STRATEGY FOR DYNAMICALLY MODELING ASN.1 DATA TO AN OBJECT MODEL

BACKGROUND OF THE INVENTION

1. Technical Field:

The present invention relates in general to computer software development. More specifically, the present invention relates to methods for dynamically mapping ASN.1 encoded data to an object model to generate an ASN.1 data structure.

2. Description of Related Art:

Abstract Syntax Notation 1 (ASN.1) is an international standard that defines abstract data and message formats for inter-operability. Though initially used for describing email messages within the Open Systems Interconnection environment, ASN.1 has since then been adopted by a wide range of other applications, as in network management, security, mobile (cellular) telephony, air traffic control, and voice and video over the Internet. Examples include X.509 certificates, Public Key Cryptography Standard, Kerberos, Generic Security Service API, and Certificate Management Protocol.

An ASN.1 data type is built up from primitive data types (i.e. INTEGER, REAL, BOOLEAN, and NULL) using three main construction mechanisms: repetition (SEQUENCE OF and SET OF), alternatives (CHOICE), and lists of fields (SEQUENCE and SET). Once an ASN.1 data type has been

defined, it can be used in the definition of other ASN.1 data types exactly as if it were a primitive data type. Such data types can be defined before use or after (forward references). Such a recursively-defined data structure could grow to be very complicated, especially with the requirement of the encoding ASN.1 descriptions into Distinguished Encoding Rules (DER) encoding byte arrays, and decoding them. DER is a standard encoding rule used to encode the structure of ASN.1 data to be transferred between the Application Layer and the Presentation Layer of the Open Systems Interconnection (OSI). It provides a means whereby the Presentation Layer can reliably exchange any arbitrary data structure with other computer systems, while the Application Layer can map the encoded data into any type of representation or language that is appropriate for the end user.

Today, object-oriented design and programming has been adopted by more and more enterprises because of its many advantages, such as reusability and ease of maintenance. Java, is one example of an object-oriented, platform-independent, and secure language that has transformed from emerging technology to become one of the dominant languages for successful and secure e-business applications.

Therefore, it would be desirable to have a tool that can map ASN.1 encoded data to an object model and translate ASN.1 encoded data to native Java source code, in order to help enterprises efficiently develop or migrate to object-oriented, cross-platform applications.

SUMMARY OF THE INVENTION

The present invention provides a method, program and system for mapping ASN.1 data to an object model. The invention consists of identifying the start of a data stream and then generating a new object name for the data. Next, the data is parsed to get the identifier and the data length. Then the data's tag type is analyzed. If the tag type is simple, a class diagram is generated for the data and then the source code for the data is generated. If the tag type is not simple, a subroutine is called to further parse the data before generating the class diagram and source code.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objectives and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

Figure 1 depicts a pictorial representation of a network of data processing systems in which the present invention may be implemented;

Figure 2 depicts a block diagram of a data processing system that may be implemented as a server, in accordance with a preferred embodiment of the present invention; and

Figure 3 depicts a block diagram illustrating a data processing system in which the present invention may be implemented;

Figure 4 depicts object diagrams generated from the ASN.1 data types in accordance with the present invention;

Figure 5 depicts a flowchart illustrating a routine to analyze data streams and create classes and ASN.1 data types in accordance with the present invention.;

Figure 6 depicts a flowchart illustrating a subroutine for parsing data in accordance with the present invention;

Figure 7 depicts an output class diagram in accordance with the present invention.

Figure 8 depicts an object diagram illustrating a

parsing routine's execution order in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference now to the figures, **Figure 1** depicts a pictorial representation of a network of data processing systems in which the present invention may be implemented. Network data processing system **100** is a network of computers in which the present invention may be implemented. Network data processing system **100** contains a network **102**, which is the medium used to provide communications links between various devices and computers connected together within network data processing system **100**. Network **102** may include connections, such as wire, wireless communication links, or fiber optic cables.

In the depicted example, a server **104** is connected to network **102** along with storage unit **106**. In addition, clients **108**, **110**, and **112** also are connected to network **102**. These clients **108**, **110**, and **112** may be, for example, personal computers or network computers. In the depicted example, server **104** provides data, such as boot files, operating system images, and applications to clients **108-112**. Clients **108**, **110**, and **112** are clients to server **104**. Network data processing system **100** may include additional servers, clients, and other devices not shown.

In the depicted example, network data processing system **100** is the Internet with network **102** representing a worldwide collection of networks and gateways that use the TCP/IP suite of protocols to communicate with one another. At the heart of the Internet is a backbone of high-speed data communication lines between major nodes or host computers, consisting of thousands of commercial,

government, educational and other computer systems that route data and messages. Of course, network data processing system **100** also may be implemented as a number of different types of networks, such as for example, an intranet, a local area network (LAN), or a wide area network (WAN). **Figure 1** is intended as an example, and not as an architectural limitation for the present invention.

Referring to **Figure 2**, a block diagram of a data processing system that may be implemented as a server, such as server **104** in **Figure 1**, is depicted in accordance with a preferred embodiment of the present invention. Data processing system **200** may be a symmetric multiprocessor (SMP) system including a plurality of processors **202** and **204** connected to system bus **206**. Alternatively, a single processor system may be employed. Also connected to system bus **206** is memory controller/cache **208**, which provides an interface to local memory **209**. I/O bus bridge **210** is connected to system bus **206** and provides an interface to I/O bus **212**. Memory controller/cache **208** and I/O bus bridge **210** may be integrated as depicted.

Peripheral component interconnect (PCI) bus bridge **214** connected to I/O bus **212** provides an interface to PCI local bus **216**. A number of modems may be connected to PCI bus **216**. Typical PCI bus implementations will support four PCI expansion slots or add-in connectors. Communications links to network computers **108-112** in **Figure 1** may be provided through modem **218** and network adapter **220** connected to PCI local bus **216** through add-in boards.

Additional PCI bus bridges **222** and **224** provide

interfaces for additional PCI buses **226** and **228**, from which additional modems or network adapters may be supported. In this manner, data processing system **200** allows connections to multiple network computers. A memory-mapped graphics adapter **230** and hard disk **232** may also be connected to I/O bus **212** as depicted, either directly or indirectly.

Those of ordinary skill in the art will appreciate that the hardware depicted in **Figure 2** may vary. For example, other peripheral devices, such as optical disk drives and the like, also may be used in addition to or in place of the hardware depicted. The depicted example is not meant to imply architectural limitations with respect to the present invention.

The data processing system depicted in **Figure 2** may be, for example, an IBM RISC/System 6000 system, a product of International Business Machines Corporation in Armonk, New York, running the Advanced Interactive Executive (AIX) operating system.

With reference now to **Figure 3**, a block diagram illustrating a data processing system is depicted in which the present invention may be implemented. Data processing system **300** is an example of a client computer. Data processing system **300** employs a peripheral component interconnect (PCI) local bus architecture. Although the depicted example employs a PCI bus, other bus architectures such as Accelerated Graphics Port (AGP) and Industry Standard Architecture (ISA) may be used. Processor **302** and main memory **304** are connected to PCI local bus **306** through PCI bridge **308**. PCI bridge **308** also may include an integrated memory controller and cache

memory for processor **302**. Additional connections to PCI local bus **306** may be made through direct component interconnection or through add-in boards. In the depicted example, local area network (LAN) adapter **310**, SCSI host bus adapter **312**, and expansion bus interface **314** are connected to PCI local bus **306** by direct component connection. In contrast, audio adapter **316**, graphics adapter **318**, and audio/video adapter **319** are connected to PCI local bus **306** by add-in boards inserted into expansion slots. Expansion bus interface **314** provides a connection for a keyboard and mouse adapter **320**, modem **322**, and additional memory **324**. Small computer system interface (SCSI) host bus adapter **312** provides a connection for hard disk drive **326**, tape drive **328**, and CD-ROM drive **330**. Typical PCI local bus implementations will support three or four PCI expansion slots or add-in connectors.

An operating system runs on processor **302** and is used to coordinate and provide control of various components within data processing system **300** in **Figure 3**. The operating system may be a commercially available operating system, such as Windows 2000, which is available from Microsoft Corporation. An object oriented programming system such as Java may run in conjunction with the operating system and provide calls to the operating system from Java programs or applications executing on data processing system **300**. "Java" is a trademark of Sun Microsystems, Inc. Instructions for the operating system, the object-oriented operating system, and applications or programs are located on storage devices, such as hard disk drive **326**, and may be loaded into main memory **304** for execution by processor **302**.

Those of ordinary skill in the art will appreciate that the hardware in **Figure 3** may vary depending on the implementation. Other internal hardware or peripheral devices, such as flash ROM (or equivalent nonvolatile memory) or optical disk drives and the like, may be used in addition to or in place of the hardware depicted in **Figure 3**. Also, the processes of the present invention may be applied to a multiprocessor data processing system.

As another example, data processing system **300** may be a stand-alone system configured to be bootable without relying on some type of network communication interface, whether or not data processing system **300** comprises some type of network communication interface. As a further example, data processing system **300** may be a Personal Digital Assistant (PDA) device, which is configured with ROM and/or flash ROM in order to provide non-volatile memory for storing operating system files and/or user-generated data.

The depicted example in **Figure 3** and above-described examples are not meant to imply architectural limitations. For example, data processing system **300** also may be a notebook computer or hand held computer in addition to taking the form of a PDA. Data processing system **300** also may be a kiosk or a Web appliance.

The present invention translates ASN.1 data to an object model, then generates the source code, displaying each attribute value in a graphical user interface (GUI). The ASN.1 data can be a piece of encoded data, a binary file, a text file written with ASN.1 notation, or just the ASN.1 notations which are entered from an input

device. A GUI can be implemented in JavaBean and packaged in a Java Archive (JAR) file that runs in Beanbox or can plug into Java development environments, such as Visual Cafe.

An example of input data is illustrated in **Table 1**, which contains a piece of a binary encoding data stream displayed in hexdecimal format.

Table 1

```
00000000: 3081CD02  01010201  003081C5  302D0201
00000010: 01041841  5A4E5F50  45524D49  4E464F5F
00000020: 41554449  544C4556  454C0030  0E300C02
00000030: 01010201  02040400  00000030  2B020101
00000040: 0416415A  4E5F5045  524D494E  474F5F51
00000050: 4F505F55  494E5400  300E300C  02010102
00000060: 01020404  00000000  302E0201  01041941
00000070: 5A4E5F55  45524D49  4E464F5F  5741524E
00000080: 494E474D  4F444500  300E300C  02010102
00000090: 01020404  00000000  30370201  01042241
000000A0: 5A4E5F50  45524D49  4E464F5F  5741524E
000000B0: 494E474D  4F444550  45524D49  54544544
000000C0: 00300E30  0C020101  02010204  04000000
```

The ASN.1 data types generated from the data stream shown in **Table 1** are shown below:

```
ClassA ::= Sequence {
            attribute1 INTEGER,
            attribute2 INTEGER,
            attribute3 OCTETSTRING
}
ClassB ::= SEQUENCEOF {
```

```
            attribute1 ClassA
}
ClassC ::= SEQUENCE {
            attribute1 INTEGER,
            attribute2 OCTETSTRING,
            attribute3 ClassB
}
ClassD ::= SEQUENCEOF {
            ClassC
}
ClassE ::= SEQUENCE {
            attribute1 INTEGER,
            attribute2 INTEGER,
            attribute3 ClassD
}
```

Referring now to **Figure 4**, object diagrams generated from the ASN.1 data types illustrated above are depicted in accordance with the present invention. The object diagrams in **Figure 4** follow the new Object Modeling Technique (OMT) notation. A diamond link represents an aggregation relationship, in which a class is composed of multiple classes. The object model is displayed with a square box representing a class object. The name of the class, attributes and methods are listed in the box, and the relationships of classes are indicated with links. Each class has a property sheet, and for binary input, this sheet lists the value of each object in it.

Referring to **Figure 5**, a flowchart illustrating a routine to analyze data streams and create classes and ASN.1 data types is depicted in accordance with the present invention. DER data is used as an example.

However, this procedure is suitable for a Basic Encoding Rules (BER) data stream too. BER or DER encoding data has three parts: identifier octets, which identify ASN.1 value tag type; length octets, which give the number of bytes as data content; and content octets, which are the real data.

The routine begins by using DER rules to identify the start of encoding data (step **501**). Encoding data starts from identifier octets. Usually it is at the start of the input byte stream or binary file, but it does not have to be. Next, a new object name is generated, which usually is a class name (step **502**). The object name could be a general name such as "ClassA" or "ObjectA" for convenient naming. The routine then parses one or more bytes of data to get the identifier (step **503**). At this point, anywhere from one up to 127 bytes of data are parsed to get the data length (step **504**). The BER rules are followed to parse data in steps **503** and **504**.

Having obtained the identifier and data length, the next step is to identify what kind of tag type the data has (step **505**). If the tag type is simple, a class diagram and ASN.1 notation are generated (step **507**). Simple data are tagged with simple encoding types such as INTEGER, GENERAL STRING, OCTET STRING, etc. In this case, the class is constructed by extending the superclass that the encoding type corresponds to. For example, INTEGER corresponds to java.lang.Integer class in the Java 2 standard edition API. GENERAL STRING corresponds to java.lang.String class, OCTET STRING corresponds to java.lang.Byte class. An example of an output class diagram is illustrated in **Figure 7**, and the

ASN.1 notation is: ClassA ::= GeneralString. The final step is to generate the source code of the data (**step 508**).

If the tag type is not simple, a subroutine is called to parse data content (step **506**).

Referring now to **Figure 6**, a flowchart illustrating a subroutine for parsing data is depicted in accordance with the present invention. Step **601** to "get identifier" and step **602** to "get data length" are the same as described in reference to **Figure 5**. The next step is to analyze the tag type (step **603**).

If the tag type is simple, the subroutine then determines if the call is from main routine (step **608**). If the call is from the main routine, the tag number is recorded for further reference (classes with same tag number are the same classes), and the class is simply return to main routine (step **611**). If the call is not from the main routine, a new attribute name is created, the data value is recorded, and the attribute is associated with its class (step **609**). For convenience, the attribute could be named "attributeA". If the end of the data has been reached, it is returned to the main routine (step **611**). If the end of the data has not been reached, the subroutine returns to step **601**.

If the tag analyzed in step **603** is structured, a new class name is generated (step **607**), and the subroutine returns to step **601** so that it can further parse the data content within the structured type. The subroutine could be recursively called in order to parse all the data contents which is within a structured type, which is within a structured type, etc. Structured types consist

of components. Examples of structured types are SEQUENCE, SEQUENCE OF, etc. SEQUENCE consists of one or more different types. SEQUENCE OF consists of one or more of a given type.

If the tag type analyzed in step **603** is explicit, it will go through "get identifier" (step **604**) and "get data length" (step **605**), similar to steps **601** and **602**. Explicitly tagged type is derived from a simple type or structured type by putting a tag on the underlying type. Therefore, the explicitly tagged type is analyzed to determine the underlying tag type (step **606**).

If the underlying tag type is structured, a new class name is generated (step **607**) and the subroutine is called again to parse data content within this structured type (return to step **601**). If the underlying tag type is simple, a new attribute name is generated following the convenient naming (step **610**).

If the end of encoding data has been reached, the created classes are returned to the main routine (step **611**). If the end of the encoding data has not been reached, the process returns to the start of the subroutine (step **601**) to further parse the rest of the data.

For text input, a string parser and syntax checker are associated underneath. They perform recursive checking on the data structure. For binary input, a byte analyzer is associated underneath, which analyzes the bytes and identifies class, tag number, data length, and contents in the byte stream.

Referring to **Figure 8**, an object diagram illustrating a parsing routine's execution order is

depicted in accordance with the present invention. This chart is an example showing how a class diagram is generated from an encoding data stream.

The sequence of creating classes while parsing data is as follows:

a. Start creation of **CLASS** (the class name is created);

b. Start creation of **component class 1** (class name is created);

c. Start and complete construction of **subcomponent class 1** (created class name, identify attributes and associated values, record the tag number if it is explicitly tagged type);

d. Start and complete construction of **subcomponent class 2** (created class name, identify attributes and their associated values, record the tag number if it is explicitly tagged type); and

e. Complete construction of **component class 1.** (Identify the construction mechanism of **component class 1.** If **subcomponent classes 1** and **2** are identical, construction mechanism is repetition. **Component class 1** has two attributes with types as "subcomponent class 1" and "subcomponent class 2". Identify attributes and their associated values, record the tag number if it is explicitly tagged type).

Component class 2 and **component class 3** follow the similar procedure as **component class 1.** Finally the construction of **CLASS** is completed, since all of its attributes are identified.

A source code engine is responsible for generating

the "skeletal" structure of Java classes in Java source code. Appropriate encoding/decoding routines are incorporated into Java code to provide a functional class. These routines make calls to a utility that contains methods for primary data types' encoding and decoding. The utility library is developed by Java Security group as part of Java Public Key Cryptography Standard product package.

ASN.1 and DER encoding are inherently complex operations. Some toolkits exist to supply basic DER classes, but they still require developers to model their ASN.1 definition and determine how to call the DER encoding/decoding routines. No tool currently exists to help developers and architects easily model ASN.1 definitions in an object oriented fashion. The present invention provides this critical function and thus allows developers and architects to focus on the problem they are trying to solve, rather than the mechanics.

The present invention decreases the time and expense associated with analysis, implementing, and testing code in a heterogeneous environment, allowing software developers to focus more on business model and architecture development. The present invention also helps developers and architects analyze the data models in current architectures and enhance the design based on the object representation. Another advantage is to help testers and network administrators analyze the data transferred on the network by dynamically building object models based on the data input stream and displaying it in a graphical user interface.

It is important to note that while the present invention has been described in the context of a fully

functioning data processing system, those of ordinary skill in the art will appreciate that the processes of the present invention are capable of being distributed in the form of a computer readable medium of instructions and a variety of forms and that the present invention applies equally regardless of the particular type of signal bearing media actually used to carry out the distribution. Examples of computer readable media include recordable-type media, such as a floppy disk, a hard disk drive, a RAM, CD-ROMs, DVD-ROMs, and transmission-type media, such as digital and analog communications links, wired or wireless communications links using transmission forms, such as, for example, radio frequency and light wave transmissions. The computer readable media may take the form of coded formats that are decoded for actual use in a particular data processing system.

The description of the present invention has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. The embodiment was chosen and described in order to best explain the principles of the invention, the practical application, and to enable others of ordinary skill in the art to understand the invention for various embodiments with various modifications as are suited to the particular use contemplated.

CLAIMS:

What is claimed is:

1. A method for mapping ASN.1 data to an object model, comprising:

identifying objects in ASN.1 data;

identifying attributes of the objects;

identifying the relationships between objects; and

generating an object model.

2. The method according to claim 1, further comprising:

identifying the start of a data stream;

generating a new object name for the data;

parsing the data to get the data identifier;

parsing the data to get the data length;

analyzing the tag type of the data;

generating a class diagram for the data if the tag type is simple; and

generating source code for the data.

3. The method according to claim 2, further comprising performing a subroutine to further parse the data content if the tag type is not simple.

4. The method according to claim 3, wherein the parsing subroutine comprises:

parsing the data content to get the identifier;

parsing the data content to get the data length; and

analyzing the tag type.

5. The method according to claim 4, further comprising:

if the tag type is simple, determining if the call

* C L M S *

to the subroutine is from the main routine;

if the call is from the main routine, recording the data tag number for further reference and returning the data to the main routine; and

if the call is not from the main routine, generating an attribute name for the data and returning the data to the main routine if the end of the data has been reached.

6. The method according to claim 5, further comprising recalling the parsing subroutine if the end of the data has not been reached.

7. The method according to claim 4, further comprising:

if the tag type is structured, generating a new class name for the data; and

recalling the parsing subroutine.

8. The method according to claim 4, further comprising:

if the tag type is explicit, further parsing the data content to get the data identifier and data length; and

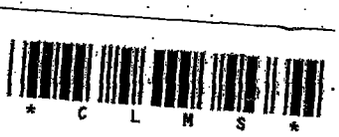
analyzing the explicit tag type to determine the underlying tag type.

9. The method according to claim 8, further comprising:

if the underlying tag type is simple, generating an attribute name for the data; and

returning the data to a main routine if the end of the data has been reached.

10. The method according to claim 9, further comprising recalling the parsing subroutine if the end of the data



has not been reached.

11. The method according to claim 8, further comprising:

if the underlying tag type is structured, generating a new class name for the data; and

recalling the parsing subroutine.

12. A computer program product in a computer readable medium for use in a data processing system, for mapping ASN.1 data to an object model, the computer program product comprising:

instructions for identifying objects in ASN.1 data;

instructions for identifying attributes of the objects;

instructions for identifying the relationships between objects; and

instructions for generating an object model.

13. The computer program product according to claim 12, further comprising:

instructions for identifying the start of a data stream;

instructions for generating a new object name for the data;

instructions for parsing the data to get the data identifier;

instructions for parsing the data to get the data length;

instructions for analyzing the tag type of the data;

instructions for generating a class diagram for the data if the tag type is simple; and

instructions for generating source code for the

* C L M S *

data.

14. The computer program product according to claim 13, further comprising a subroutine for further parsing the data content if the tag type is not simple.

15. The computer program product according to claim 14, wherein the parsing subroutine comprises:

instructions for parsing the data content to get the identifier;

instructions for parsing the data content to get the data length; and

instructions for analyzing the tag type.

16. The computer program product according to claim 15, further comprising:

if the tag type is simple, instructions for determining if the call to the subroutine is from the main routine;

if the call is from the main routine, instructions for recording the data tag number for further reference and returning the data to the main routine; and

if the call is not from the main routine, instructions for generating an attribute name for the data and returning the data to the main routine if the end of the data has been reached.

17. The computer program product according to claim 16, further comprising instructions for recalling the parsing subroutine if the end of the data has not been reached.

18. The computer program product according to claim 15,

* C L M S *

further comprising:

if the tag type is structured, instructions for generating a new class name for the data; and

instructions for recalling the parsing subroutine.

19. The computer program product according to claim 15, further comprising:

if the tag type is explicit, instructions for further parsing the data content to get the data identifier and data length; and

instructions for analyzing the explicit tag type to determine the underlying tag type.

20. The computer program product according to claim 19, further comprising:

if the underlying tag type is simple, instructions for generating an attribute name for the data; and

instructions for returning the data to a main routine if the end of the data has been reached.

21. The computer program product according to claim 20, further comprising instructions for recalling the parsing subroutine if the end of the data has not been reached.

22. The computer program product according to claim 19, further comprising:

if the underlying tag type is structured, instructions for generating a new class name for the data; and

instructions for recalling the parsing subroutine.

23. A system for mapping ASN.1 data to an object model,

comprising:

means for identifying objects in ASN.1 data;

means for identifying attributes of the objects;

means for identifying the relationships between objects; and

means for generating an object model.

