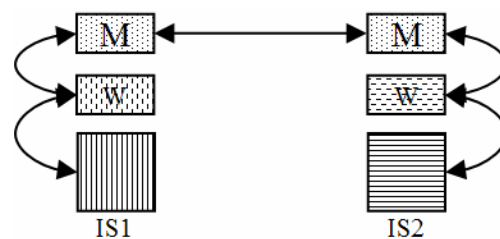


Figure 6. Mediation approach



information systems. There are two types of federations. A tightly coupled federation is based on a global federated schema that combines all participant schemas. The federated schema is constructed and maintained by the federation administrator. A loosely coupled federation includes one or more federated schema that are created by users or the local database administrator. The federated schema incorporates a subset of the schema available in the federation. This approach becomes rapidly complex when the number of translators required becomes large. In our example, the existing information systems are completely operational for local users. Only the shared data are integrated in the federated schema. The federated

system is made only of horizontal and vertical lines that IS1 and IS2 want to exchange.

Language-based multibase systems (Figure 4) consist of a loosely connected collection of databases in which a common query language is used to access the contents of the local and remote databases (Keim, Kriegel, & Miethsam, 1994). In this approach, in contrast to the distributed and federated systems, the burden of creating the federated schema is placed on the users, who must discover and understand the semantics of the remote databases. In our example, the various companies have to define a global common language (Q) to query their information systems (IS1, IS2). This solution is well

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