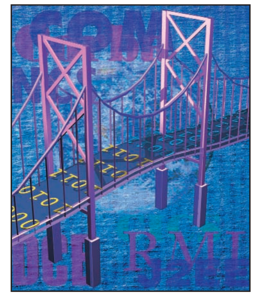
The More Things Change . . .



Steve Vinoski • *IONA Technologies* • *vinoski@ieee.org*

Developing any nontrivial middleware-based distributed system is hard, regardless of the middleware technology. Although technology's continuous march should make systems easier to develop, somehow the details always remain challenging. New technologies only seem to make simple things simpler; they don't help with the more complex things. Horizontal concerns, such as security, transactions, fault tolerance, load balancing, and enterprise management, never seem to get easier, regardless of what middleware development platform you choose.

The complexity in deploying a production-quality middleware system dwarfs its development difficulty. Along with the application, a lot of moving parts come into play in a production deployment: network and computing hardware, operating systems, and all the software the application depends on, including databases, management systems, security systems, runtime libraries, and virtual machines, each of which must be proven production-worthy. Production testing involves many hours of verification and burn in, and the problems that invariably crop up during these test periods typically are hard to reproduce and complex to solve.

Of course, a system's care and feeding does not end at deployment. If applications were static, maintenance efforts primarily could focus on tracking down and fixing intermittent bugs that appeared only after days or weeks of continuous operation. Unfortunately, middleware applications rarely are static. Not only do changing business requirements impact the applications themselves, but for a variety of reasons, the various platforms, operating systems, and middleware underneath the applications also change. Dealing with versioning and change management in a deployed middleware application can be complicated and costly.

Version Control

Versioning a stand-alone monolithic application usually is straightforward; you ship a new one, and the biggest problem you might have to worry about is backward compatibility with data read or written by the previous version. Unfortunately, it's not so simple with middleware applications, which typically involve *libraries* and *distribution*. These libraries are dynamic link libraries (DLLs), shared libraries, and Java archive (JAR) files, which are physically separate from the application itself. Distribution means that middleware applications typically consist of numerous smaller applications or components that work together over a network.

A good example of versioning coming into play for distributed middleware systems is the interface between any two applications or components. For a client or sender to interact over a network with a server or receiver, the former must know the message syntax that the latter expects. The network message that the sending application creates typically indicates the target operation or service and includes data the receiver expects. If the receiving application were to change its interface so its operations or services changed, sending applications that based their messages on previous interface versions could very well send messages or requests that no longer conformed to the expected syntax.

Arguments abound about whether distributed systems should have explicit interface definitions, with some claiming that explicit definitions result in tight coupling, where dependencies between two or more application components are so great that no component can be maintained or modified without also requiring changes to the others. It's true that wherever tight coupling exists in a deployed application, versioning issues invariably crop up, but explicit interface definitions by themselves are not the primary cause of tight coupling. Such arguments are misguided. Interface versioning issues apply whether the middleware explicitly employs an interface definition language (IDL), as in distributed-object systems like Corba and Microsoft COM, or whether "interfaces" really are represented as exchanged documents, as in many messag-

 1089-7801/04/$20.00 © 2004 IEEE Published by the IEEE Computer Society JANUARY • FEBRUARY 2004

ing systems. Let's look at each of these in turn.

Distributed-Object Versioning

Let's consider modifying an already-deployed Corba interface. If you change one interface operation's name, all applications using that interface must be recompiled with the new interface definition. Otherwise, clients based on the original interface will send the old operation name in their requests, and the server will reject them. Similarly, if you change an operation parameter type definition, then those clients will marshal data for a parameter that doesn't match the data expected by the revised server. The server also will likely reject this request.

Corba assumes that sender and receiver have the same understanding of their marshaled request data; thus, Corba requests contain no type information. This means that some data type changes could find the server accepting malformed requests and attempting operations on the incorrect data they contain. Changing an operation's signature also is problematic because data marshaled by a sender wouldn't match what the receiver is expecting.

These problems imply that if you want to modify a Corba server without affecting clients, you should never modify its operations' names or signatures or its operation parameter types. So, what changes can you make to an interface without adversely affecting existing client applications?

Adding an operation generally is acceptable because Corba operations are identified by name in marshaled requests, unlike other systems in which numbers identify operations (as offsets from the beginning of the interface definition). The IDL compiler guarantees operation name uniqueness because it won't let you overload interface operation names. Thus, clients aware of the new operation can send requests for it, but not knowing about it generally won't break existing clients. Adding an operation can be harmful, however, if the operation introduces state manipulations on which other existing operations have been modified to rely. Changes to implementations of existing operations always must be backward compatible so existing clients can rely on semantics equivalent to those provided by the previous versions.

Other additions are problematic, though. Adding an exception to the list of exceptions that an existing operation can raise is a no-no: it could cause an existing client to receive an unexpected exception. However, removing an exception from the list is okay because existing clients that know about that particular exception never will receive it.

Some practitioners dislike the idea of changing interfaces altogether. For example, if your interface is used locally within an application, such as across the boundary of a shared library or DLL, then adding operations to an interface could break existing code, depending on which programming language is used. In C++, for instance, adding an operation to an object in a shared library or DLL could break an existing application using that library because the addition could change the layout of the object's virtual table. Java binary compatibility is not as tricky or difficult as in C++, mainly because the language specification defines precisely what it means.[1] Even so, changing published interfaces used locally within a single application and as distributed interfaces between applications is inherently difficult.

Because of local–remote transparency problems that can arise from changing distributable interfaces, some practitioners suggest that you should avoid ever modifying an interface once it's been deployed. Instead, you should add operations and types by deriving a new interface from the existing one. You then could declare all the new types and operations in the new derived interface. Changing a Corba object's interface to one that's more derived will not break existing clients because, by definition, the object still supports the original interface.

Using interface inheritance for versioning can work, but only in limited cases. In this case, inheritance uses — or, perhaps more accurately, abuses — a type classification mechanism as a versioning mechanism, and it can get confusing once multiple versions are required. Microsoft COM, which uses virtual tables as a fundamental function-dispatching mechanism, recommends using inheritance for versioning because doing so essentially extends the virtual table with the new operations supplied by the derived class. However, unlike its COM predecessor, Microsoft .NET does not recommend using inheritance in this fashion. Instead, .NET includes explicit versioning support.[2] Specifically, .NET *assemblies* — collections of modules and resources that make up a single unit of deployment — include versioning information in their identifiers, and the .NET runtime ensures that only the correct assembly versions load for each application.

The .NET versioning mechanisms have not yet been widely proven through years of deployment, but given that they're based on lessons learned from COM, they likely will work quite well for versioning real-world applications. Note, though, that while these mechanisms ensure version compatibility within a single application, they do not address the distributed application interface versioning problem. And unlike .NET, Corba supplies no versioning support whatsoever. In general, it's important when developing Corba or .NET distributed systems to know the rules about what changes maintain backward compatibility. Depending on your application, it might make sense to combine Corba with other technologies such as XML[3] to help with versioning, or use an entirely different distributed-object system.[4]

Messaging Versioning

Messaging systems typically do not have, or need, a distributed-object system's interface extensibility. Unlike distributed-object systems in which variation and versioning occurs at the interface and message levels, messaging systems tend to have fixed interfaces with variable messages. The lack of interface variation is the principal reason that messaging systems generally are less-tightly coupled than distributed-object systems. Because the messaging interface doesn't typically change, versioning issues apply only to messages sent through the system. I can't cover all the variations of message types and formats available in message-oriented middleware, so I'll focus on a common popular approach: XML messages.

Proponents often claim that XML makes applications easier to change, but XML-based applications can have just as many versioning issues as any others. XML itself does not provide any explicit versioning support or automatically insulate your application from versioning issues. For example, your sending application can encode an XML message and drop it into a messaging queue, but the receiving application might not be able to decode it. Proponents often have touted XML messages as being self-describing, but that's a myth. If an application does not understand the semantics associated with the XML tags that appear in a message, then it will not understand that message, period. XML tags alone don't let applications determine what unknown messages mean.

The main reason that XML can help with versioning issues is its flexibility. For example, you can make attributes and elements in XML optional, which means that you can add them to an existing definition without automatically breaking all applications using that definition. For example, an XML description of a music CD might include separate elements for artist, album title, and the year the album came out. Adding an optional new element to include the producer's name wouldn't necessarily break existing applications. However, depending on how the applications are designed and implemented, they are not immune to breakage.

One popular approach to handling XML messages in applications is to generate Java or C++ classes based on the message definitions. This is the approach of JSR 31, the Java API for XML Data Binding (JAXB), as well as that of its successor, JSR 222 (JSR 222: Java API for XML Data Binding; www.jcp.org/en/jsr/detail?id=222).

The principal reason for taking this approach is to minimize the impedance mismatch between the XML definitions and the programming language in which the application is written. This impedance mismatch arises because general tools such as the Document Object Model (DOM) or Simple API for XML (SAX) are not language-specific and, thus, do not take advantage of any language's native type system or libraries. Rather than having to read XML messages and parse them using such general tools, the JAXB approach tries to fit more closely into the Java language, thus trading away flexibility for programmer convenience and stronger typing (and presumably fewer programming errors as a result). Unfortunately, this type of mapping eliminates XML's flexibility.

In XML, the convention is to ignore unknown elements, but with programming languages, the norm is to abort if the application doesn't understand something. If the music CD XML definition previously described is mapped into a Java class that gets compiled into one or more applications, and the new element for the album producer is subsequently added to the XML definition, then those Java classes must be regenerated, and each application using them must be recompiled, retested, and redeployed. There is no practical way around this.

If the applications instead use the more general SAX or DOM approaches, then the code to read and manipulate the music CD XML definitions is much longer, more awkward, and potentially slower than that required to deal with the JAXB classes. However, the approach also is more flexible and — if coded properly to ignore unknown optional elements — can easily result in an application being able to silently handle the album-producer element or any other optional element or attribute added to the revised XML definition.

Versioning Approaches

This column barely scratches the surface of the versioning problem. However, the major issues I touched on give a good indication of the state of the middleware versioning problem, which can be summed up as follows: basically, you're on your own. Most middleware does little to nothing to help applications with versioning problems. Even worse, sometimes middleware vendors directly contribute to the problem by failing to properly version their own platforms. As a result, application versioning tends to revolve around conventions and best practices learned along the way. I wish I had better news, but how you deal with versioning depends heavily on each application.

References

1. B. Joy et al., *The Java Language Specification*, 2nd ed., Addison-Wesley, 2000; http://java.sun.com/docs/books/jls/.
2. D. Watkins, M. Hammond, and B. Abrams, *Programming in the .NET Environment*, Addison-Wesley, 2003.
3. D.C. Schmidt and S. Vinoski, "Corba and XML, Part 1: Versioning," *C/C++ Users J.*, vol. 19, no. 5, 2001; www.cuj.com/documents/s=7995/cujcexp1905vinoski/.
4. M. Henning, "A New Approach to Object-Oriented Middleware," *IEEE Internet Computing*, vol. 8, no. 1, 2004, pp. 66–75.

Steve Vinoski is chief engineer of product innovation for IONA Technologies. He's been involved in middleware for 15 years. Vinoski is the coauthor of *Advanced Corba Programming with C++* (Addison Wesley Longman, 1999), and he has helped develop middleware standards for the OMG and W3C.