Recently, Web technologies have emerged as a credible alternative to client-server computing in corporate enterprise. Using information extracted from any ODBC-compliant DBMS and delivered over the Net, today's Web applications are moving from static HTML pages to full interoperability with corporate databases. Java, COM, CORBA, and related technologies (see sidebar, "Related Web Programming Technologies") are driving this shift in application design. Web-based enterprise computing allows corporate IT to integrate disparate systems into a single, coherent environment. This shift from a traditional Web server with database connectivity to integrated systems that support the use of Web technologies facilitates business processes and allows corporations to service both internal and external customers effectively.

DATABASE CONNECTIVITY WITH CGI SCRIPTS

First-generation Web-based applications for enterprise computing typically use a traditional client-server architecture with CGI programs (often Unix shell scripts, C, and/or Perl programs). To develop a Web interface for an existing database, we can simply write a CGI database script. This script is an external program run by the Web server to access the database and create output in the form of an HTML document, which is then presented on a Web client.

This is a proven architecture, but it has several major limitations:

- Difficult to maintain state and session connection
- Performance bottlenecks can occur
- Can involve proprietary APIs
- Limited extensibility and robustness
- Lacks end-to-end security features

These limitations can create significant problems when trying to develop enterprise-based Web applications.

DIRECT WEB CLIENT CONNECTIVITY

An alternate architecture is to do away with the Web server (and possibly the OS as well) and simply add HTTP functionality to the database software. As shown in Figure 1, this approach allows Java applets running in the browser to make calls directly to the database, eliminating the overhead of the Web server. The downside of this design is poor security since you are allowing anyone with a Web browser and a connection to the network to interact directly with your database. In addition, most Java applet-to-database programs are likely to be proprietary code, limiting portability.

SERVER-SIDE WEB APPLICATIONS

Using JDBC with Java servlets to replace CGI is a different architecture that not only solves typical client-server problems, but also gives code portability and allows your server-side application to interface with a wide range of relational databases.

A servlet, coined in the same context as the Java applet, is a small program that runs on a server. Java applets, usually intended for running on a client, allow services such as performing a calculation for a user or positioning an image based on user interaction. Some programs, often those that access databases based on user input, need to be on the server. With a Java virtual machine running in the server, servlets can be implemented with Java.

The advantage of having Java servlets in servers with lots of traffic is that they can execute more quickly than CGI applications. In addition, servlets can maintain state information, use a standard database API like JDBC, and significantly increase performance because they have no heavy process startup and initialization for each client request like CGI. Add-on modules allow Java servlets to run in Netscape Enterprise, Microsoft Internet Information Server (IIS), and other servers.

Another popular way of doing server-side programming is to use Microsoft's Active Server Pages. ASP also supports server components built with other languages. Developers can assemble their compiled code easily into a component.
that HTML programmers can call within their ASP. ASP scripts are pure ASCII and can be edited with Notepad or more sophisticated tools like Visual Interdev. Although ASP was designed primarily for Microsoft's IIS, it is now available (for a fee) on Unix, Lotus Domino, and Netscape Enterprise servers.

The trend for enterprise computing is toward ODBC/JDBC-enabled Web servers, depicted in Figure 2. Commercial examples of ODBC/JDBC-compliant Web servers include:

- Sun's JavaServer: Allows Java programming on the server side. Its API provides a framework for what are called Java Services. The Server API also defines servlets that extend the functionality of Java Services.
- IBM's Lotus Domino Web Server: Provides Web client access to dynamic data and applications on a Notes server. Domino converts Notes documents into HTML pages. There is a CORBA interface for Java programs, driver support for JDBC, and an ODBC driver called NotesSQL.
- Allaire's ColdFusion: Offers advanced database connectivity, including support for ODBC and native database drivers for Oracle and Sybase. The server is integrated with the full range of Internet protocols and services from e-mail to FTP, making it easy to use these technologies in applications. The ColdFusion programming environment uses ColdFusion markup language. CFML is a tag-based server scripting language that integrates with HTML and XML.

Related Web Programming Technologies

Component Object Model: COM is Microsoft's component software specification for using objects produced by various vendors within a single application. OLE is part of COM and defines a standard structure for reusable components. OLE is used as part of Windows 95/NT.

Object Linking and Embedding (OLE): OLE is part of COM and defines a standard structure for reusable components to communicate with other components, regardless of network location or platform. Using the OLE standard to build components assures their integration (without modification) within a system.

Common Gateway Interface Script: A CGI script is a program that can be executed by a Web server in response to Web requests. When a client browser requests the URL of something that is actually a program, the server executes the requested program and returns the results (not the program) to the client.

Open Database Connectivity Standard: ODBC inserts a middle layer, called a database driver, between an application and the DBMS. This layer translates the application's data queries into commands the DBMS understands. For this to work, the application must be capable of issuing ODBC commands and the DBMS must be capable of responding to them. Most commercial databases, including those made by Informix, Oracle, Sybase, and Microsoft, now come with ODBC drivers.

Java Database Connectivity Standard: JDBC is JavaSoft's database connectivity specification. It creates a programming-level interface for communicating with databases in a uniform manner, similar in concept to ODBC. The JDBC standard is based on the X/Open SQL Call Level Interface, the same basis as for ODBC. Most database vendors now support JDBC components for their databases.

Structured Query Language: SQL can be used to enter, query, and change data in a database. SQL is also used to create and administer databases. The SQL standard is supported by all commercial database management systems.
sensitive invocations; and control routing policy and network routing hop count. Some of these controls only affect messaging-enabled CORBA installations, an optional part of the specification.

Minimum CORBA is primarily intended for embedded systems. Once they are finalized and burned into chips for production, embedded systems are fixed, and their interactions with the outside network are predictable. They have no need for the dynamic aspects of CORBA, such as the Dynamic Invocation Interface or the Interface Repository that supports it, which are therefore not included in minimum CORBA.

Real-time CORBA standardizes resource control—threads, protocols, connections, and so on—using priority models to achieve predictable behavior for both hard and statistical real-time environments. Dynamic scheduling, not a part of the current specification, is being added. Fault tolerance for CORBA is being addressed by an RFP, also in process, for a standard based on entity redundancy and fault management control.

**CORBA COMPONENTS PACKAGE**

Called valuetypes, objects passable by value add a new dimension to the CORBA architecture, which previously supported only passing (and invocation) by reference. Like conventional CORBA objects, valuetypes have state and methods; unlike CORBA objects, they do not (typically) have object references and are invoked in-process as programming language objects.

It is only when they are included in parameter lists of CORBA invocations that they show their talent of packaging up their state in the sending context, sending it over the wire to the receiving context, creating a running instance of the object there, and populating it with the transmitted state. Frequently used to represent nodes in binary trees or cyclically linked lists, valuetypes are specified and implemented to represent these important constructs faithfully.

One of the most exciting developments to come out of OMG since the IIOP protocol defined CORBA 2, CORBA components represent a multipronged advance with benefits for programmers, users, and consumers of component software. The three major parts of CORBA-components are:

- a container environment that packages transactions, security, and persistence and provides interface and event resolution;
- a component system that can be integrated with Enterprise JavaBeans; and
- a software distribution format that enables a CORBA component software marketplace.

For the programmer, the prepackaged CORBA components provide a higher level of abstraction than CORBA services, leveraging the expertise of business programmers who are not necessarily skilled at building transactional or secure applications. These programmers can now use their talents to produce business applications that acquire these attributes automatically.

After 10 years of cooperative work by OMG members, the base CORBA infrastructure is complete and in constant use at thousands of sites. The extensions bundled under the banner CORBA 3 bring ease-of-use and precise control to this established architecture.

All of us expect the result to be worthwhile. Although the IDL and CORBA services make CORBA accessible to programmers now, their low-level interfaces sometimes represent a barrier to business programmers who want to manipulate objects that look just like business entities. CORBA components and scripting will soon make it possible for these business users to assemble applications tailored precisely to their needs, while asynchronous invocation interfaces and QoS control allow sites to take advantage of networked facilities even where resources are stressed.

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In the near future, even nonprogrammers will be able to build data-driven Web applications with new software development tools that are being introduced in the marketplace. One such tool is Elemental Software’s Drumbeat 2000 development environment. Drumbeat 2000 uses ASPs to build Web applications. It applies an object-oriented approach to software development via the rapid assembly of reusable components. Although you can edit code within Drumbeat 2000, direct programming is not readily supported. A visual programming wizard allows users to generate SQL and ODBC code without programming. When applications are completed, they are moved to an ASP-enabled Web server.

As additional high-level software development tools become available, developers will use them to build secure, enterprise-wide Web applications that apply the power of a database to store, retrieve, and manipulate content.

**Related URLs**

- CGI scripts and resources: http://desktoppublishing.com/cgi.html
- Oracle’s Raw Iron initiative: http://oracle.com
- Servlet Central: http://www.servletcentral.com
- Active Server Pages: http://www.activeserverpages.com
- ASP resources: http://www.asp101.com
- Sun’s JavaServer: http://jserv.javasoft.com/products/java-server
- IBM/Lotus Domino server: http://domino.lotus.com
- Microsoft’s IIS: http://www.microsoft.com/ntserver/web
- Allaire Corporation: http://www.allaire.com
- Elemental Software: http://www.drumbeat.com