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(54) SYSTEM AND METHOD FOR PROVIDING DATA MANIPULATION AS A WEB SERVICE

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(52) **U.S. Cl.** **715/505**

(57) **ABSTRACT**

A method of transforming data includes receiving information defining a transformation of an input data object to an output data object and generating, based on the received information, a script operable when executed to implement the defined transformation. The script is then stored. The method also includes receiving a service request from a remote client that requests a particular transformation and identifies a request data object and identifying a script that performs the requested transformation. Additionally, the method includes generating a response data object by executing the identified script on the request data object and transmitting the response data object to the remote client.

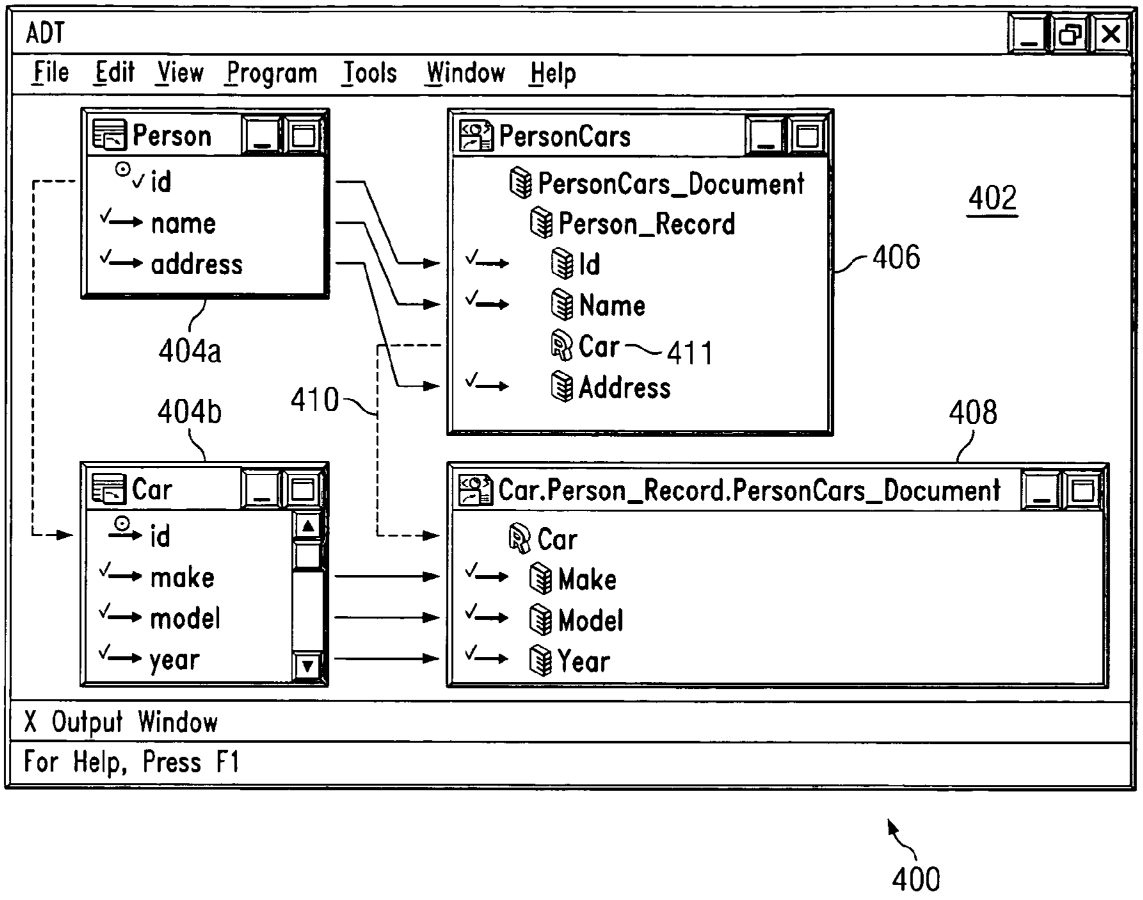


FIG. 1

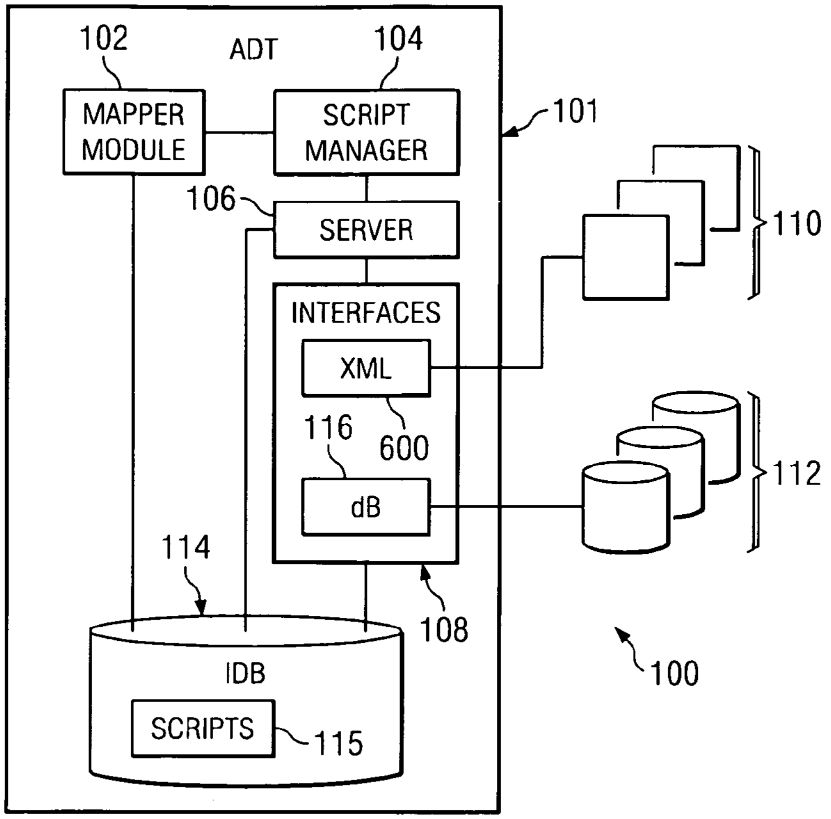
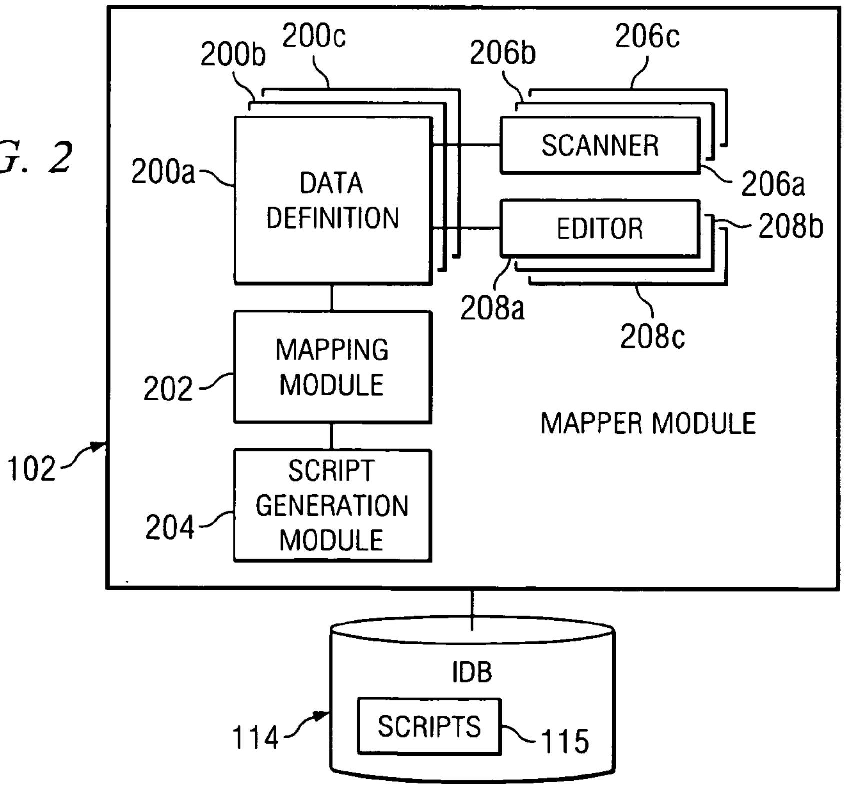
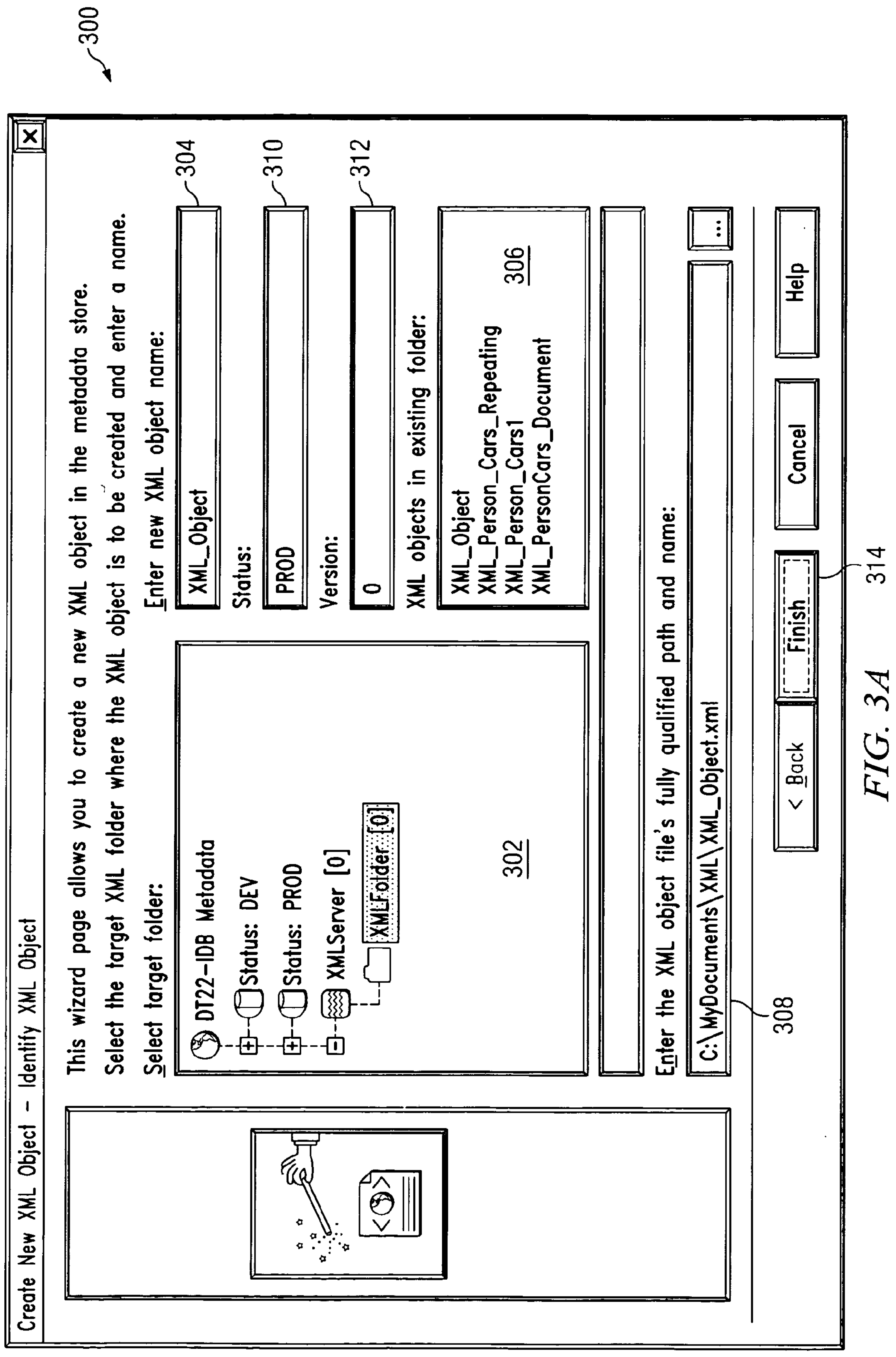

ADT
102
104
MAPPER MODULE
SCRIPT MANAGER
101
106
SERVER
110
INTERFACES
XML
116
600
dB
112
114
108
IDB
SCRIPTS
115
100

FIG. 2


200b
200c
206b
206c
200a
DATA DEFINITION
SCANNER
206a
EDITOR
208b
208a
208c
MAPPING MODULE
202
MAPPER MODULE
102
SCRIPT GENERATION MODULE
204
IDB
SCRIPTS
114
115



Create New XML Object – Identify XML Object

This wizard page allows you to create a new XML object in the metadata store.

Select the target XML folder where the XML object is to be created and enter a name.

Select target folder:

- DT22-IDB Metadata
  - Status: DEV
  - Status: PROD
  - XMLServer [0]
    - XMLFolder [0]

Enter new XML object name: XML_Object

Status: PROD

Version: 0

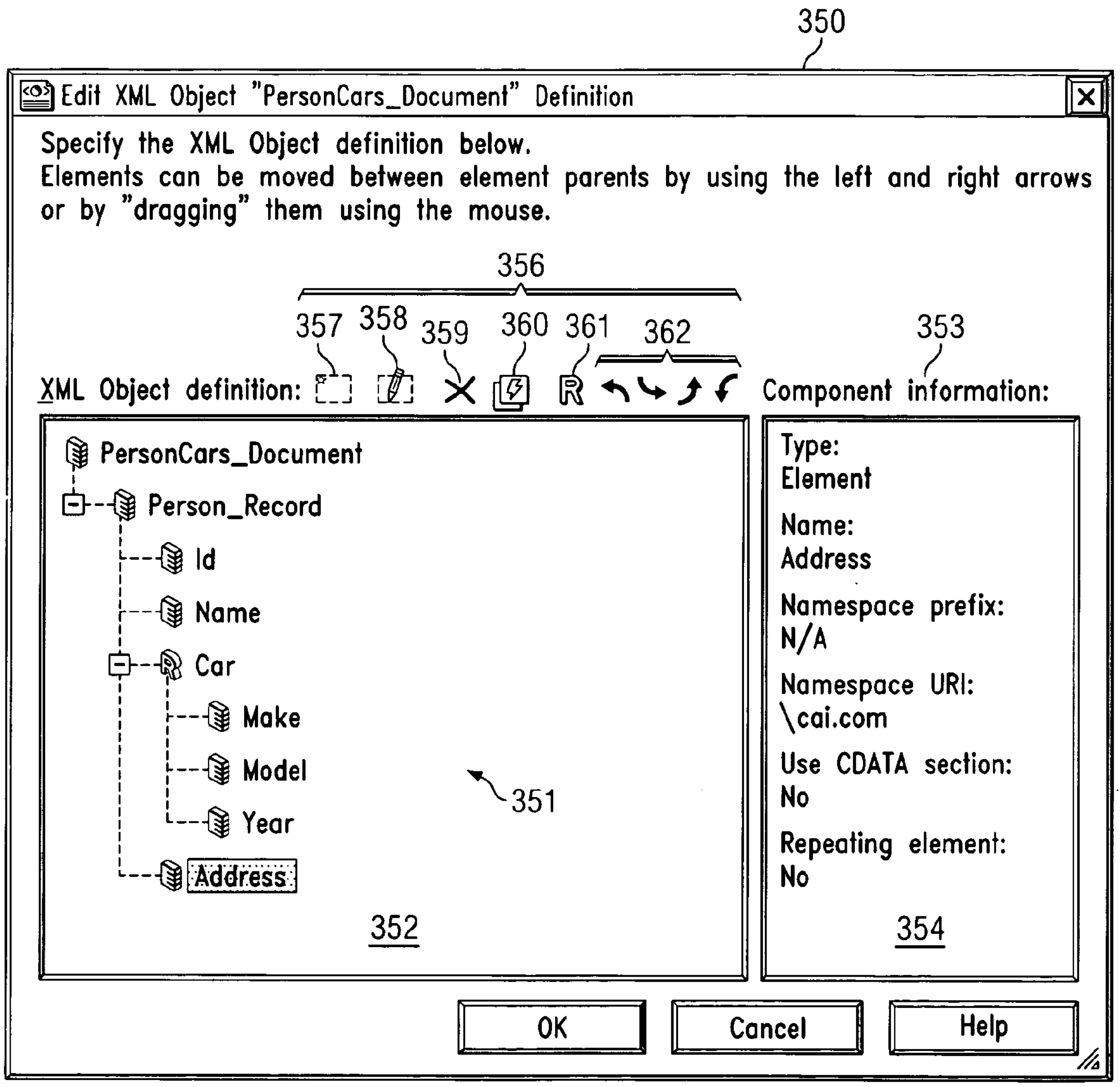
XML objects in existing folder:

XML_Object
XML_Person_Cars_Repeating
XML_Person_Cars1
XML_PersonCars_Document

Enter the XML object file's fully qualified path and name:

C:\MyDocuments\XML\XML_Object.xml

FIG. 3A



Specify the XML Object definition below.
Elements can be moved between element parents by using the left and right arrows or by "dragging" them using the mouse.

Type:
Element
Name:
Address
Namespace prefix:
N/A
Namespace URI:
\cai.com
Use CDATA section:
No
Repeating element:
No

FIG. 3B

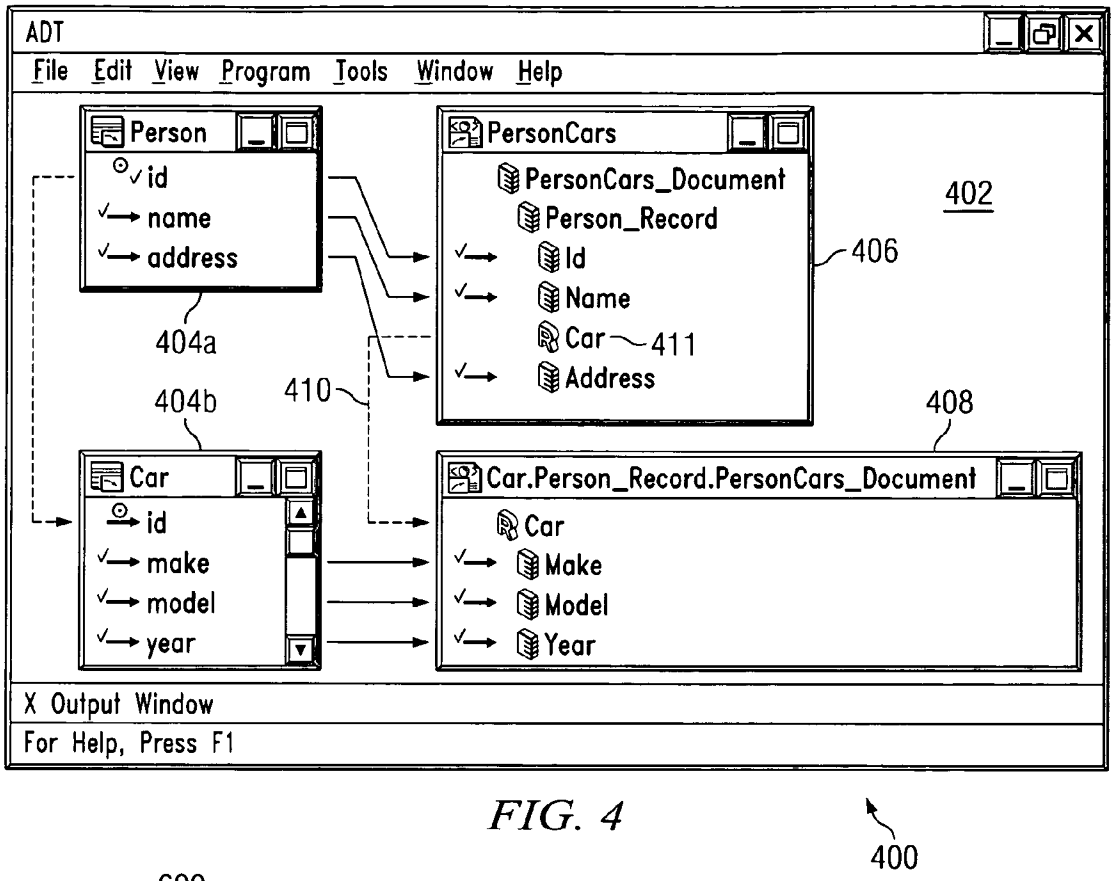

ADT
File Edit View Program Tools Window Help
Person
id
name
address
PersonCars
PersonCars_Document
Person_Record
Id
Name
Car
411
Address
402
406
404a
404b
410
408
Car
id
make
model
year
Car.Person_Record.PersonCars_Document
Car
Make
Model
Year
X Output Window
For Help, Press F1
400

FIG. 4

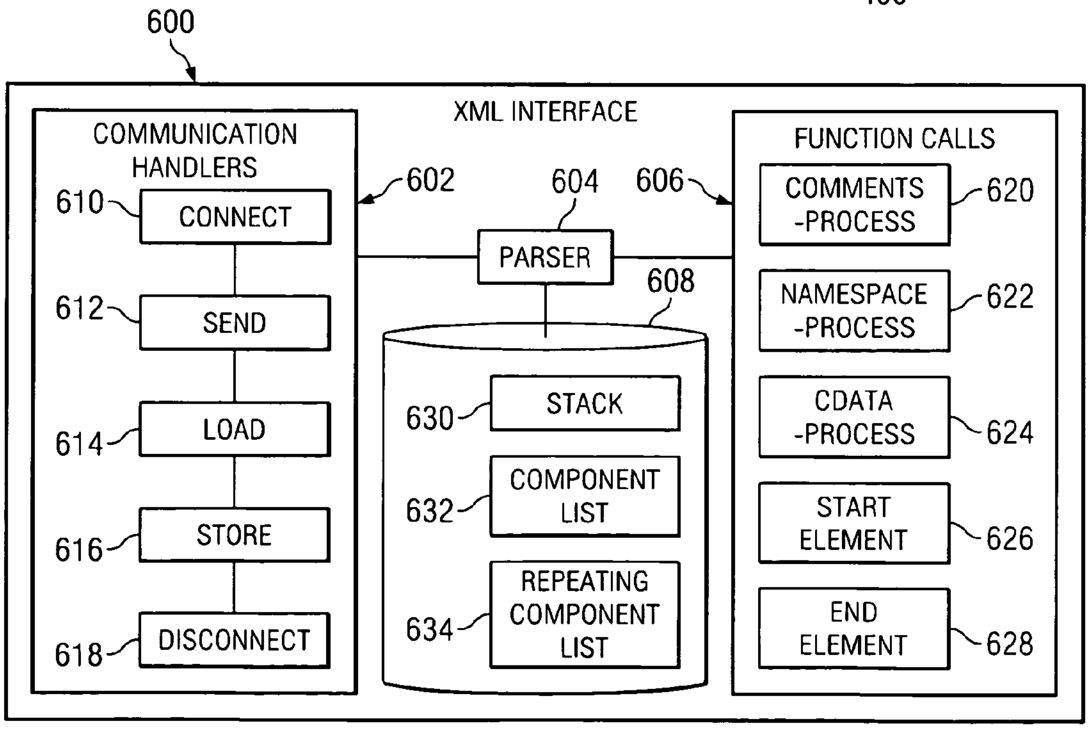

600
XML INTERFACE
COMMUNICATION HANDLERS
610
CONNECT
612
SEND
614
LOAD
616
STORE
618
DISCONNECT
602
604
PARSER
606
608
630
STACK
632
COMPONENT LIST
634
REPEATING COMPONENT LIST
FUNCTION CALLS
COMMENTS -PROCESS
620
NAMESPACE -PROCESS
622
CDATA -PROCESS
624
START ELEMENT
626
END ELEMENT
628

FIG. 6

FIG. 5A

500

```
REM * Structure definitions
DEF Person AS PersonDef
DEF Car AS CarDef
DIM PersonCars_Document(10) AS xmlComponentDef
ARRAYCLEAR(PersonCars_Document)
   PersonCars_Document(0).comp_name = "PersonCars_Document"
   PersonCars_Document(0).comp_type = 1
   PersonCars_Document(0).comp_id = 0
   PersonCars_Document(0).comp_parent = 0
   PersonCars_Document(0).comp_level = 0
   PersonCars_Document(1).comp_name = "Person_Record"
   PersonCars_Document(1).comp_type = 1
   PersonCars_Document(1).comp_id = 1
   PersonCars_Document(1).comp_parent = 0
   PersonCars_Document(1).comp_level = 1
   PersonCars_Document(2).comp_name = "Id"
   PersonCars_Document(2).comp_type = 1
   PersonCars_Document(2).comp_id = 2
   PersonCars_Document(2).comp_parent = 1
   PersonCars_Document(2).comp_level = 2
   PersonCars_Document(3).comp_name = "Name"
   PersonCars_Document(3).comp_type = 1
   PersonCars_Document(3).comp_id = 3
   PersonCars_Document(3).comp_parent = 1
   PersonCars_Document(3).comp_level=2
   PersonCars_Document(4).comp_name="Car"
   PersonCars_Document(4).comp_type=1
   PersonCars_Document(4).comp_id=4
   PersonCars_Document(4).comp_parent=1
   PersonCars_Document(4).comp_IsRepeating=TRUE
   PersonCars_Document(4).comp_level=2
   PersonCars_Document(5).comp_name="Make"
   PersonCars_Document(5).comp_type=1
   PersonCars_Document(5).comp_id=5
   PersonCars_Document(5).comp_parent=4
   PersonCars_Document(5).comp_level=3
   PersonCars_Document(6).comp_name="Model"
   PersonCars_Document(6).comp_type=1
   PersonCars_Document(6).comp_id=6
   PersonCars_Document(6).comp_parent=4
   PersonCars_Document(6).comp_level=3
   PersonCars_Document(7).comp_name="Year"
   PersonCars_Document(7).comp_type=1
   PersonCars_Document(7).comp_id=7
   PersonCars_Document(7).comp_parent=4
   PersonCars_Document(7).comp_level=3
   PersonCars_Document(8).comp_name="Address"
   PersonCars_Document(8).comp_type=1
   PersonCars_Document(8).comp_id=8
   PersonCars_Document(8).comp_parent=1
   PersonCars_Document(8).comp_level=2
```

502

TO FIG. 5B

500

FIG. 5B

FROM FIG. 5A

```
REM * End of structure definitions
*
*
*

REM *
REM * Connect to data sources and targets
REM *
CONNECT PersonProfile ()                          ]
CONNECT CarProfile ()                             } 509
CONNECT PersonCars_DocumentProfile ()             ]
Person_Done = FALSE
REM * Request/query the result set to transfer
PersonQuery = "SELECT P.id, P.name, P.address FROM JohnsTestDatabase.dbo.Person" +
"P"
SEND PersonProfile (#sql PersonQuery) 510
DO WHILE FALSE = Person_Done
   returnValue = LOAD PersonProfile (#data Person) 512
   IF _IPRET_SUCCESS <> returnValue THEN
     Person_Done = TRUE
     IF _IPRET_NO_DATA_AVAIL = returnValue THEN
       IF 0 = PersonCount THEN
         MESSAGE("No rows read")
       ELSE
           MESSAGE(PersonCount, "total rows read from Person")
       END IF
       STRUCTCLEAR(Person)
       REM * DO NOT PROCESS THE LAST (NULL) RECORD
       CONTINUE
     ELSE
       MESSAGE("LOAD returned", returnValue, "at line", ERL())
       CONTINUE
     END IF
   ELSE
     PersonCount = PersonCount + 1
   END IF
   Car_Done = FALSE
REM * Request/query the result set to transfer
   CarQuery = "SELECT C.make, C.model, C.year FROM JohnsTestDatabase.dbo.Car" +
"C WHERE" + TOSTRING(Person.id) + "= C.id"
   SEND CarProfile (#sql CarQuery) 510
   DO WHILE FALSE = Car_Done
     returnValue = LOAD CarProfile (#data Car) 512
     IF _IPRET_SUCCESS <> returnValue THEN
       Car_Done = TRUE
       IF _IPRET_NO_DATA_AVAIL = returnValue THEN
```

504

TO FIG. 5C

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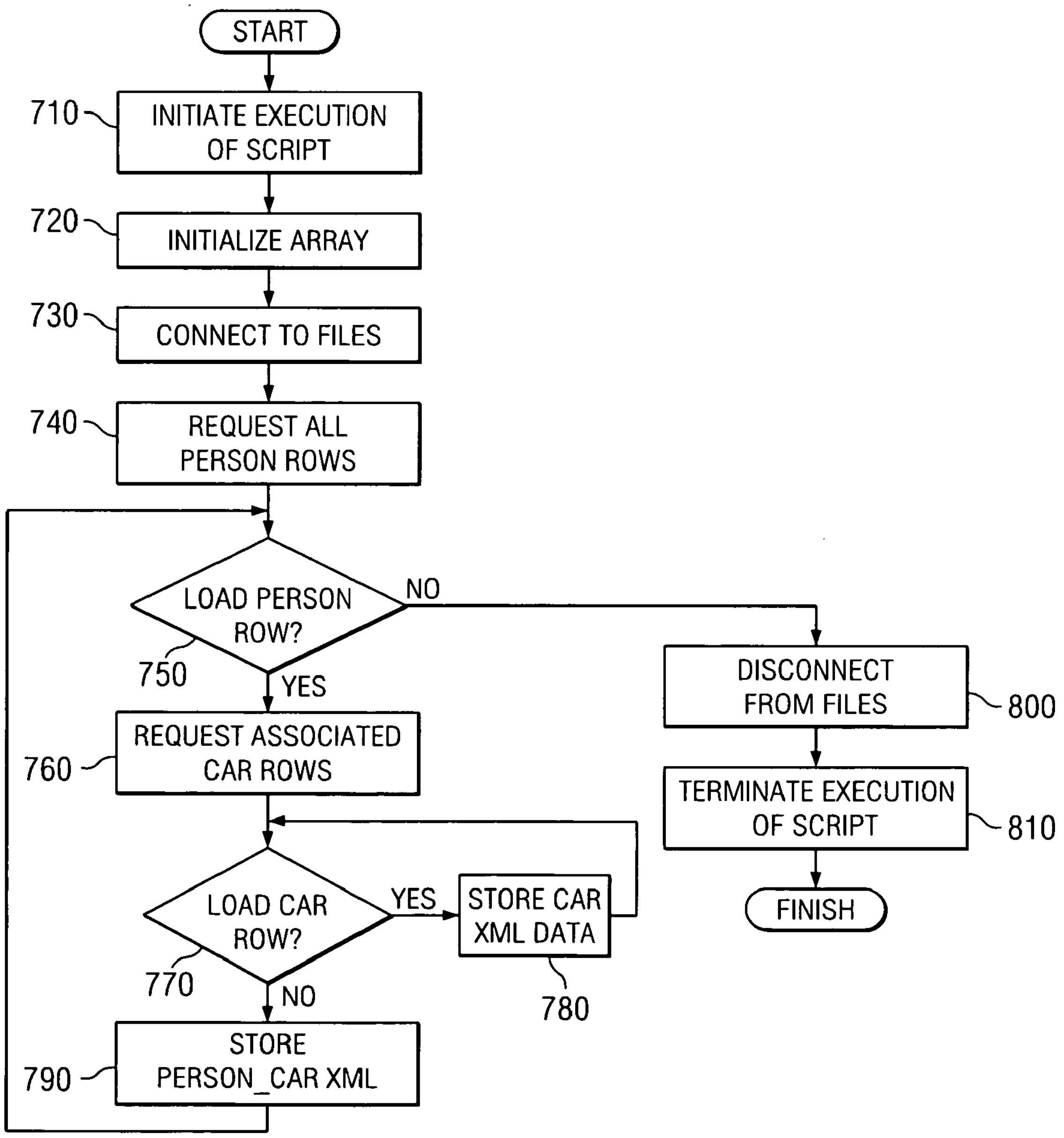
FIG. 5C

FROM FIG. 5B

```
          IF 0 = CarCount THEN
              MESSAGE("No rows read")
            ELSE
                MESSAGE(CarCount, "total rows read from Car")
          END IF
          STRUCTCLEAR(Car)
          REM * DO NOT PROCESS THE LAST (NULL) RECORD
          CONTINUE
        ELSE
          MESSAGE("LOAD returned", returnValue, "at line", ERL())
          CONTINUE
          END IF
      ELSE
          CarCount = CarCount + 1
      END IF

      PersonCars_Document(5).comp_value = Car.make
      PersonCars_Document(6).comp_value = Car.model
      CONVERT(Car.year, PersonCars_Document(7).comp_value)

      returnValue = STORE PersonCars_DocumentProfile (#data PersonCars_Document,
                                                     #create TRUE,
      514    516                                     #map_type TRUE,
                                                     #mode PersonCars_DocumentStoreMode, #file
"C:\\My Documents\\XML\\PersonCars_Document.xml", #repeating_element_index 4)
      IF _IPRET_SUCCESS <> returnValue THEN
        MESSAGE("STORE returned", returnValue, "at line", ERL())
      ELSE
        PersonCars_DocumentCount = PersonCars_DocumentCount + 1
      END IF
    LOOP

    CONVERT(Person.id, PersonCars_Document(2).comp_value)
    PersonCars_Document(3).comp_value = Person.name
    PersonCars_Document(8).comp_value = Person.address

    returnValue = STORE PersonCars_DocumentProfile (#data PersonCars_Document,
                                                     #create TRUE,
                                                     #map_type TRUE,
                                                     #mode PersonCars_DocumentStoreMode, #file
"C:\\My Documents\\XML\\PersonCars_Document.xml")
    IF _IPRET_SUCCESS <> returnValue THEN
      MESSAGE("STORE returned", returnValue, "at line", ERL())
    ELSE
      PersonCars_DocumentCount = PersonCars_DocumentCount + 1
    END IF
LOOP

REM * Disconnect

DISCONNECT PersonProfile ()
DISCONNECT CarProfile ()                             519
DISCONNECT PersonCars_DocumentProfile ()
```

504

FIG. 7A


START
710
INITIATE EXECUTION OF SCRIPT
720
INITIALIZE ARRAY
730
CONNECT TO FILES
740
REQUEST ALL PERSON ROWS
LOAD PERSON ROW?
750
NO
YES
DISCONNECT FROM FILES
800
TERMINATE EXECUTION OF SCRIPT
810
FINISH
760
REQUEST ASSOCIATED CAR ROWS
LOAD CAR ROW?
770
YES
STORE CAR XML DATA
780
NO
790
STORE PERSON_CAR XML

798

```
<PersonCars_Document>
  <Person_Record>
      <id> 1 <id/>
      <Name> Jack Smith <Name/>
      <Car>
            <Make> Ford <Make/>
            <Model> Explorer <Model/>
            <Year> 1998 <Year/>
      <Car>
            <Make> Dodge <Make/>
            <Model> Ram <Model/>
            <Year> 2000 <Year/>
      <Address> 125 Elm St, Smithsville, TX, 82671 <Address/>
  <Person_Record/>
  <Person_Record>
      <id> 2 <id/>
      <Name> Sue Jones <Name/>
      <Car>
            <Make> Buick <Make/>
            <Model> Le Saber <Model/>
            <Year> 1999 <Year/>
      <Car>
            <Make> Chevrolet <Make/>
            <Model> Impala <Model/>
            <Year> 2002 <Year/>
      <Address> 5 Main St, Crosstown, IA, 82671 <Address/>
  <Person_Record/>
<PersonCars_Document/>
```

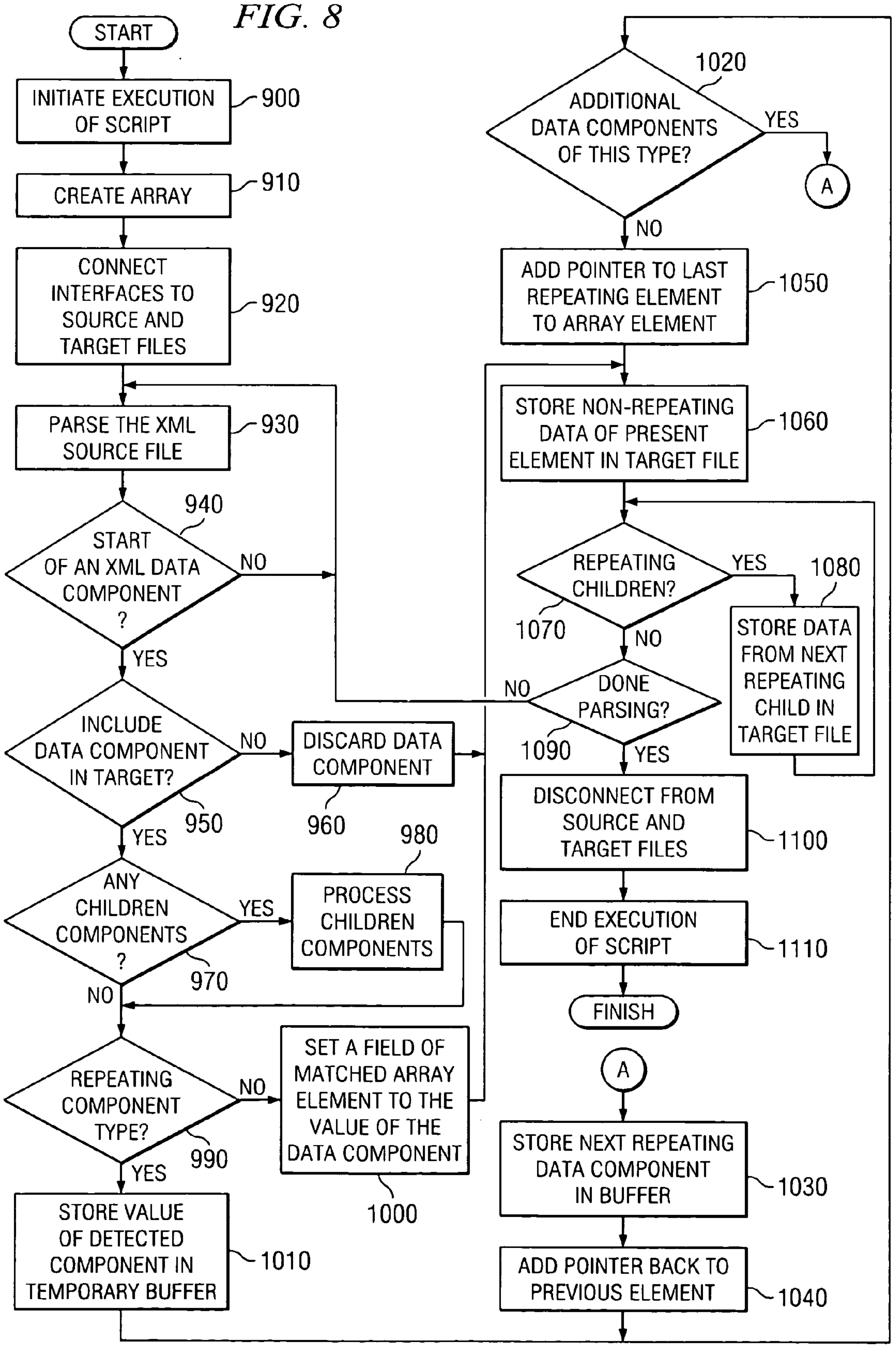
FIG. 7B

FROM FIG. 12A

FIG. 12B

```
      DO WHILE LOAD StockCompanies
1310e   in_GetQuoteWS(2).comp_value = StockCompanies.StockSymbol

1310f   webServiceReturn = CallWebService1(GetQuoteWS, in_GetQuoteWS, out_GetQuoteWS)

        IF webServiceReturn< > 0 THEN
          MESSAGE("Web Service GetQuoteWS returned ", webServiceReturn, " at line", ERL())
1310g     MESSAGE(GetQuoteWS.errorMessage)
          CONTINUE
        END IF

1310h   CONVERT(out_GetQuoteWS(2).comp_value, StockQuotes.StockPrice)
      STORE StockQuotes
```

FIG. 8


START
INITIATE EXECUTION OF SCRIPT
900
CREATE ARRAY
910
CONNECT INTERFACES TO SOURCE AND TARGET FILES
920
PARSE THE XML SOURCE FILE
930
START OF AN XML DATA COMPONENT ?
940
NO
YES
INCLUDE DATA COMPONENT IN TARGET?
950
NO
DISCARD DATA COMPONENT
960
YES
ANY CHILDREN COMPONENTS ?
970
YES
PROCESS CHILDREN COMPONENTS
980
NO
REPEATING COMPONENT TYPE?
990
NO
SET A FIELD OF MATCHED ARRAY ELEMENT TO THE VALUE OF THE DATA COMPONENT
1000
YES
STORE VALUE OF DETECTED COMPONENT IN TEMPORARY BUFFER
1010
ADDITIONAL DATA COMPONENTS OF THIS TYPE?
1020
YES
A
NO
ADD POINTER TO LAST REPEATING ELEMENT TO ARRAY ELEMENT
1050
STORE NON-REPEATING DATA OF PRESENT ELEMENT IN TARGET FILE
1060
REPEATING CHILDREN?
1070
YES
STORE DATA FROM NEXT REPEATING CHILD IN TARGET FILE
1080
NO
DONE PARSING?
1090
NO
YES
DISCONNECT FROM SOURCE AND TARGET FILES
1100
END EXECUTION OF SCRIPT
1110
FINISH
A
STORE NEXT REPEATING DATA COMPONENT IN BUFFER
1030
ADD POINTER BACK TO PREVIOUS ELEMENT
1040

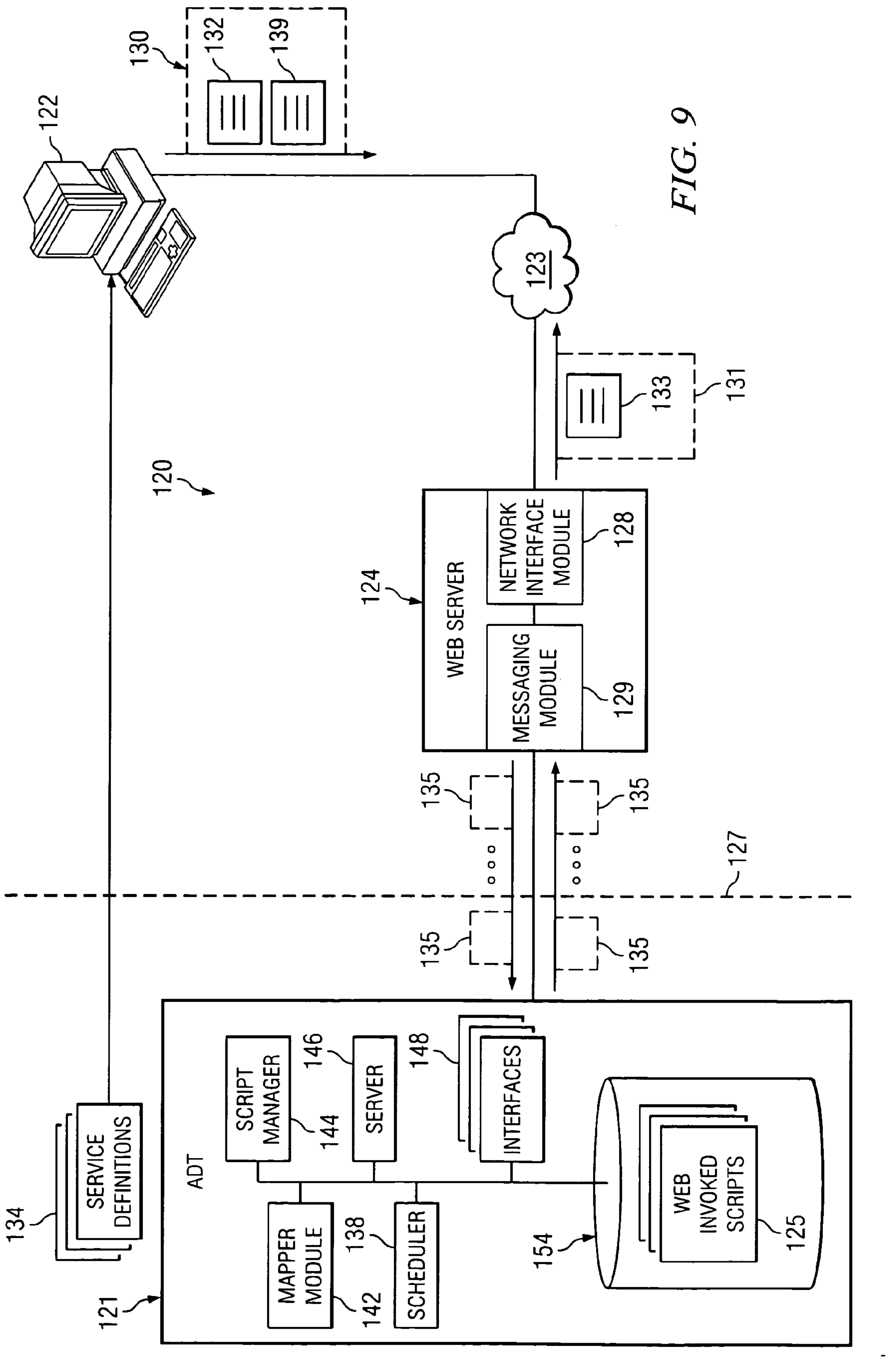

122
130
132
139
123
133
131
120
124
WEB SERVER
NETWORK INTERFACE MODULE
128
MESSAGING MODULE
129
135
127
134
SERVICE DEFINITIONS
121
ADT
SCRIPT MANAGER
144
SERVER
146
INTERFACES
148
MAPPER MODULE
142
SCHEDULER
138
154
WEB INVOKED SCRIPTS
125

FIG. 9

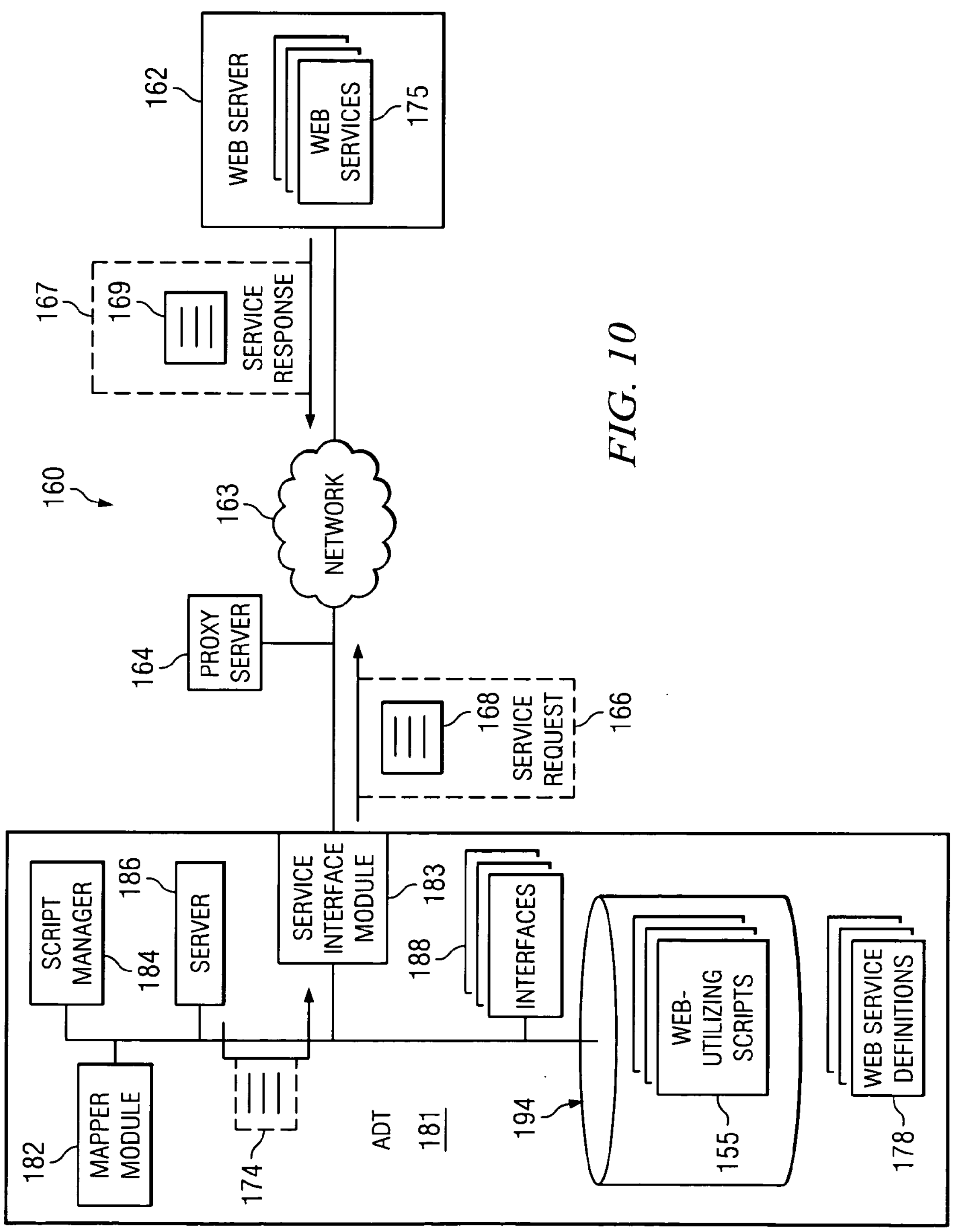

160
WEB SERVER
162
WEB SERVICES
175
167
169
SERVICE RESPONSE
163
NETWORK
164
PROXY SERVER
168
SERVICE REQUEST
166
SCRIPT MANAGER
184
186
SERVER
SERVICE INTERFACE MODULE
183
188
INTERFACES
182
MAPPER MODULE
174
ADT
181
194
WEB-UTILIZING SCRIPTS
155
WEB SERVICE DEFINITIONS
178

FIG. 10

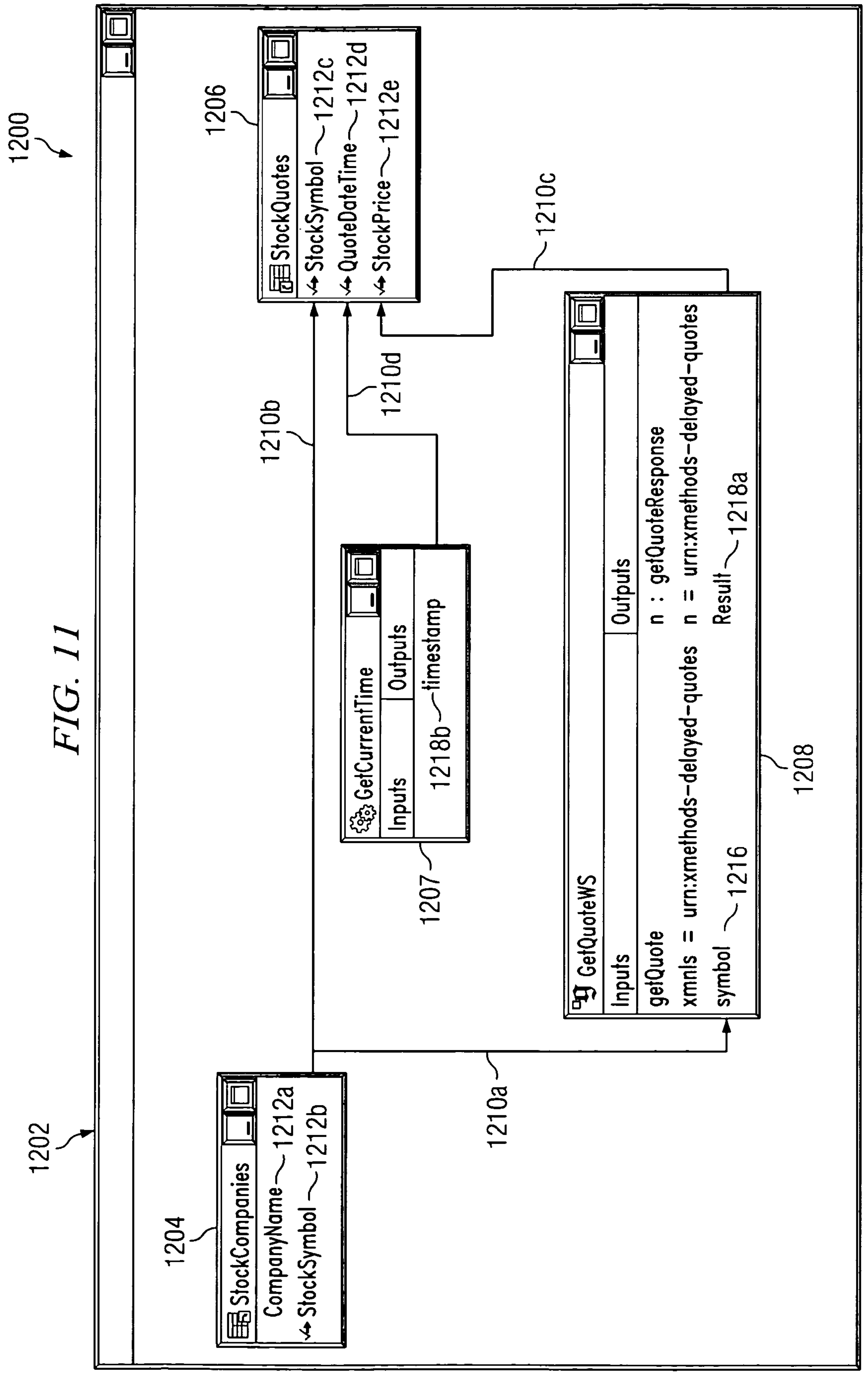

1200
1202
1204
StockCompanies
CompanyName
1212a
StockSymbol
1212b
1206
StockQuotes
StockSymbol
1212c
QuoteDateTime
1212d
StockPrice
1212e
1207
GetCurrentTime
Inputs
Outputs
1218b
timestamp
1208
GetQuoteWS
Inputs
Outputs
getQuote
xmnls = urn:xmethods-delayed-quotes
symbol
1216
n : getQuoteResponse
n = urn:xmethods-delayed-quotes
Result
1218a
1210a
1210b
1210c
1210d

FIG. 11

FIG. 12A

```
1310a ~ !INCLUDE "WebService_Declarations"

        DIM in GetQuoteWS(3) AS xmlComponentDef
        ARRAYCLEAR(in_GetQuoteWS)
         in_GetQuoteWS(0).comp_name = "getQuote"
         in_GetQuoteWS(0).comp_type = 1
         in_GetQuoteWS(0).comp_id = 0
         in_GetQuoteWS(0).comp_parent = 0
         in_GetQuoteWS(0).comp_namespaceURI = "urn:xmethods-delayed-quotes"
         in_GetQuoteWS(1).comp_name = "xmlns"
         in_GetQuoteWS(1).comp_type = 2
1310b {  in_GetQuoteWS(1).comp_id = 1
         in_GetQuoteWS(1).comp_parent = 0
         in_GetQuoteWS(1).comp_namespaceURI = "urn:xmethods-delayed-quotes"
         in_GetQuoteWS(1).comp_datatype = 14
         in_GetQuoteWS(2).comp_name = "symbol"
         in_GetQuoteWS(2).comp_type = 1
         in_GetQuoteWS(2).comp_id = 2
         in_GetQuoteWS(2).comp_parent = 0
         in_GetQuoteWS(2).comp_namespaceURI = "urn:xmethods-delayed-quotes"
         in_GetQuoteWS(2).comp_datatype = 14

        Def GetQuoteWS AS webServiceDef1
         GetQuoteWS.location = "http://66.28.98.121:9090/soap"
1310c {  GetQuoteWS.SOAPAction = "urn:xmethods-delayed-quotes#getQuote"
         GetQuoteWS.proxyHost = "caproxy.ca.com"
         GetQuoteWS.proxyPort = "80"
         GetQuoteWS.proxyProfile = "WSTProfile"
        DIM out_GetQuoteWS(3) AS xmlComponentDef
        ARRAYCLEAR(out_GetQuoteWS)
         out_GetQuoteWS(0).comp_name = "getQuoteResponse"
         out_GetQuoteWS(0).comp_type = 1
         out_GetQuoteWS(0).comp_id = 0
         out_GetQuoteWS(0).comp_parent = 0
         out_GetQuoteWS(0).comp_namespaceURI = "urn:xmethods-delayed-quotes"
         out_GetQuoteWS(0).comp_NS_Prefix = "n"
         out_GetQuoteWS(1).comp_name = "n"
         out_GetQuoteWS(1).comp_type = 2
1310d {  out_GetQuoteWS(1).comp_id = 1
         out_GetQuoteWS(1).comp_parent = 0
         out_GetQuoteWS(1).comp_namespaceURI = "urn:xmethods-delayed-quotes"
         out_GetQuoteWS(1).comp_NS_Prefix = "n"
         out_GetQuoteWS(1).comp_datatype = 14
         out_GetQuoteWS(2).comp_name = "Result"
         out_GetQuoteWS(2).comp_type = 1
         out_GetQuoteWS(2).comp_id = 2
         out_GetQuoteWS(2).comp_parent = 0
         out_GetQuoteWS(2).comp_datatype = 14
```

TO FIG. 12B

SYSTEM AND METHOD FOR PROVIDING DATA MANIPULATION AS A WEB SERVICE

RELATED APPLICATIONS

[0001] This application claims the priority under 35 U.S.C. §119 of provisional application Ser. No. 60/659,264 filed Mar. 7, 2005, which is incorporated by reference.

TECHNICAL FIELD OF THE INVENTION

[0002] This disclosure relates generally to the field of data processing and, more particularly, to a system and method for manipulating data.

BACKGROUND OF THE INVENTION

[0003] In the rapidly-evolving competitive marketplace, data is among an organization's most valuable assets. Business success demands access to data and information, and the ability to quickly and seamlessly distribute data throughout the enterprise to support business process requirements. Organizations must extract, refine, manipulate, transform, integrate and distribute data in formats suitable for strategic decision-making. This poses a unique challenge in heterogeneous environments, where data is housed on disparate platforms in any number of different formats and used in many different contexts.

SUMMARY OF THE INVENTION

[0004] In accordance with the present invention, the disadvantages and problems associated with data processing have been substantially reduced or eliminated. In particular, methods and systems for transforming data are disclosed that provide a flexible, robust manner for providing data transformation functionality as a web service.

[0005] In accordance with one embodiment of the present invention, a method of transforming data includes receiving information defining a transformation of an input data object to an output data object and generating, based on the received information, a script operable when executed to implement the defined transformation. The script is then stored. The method also includes receiving a service request from a remote client that requests a particular transformation and identifies a request data object and identifying a script that performs the requested transformation. Additionally, the method includes generating a response data object by executing the identified script on the request data object and transmitting the response data object to the remote client.

[0006] In accordance with another embodiment of the present invention, a method of transforming data includes receiving information defining a transformation of an input data object to an output data object and generating, based on the received information, a script operable when executed to implement the defined transformation based on the received information. The script is then stored. The method also includes receiving, from a remote client, a service request that requests the defined transformation and identifies a request data object and a requested execution time. Additionally, the method includes generating a response data object by executing the script on the request data object at a time determined based on the requested execution time and storing the response data object in memory.

[0007] Some embodiments of the present invention provide numerous technical advantages. Other embodiments may realize some, none, or all of these advantages. For example, particular embodiments may provide a data extraction, transformation, and load tool that features a flexible, easy-to-use, and comprehensive application-development environment. Particular embodiments may also reduce and/or eliminate the programming complexities of extracting, transforming, and loading data from disparate sources and targets and eliminate a need for users to learn XML programming or database-specific API's. Embodiments of the invention may facilitate seamless extraction and integration of data from and to AS/400, DB2, DB2 MVS, DBASE, flat files, COBOL files, Lotus Notes, Microsoft ODBC, Microsoft SQL Server, Oracle, Sybase, Microsoft Access, CA Ingres and UDB.

[0008] In particular embodiments, some features provide the ability to process and output a wide variety of different types of input files and output files with significant flexibility in how the data may be transformed. As one example, particular embodiments of the described system may be capable of accepting input files in an XML format, transforming the data, and outputting the transformed data in one or more database tables or flat files. Similarly, particular embodiments may be capable of accepting input database tables or flat files, transforming the data contained in these files, and outputting the transformed data in one more XML files. As another example, particular embodiments of the described system may be capable of reading and transforming documents having a variable number of instances of a particular data object. As a result, the described system and methods provide a powerful, robust data transformation solution

[0009] Other technical advantages of the present invention will be readily apparent to one skilled in the art from the following figures, descriptions, and claims. Moreover, while specific advantages have been enumerated above, various embodiments may include all, some, or none of the enumerated advantages.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] **FIG. 1** is a block diagram illustrating a system for data manipulation according to one embodiment of the invention;

[0011] **FIG. 2** is a block diagram illustrating a mapper for data manipulation according to one embodiment of the invention;

[0012] **FIGS. 3A and 3B** are example screen shots illustrating some functionality of an XML Object Definition of the mapper of **FIG. 2**;

[0013] **FIG. 4** is an example screen shot illustrating some functionality of an example Mapping module of the mapper of **FIG. 2**;

[0014] **FIGS. 5A-5C** illustrate an example script generated by a particular embodiment of the data manipulation system;

[0015] **FIG. 6** is a block diagram illustrating an XML Interface for data manipulation according to one embodiment of the invention;

[0016] **FIG. 7A** is a flowchart illustrating an example method of executing a script to perform a first transformation of data from a database source file to an XML target file according to one embodiment of the invention;

[0017] **FIG. 7B** is an example output of the example method of **FIG. 7A** according to one embodiment of the invention;

[0018] **FIG. 8** is a flowchart illustrating an example method of executing a script to perform a second transformation of data from an XML source file to a database target file according to one embodiment of the invention;

[0019] **FIG. 9** shows a particular embodiment of a data transformation system capable of providing data transformation functionality to remote clients as a web service; and

[0020] **FIG. 10** show a particular embodiment of a data transformation system capable of utilizing web services offered by remote web servers as part of data transformation functionality supported by the system;

[0021] **FIG. 11** is an example screen shot illustrating some functionality of an example Mapping module that may be utilized by particular embodiments of the system shown in **FIG. 10**; and

[0022] **FIGS. 12A and 12B** show an example script that may be generated by particular embodiments of the system illustrated in **FIG. 10**.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

[0023] **FIG. 1** is a block diagram illustrating a system **100** for data manipulation according to one embodiment of the present invention. Generally, system **100** includes a graphical data movement tool that is referred to herein as Advantage Data Transformer ("ADT") **101**. Some embodiments of the invention facilitate extensible Markup Language ("XML") functionality with an ability to use XML document files as either sources or targets and transform data between XML format and database format, flat file format, or any other appropriate formats. Various embodiments of system **100** and ADT **101** are described below in conjunction with **FIGS. 1 through 8**.

[0024] In the illustrated embodiment, ADT **101** includes a mapper module **102**, a script manager **104**, a server **106**, interfaces **108**, XML files **110**, database tables or files **112**, and an internal database **114**. The present invention contemplates more, fewer, or different components associated with ADT **101** than those illustrated in **FIG. 1**. In addition, any of the elements or various functions of the elements of ADT **101** may be suitably distributed among one or more computers, servers, computer systems, and networks in any suitable location or locations. As such, any suitable number of processors may be associated with, and perform the functions of, ADT **101**.

[0025] Mapper module **102** includes any suitable hardware, software, firmware, or combination thereof operable to receive a first data definition (or file format) of a source file, receive a second data definition (or file format) of a target file, and automatically generate a script **115** to represent a movement of data from the source file to the target file. For the purposes of this description and the claims that follow, the term "file" may be used to refer to a collection of data structured in any suitable manner. As a result, a "file" may contain data stored in a hierarchical structure, in a relational form, or any other appropriate manner, and a "file" may represent all or a portion of an XML file, a relational database, a flat file, or any other appropriate collection of data. Furthermore, as used herein, the term "automatically" generally means that the appropriate processing is substantially performed by mapper module **102**. However, in particular embodiments, use of the term "automatically" may contemplate appropriate user interaction with mapper module **102**. As described in greater detail below, mapper module **102** includes one or more suitable graphical user interfaces ("GUIs") and, among other functions, allows a user to design data formats, scan data formats from existing definitions, edit existing data formats, and design data transformation programs via drag-and-drop functionality. Further details of mapper module **102** are described below in conjunction with **FIG. 2**.

[0026] Script manager **104** includes any suitable hardware, software, firmware, or combination thereof operable to manage scripts **115** generated by mapper module **102**. This may include storing scripts **115** in internal database **114** or other suitable storage locations, and may include scheduling scripts **115** for execution by server **106**. Script manager **104** may also provide database connection information to source tables and target tables through suitable database profiles. In particular embodiments, database profiles may specify a particular interface, server name, database name, user ID, and password for a particular program.

[0027] Server **106** includes any suitable hardware, software, firmware, or combination thereof operable to execute scripts **115** when directed by script manager **104**. The transformation of data formats takes place in scripts **115** when executed by server **106**. In other words, server **106** may perform the data movements from one or more source files to one or more target files. As used herein, Other functionalities performed by server **106** are contemplated by the present invention.

[0028] In one embodiment, the flow between script manager **104** and server **106** is as follows: script manager **104** puts a script run request in a queue in internal database **114** when a user selects a script to run. A scheduler function within server **106** picks up the run request and verifies the script is valid to run. Server **106** then starts an interpreter function to run the relevant script. The interpreter pulls the compiled script from internal database **114** and starts interpreting (i.e., running) the script. The interpreter loads interfaces **108** during script execution. The interfaces **108** access files based on the script. Messages from the script get logged in internal database **114**. The scheduler logs script return code in internal database **114**, and script manager **104** inspects internal database **114** logs for script messages and return codes. Script manager **104** can view the execution and message logs from internal database **114** to report on status and completion of script execution.

[0029] Interfaces **108**, in the illustrated embodiment, include an XML interface **600** and a database interface **116**. However, the present invention contemplates other suitable interfaces. Interfaces **108** include any suitable hardware, software, firmware, or combination thereof operable to load and store a particular format of data when called by server **106** in accordance with scripts **115**. Interfaces **108** may couple to source files and target files during execution of scripts **115**. For example, in the embodiment illustrated in **FIG. 1**, XML interface **600** is coupled to XML files **110** and database interface **116** is coupled to database tables **112**. XML files **110** and database tables **112** are representative of various data stored in various file formats and may be associated with any suitable platform including, but not limited to, Windows NT, Windows 2000, Windows 2003, Windows XP, Linux, AIX, HP-UX, and Sun Solaris. The present invention contemplates interfaces **108** having other suitable functionalities. Further details of XML interface **600** are described below in conjunction with **FIG. 6**.

[**0030**] **FIG. 2** is a block diagram illustrating mapper module **102** according to one embodiment of the invention. In the illustrated embodiment, mapper module **102** includes one or more editors **208** and Script Generation module **204**. Mapper module **102** also includes one or more data definitions **200**, a Mapping module **202**, and one or more scanners **206** each associated with one or more data formats that mapper module **102** is capable of receiving and/or outputting. For example, in the illustrated example mapper module **102** includes or stores an XML Object Definition **200***a*, and an XML Scanner **206***a* for supporting functionality associated with the transformation of XML data. Similarly, the illustrated example also includes additional data definitions **200** (e.g. relational table definition **200***b* and flat file record definition **200***c*), and scanners **206** associated with DBMS files and flat files respectively. Although **FIG. 2** illustrates a particular embodiment of mapper module **102** that includes particular components capable of supporting a number of specific data formats, alternative embodiments may include mapper modules **102** capable of supporting any appropriate number and types of data formats.

[**0031**] Data Definitions **200**, in particular embodiments, are each operable to receive a data definition (or file format) of a source file and/or a target file. This may be accomplished in any suitable manner and particular embodiments may allow a user to define or design such data format. Two ways to define a particular data format may be via scanning with an appropriate Scanner **206** or by manual entry with the help of an appropriate editor **208**. Pre-existing data definitions (i.e., file formats) may also be stored in internal database **114**.

[**0032**] Scanners **206** are each operable to automatically generate a data format from an existing definition that contains the associated data format. One example of such data format scanning is described in U.S. patent application Ser. No. 11/074,502, which is herein incorporated by reference. The manual definition of an example XML document file format is shown and described below in conjunction with **FIGS. 3A and 3B**. Manual definitions for files of other formats maybe entered in a similar fashion with appropriate modifications using an editor **208** corresponding to the relevant file format.

[**0033**] Mapping module **202** is operable to allow a user to design a transformation program to transform data of a particular format (e.g. XML) via mappings from one or more source files to one or more target files. This may be accomplished via a GUI having a program palette in which a user is allowed to drag and drop source data definitions into a target data definition therein in order to perform the desired connection. Such a program palette is shown and described below in conjunction with **FIG. 4**. These graphical mappings by a user represents a desired movement of data from the source files to the target file.

[**0034**] Script Generation module **204** is operable to automatically convert the mappings captured by Mapping module **202** into a script to represent the movement of data from the source files to the target file. An example script is shown and described below in conjunction with **FIGS. 5A-5C**.

[**0035**] **FIGS. 3A and 3B** are example screen shots illustrating some functionality of XML Object Definition **200** according to a particular embodiment. Although the description below focuses for purposes of illustration on the transformation of XML data, as noted above, mapper module **102** may be configured to utilize any appropriate form of data for input and output files. Referring first to **FIG. 3A**, a "Create New XML Object" dialog **300** is illustrated. Dialog **300** allows a user to create a new XML object. The user may select the target folder where the XML object is to be created by using a window **302**. A browser tree may be associated with window **302** from which a user may select a desired XML folder. The user may enter a name for the new XML object into window **304**. A list of existing XML objects in the selected folder may be displayed in a window **306** to aid the user when defining the name of a new XML object. The XML object's fully qualified path and name may be also shown in a window **308**. Other suitable windows may be associated with dialog **300**, such as a status window **310** and a version window **312**. Once all the desired information is entered into dialog **300**, a user clicks on a Finish button **314** to create the XML object. XML Object Definition **200** then launches an "XML Object Definition" dialog **350**, as illustrated in **FIG. 3B** below.

[**0036**] XML Object Definition dialog **350** allows a user to define elements, attributes, namespaces, comments, and/or other markup language components (generically referred to here as "data components") that define the layout of an XML object that the user may later use as a source or target on a program palette. The XML Object definition defines the layout of the object and controls how the data is read/written when used in a program. In the illustrated embodiment, dialog **350** illustrates an XML file format **351** in a window **352** for the PersonCars_Document file that is shown in the Create New XML Object dialog **300** above. The XML Object Definition dialog **350** allows a user to create and/or modify XML data components of an XML object that include elements, repeating elements, attributes, namespaces, and comments. An icon with a particular letter or symbol may be displayed for each component in XML file format **351**. In the illustrated embodiment, an "E" is used to illustrate an element type, an "R" is used to illustrate a repeating element type, an "A" is used to illustrate an attribute of an element, an "N" is used to illustrate a namespace, and an "!" is used to illustrate a comment. Nonetheless, particular embodiments of XML Object Definition dialog **350** may use other appropriate designations.

[**0037**] Component information **353** describing characteristics of a particular component in XML file format **351** is displayed in a component information window **354** as a user moves a cursor over a particular component or when a user selects a single item in XML file format **351**. Component information window **354** shows component information, such as the type, name, value, namespace prefix, namespace

URI, use CDATA, and whether or not it is a repeating element. Dialog **350** may have a number of suitable operations **356** associated with it. A "New" operation **357** invokes an XML component dialog to create a new XML component using the currently selected element or element parent. An "Edit" operation **358** invokes an XML component dialog to edit an existing XML component. In this case, the XML file format **351** may be synchronized with the updated component data. A "Delete" operation **359** deletes the selected component and children, if desired. Deleting an element may result in deleting other XML components, such as children elements, attributes, comments, or namespaces.

[0038] Additionally, a "Validate XML file format" operation **360** may perform validation of a current file format **351**. For example, in particular embodiments, the "Validate XML file format" operation **360** may perform the following checks for a particular file format, report the appropriate results, and select the offending component in the file format for further correction:

[0039] 1. Verify that the namespace prefixes and URIs are correct for their relevant scope

[0040] 2. Verifies that the XML data component names are valid and do not contain invalid characters.

[0041] 3. Verifies that the XML data component names are unique for the scope under which they are defined.

[0042] 4. Performs special tests for element names including, for example, determining whether second level (record) qualified element names are unique and determining whether the qualified names for "repeating" elements at the third level or lower are unique.

[0043] 5. Checks to see if an XML file format contains valid second level elements. The definition may be invalid if it contains two or more second level elements and has repeating elements designated.

Alternative embodiments may utilize additional or alternative checks to verify the data component.

[0044] A "Repeating Element" operation **361** is used to designate an element as repeating or not repeating. The handling of repeating elements is described in further detail below. "Movement" operations **362** move a single or group of components in a particular direction to change the order of hierarchy of data components within file format **351**.

[0045] Although the above description focuses on a particular embodiment of ADT **101** that supports certain functionality for "Create New XML Object" dialog **300** and XML Object Definition dialog **350**, alternative embodiments may support any appropriate functionality for the creation and definition of XML objects. For example, in particular embodiments, a user may be able to drag and drop one or more data components in a single operation. In addition, a context menu or other suitable menu may be shown when a user right clicks on components of file format **351**. This menu may have suitable menu items that are comparable to the operations **356** discussed above.

[0046] **FIG. 4** is an example screen shot **400** illustrating some functionality of Mapping module **202** according to one embodiment of the invention. Screen shot **400** includes a GUI with a program palette **402** that allows a user to design a desired movement of data from one or more source database tables **404** to a target data definition **406** using one or more graphical mappings. These mappings are first facilitated by a simple dragging and dropping of data definitions into program palette **402**. For example, in the illustrated embodiment, source tables **404***a*, **404***b* are dragged-and-dropped into program palette **402**. In addition, a target data definition **406** is dragged-and-dropped into program palette **402**. Then the individual "fields" from source tables **404***a*, **404***b* are mapped to individual elements in target data definition **406**. As indicated by the arrows in program palette **402**, the "id" field in source table **404***a* is mapped by the user to the "Id" element in target data definition **406**, the "name" field in source table **404***a* is mapped to the "Name" element in target data definition **406**, and the "address" field in source table **404***a* is mapped to the "Address" element in target data definition **406**. In this example, a car element **411** in target data definition **406** is designated as a repeating element and has its own repeating element definition **408**. Thus, there are mappings from source table **404***b* to repeating element definition **408**. Any suitable mappings are contemplated by the present invention and are controlled by the desires of the user.

[0047] A connection indicator **410** indicates that target data definition **406** and repeating element definition **408** are related and also shows the dependency between elements and the direction of the dependency. In addition to showing the relationship between target data definition **406** and repeating element definition **408**, connection indicator **410** may also maintain and enforce the correct process order for the parent/child relationships between components on program palette **402**, and may enforce the correct process order when the order is manually updated in a suitable process order dialog. More specifically, the order of script statements that is produced in the resulting script uses a process order algorithm that uses the program palette source to target relationships (e.g., mappings, user-constraints, foreign keys, and repeating element connections) and produces the required DO/WHILE loops, CONNECT, SEND, LOAD, STORE, DISCONNECT, nested loops, source to target column/element assignment statements, conditional statements, transformations and other script constructs. In one embodiment, a user may be prohibited from deleting connection indicator **410**.

[0048] In particular embodiments, an expand/collapse usability feature allows a user to expand and collapse the display of target object definition **406** and repeating element definition **408** on program palette **402**. This feature may allow a user to see target object definition **406** in a single palette object in the same form as shown in XML Object Definition dialog **350**. The collapsed view presents target object definition **406** in a form that may help aid the user when viewing the mapping relationships between other objects on program palette **402**.

[0049] In the embodiment illustrated in **FIG. 4**, source table **404***a* is a database table that contains the IDs, names, and addresses of persons, and source table **404***b* is a database table that contains the IDs, makes, models, and years of cars associated with those persons in source table **404***a*. The data in source tables **404***a*, **404***b* are desired to be transformed into an XML document that has a format defined by target data definition **406**, which may have been designed using the XML Object Definition **200** illustrated in **FIG. 2**. The example mappings in **FIG. 4** are examples that illustrate the use of program palette **402** to perform graphical mappings that correspond to a transformation of data from one format to another format. Any suitable mappings are contemplated by the present invention and transformations from any suitable format to any other suitable format are contemplated by the present invention. For example, transformations may be desired from database tables to XML files, XML files to database tables, XML files to other XML files, database tables to other database tables, and/or any other suitable transformations.

[**0050**] Once the desired mappings are entered by a user, script generation module **204** may then, in response to a selection by the user, automatically convert the mappings into a script to represent the movement of data from source tables **404** to target data definition **406**. An example script **500** is shown and described below in conjunction with **FIGS. 5A-5C**.

[**0051**] Thus, target data definition **406** and repeating element definition **408** on program palette **402** allow a user to graphically see DO WHILE loops and corresponding LOAD/STORE units that are implicit in the transformation defined by the user to be implemented by the generated script. Repeating element connections, as indicated by connection indicator **410**, show control sequence of execution operations and corresponding execution loops.

[**0052**] Mapping module **202** supports other suitable operations and/or mapping gestures for adding, deleting, and modifying data definitions defined in a transformation program. Mapping module **202** also contains special operations for selecting, updating, and moving objects on program palette **402**. In addition, it includes a unique "Generate Layout" feature that arranges the palette objects for main data definition **406** and repeating element definition **408** using non-overlapping hierarchical representation as defined in XML file format **351** (**FIG. 3B**). This feature is useful for automatically generating a layout that shows the parent/child relationships and hierarchy without using dialog **350** as a reference.

[**0053**] **FIGS. 5A, 5B**, and **5**C illustrate an example script **500** for transforming XML data according to one embodiment of the invention that is generated by script generation module **204** (**FIG. 2**). As described above, in particular embodiments, a user may define a transformation program via the graphical mappings by dragging various source data definitions and target data definitions onto a program palette. In one embodiment, each definition on the program palette is represented in memory as a C++ object, which includes information about whether the file is a source or a target, whether the data is a table in a relational database or an XML file, and what columns or elements participate in the transformation. When the user maps a column or element of one source to a column or element of a target, an in-memory C++ connection object is created containing the source/target information.

[**0054**] During script generation, the information in the in-memory palette source/target and connection objects is translated into data structures that are used to define the corresponding script code and corresponding script structures used during the script creation process. Whereas the first in-memory palette and connection objects represent the appearance of the program on the program palette, the later script data structures represent the processing implied by that appearance. A list of script data structures may be used to represent such granular pieces of processing as CONNECTing to a database table, starting a DO WHILE loop to LOAD a row of a source table, assigning the value of one script variable to another, STORing a row to a target table, or terminating a DO WHILE loop.

[**0055**] Finally, a number of passes are made through the array of script data structures to write out actual script statements to define the standard script constants, script structures to hold table column values, data profile names, and the actual CONNECT/DO WHILE/LOAD/IF/assignment/STORE/DISCONNECT processing statements.

[**0056**] As shown in **FIGS. 5A-5C**, example script **500** may define an array **502** and a transformation routine **504**. The array **502** is an example of how an XML file format or data definition may be defined within the programming code. Whereas LOAD and STORE handlers for other interfaces, such as database interface **116**, may take a #DATA parameter (as shown by the line of code at reference numerals **512**) that specifies a structure within which each field corresponds to a column within a database table, the #DATA parameter (as shown by the line of code at reference numeral **514**) for XML LOAD and STORE handlers, according to particular embodiments, specifies an array of structures. Each of the structures in the array corresponds to an element, attribute, namespace, or comment specified in the XML document. As one example, the structure may look like this:

[**0057**] TYPE xmlComponentDef AS STRUCTURE

```
(
comp__name           STRING, REM* Element tag, attribute name, or null
comp__value          STRING, REM* character value of element or attribute
comp__type           INT,                                                    REM*
0=attribute, 1=element,2=namespace,3=comment
comp__id             INT, REM* id of the component
comp__parent         INT, REM* id of the parent element-type component
comp__namespaceURI   STRING, REM* full URI of namespace
comp__NS__Prefix     STRING, REM* prefix for namespace qualification
comp__IsCDATA        BOOLEAN, REM* TRUE = data to be wrapped in CDATA
tags
comp__datatype       INT, REM* datatype of element
comp__IsRepeating    BOOLEAN, REM* TRUE = element may repeat
comp__level          INT, REM* level of the component
)
```

-continued

```
CONST__comptype__attribute = 0
CONST__COMPTYPE__ATTRIBUTE = 0
CONST__comptype__element = 1
CONST__COMPTYPE__ELEMENT = 1
CONST__comptype__namespace = 2
CONST__COMPTYPE__NAMESPACE = 2
CONST__comptype__comment = 3
CONST__COMPTYPE__COMMENT = 3
```

[0058] In the illustrated example, the fields are defined as follows:

comp__name	simple name of element or attribute or text of comment
comp__value	character value of element or attribute
comp__type	0 => element, 1 => attribute, 2 => namespace component, 3 => comment
comp__id	a unique number to identify a component; sequentially assigned starting with zero
comp__parent	id of this component's parent component
comp__namespaceURI	the Uniform Resource Identifier for the component's namespace
comp__NS__Prefix	the prefix associated with the namespaceURI
comp__IsCDATA	used to indicate that the character value may contain problematic characters like <, >, ", ', or &
comp__IsRepeating	indicates an element may repeat zero or more times in the XML definition
comp__level	hierarchical level of the component, starting with zero for the root element

[0059] As described further below, by creating an array of xmlComponentDef structures and then setting the value of the various fields based on the data read from the source file, XML interface **600** can create a data structure holding all of the data necessary for the defined transformation.

[0060] Since data is being transformed into XML format, XML interface **600** (**FIG. 1**), in this example, is called by server **106** to help perform the transformation. Details of XML interface **600** and its associated communication handlers are described in greater detail below in conjunction with **FIG. 6**.

[0061] The CONNECT handler (see reference numeral **509**) establishes a connection to XML interface **600** and references an XML profile. The SEND handler (see reference numerals **510**) is called before the LOAD handler (see reference numerals **512**), and prepares the XML interface **600** for the load. The LOAD handler **512** loads data from a source file into an array element that is passed by the example script **500**. The STORE handler **514** is used to create the specified target file from the target data definition that is passed by example script **500** to XML interface **600**. The DISCONNECT handler (see reference numeral **519**) disconnects from the XML interface **600**.

[0062] With respect to the LOAD handler, #FILE may be used to specify the name of the file from which the XML document may be read. #DATA may be required to specify the array of structures that describe the XML document to be read. #repeating_element_index is used on the LOAD of a repeating element and specifies the element's index in the array of structures.

[0063] While parsing the XML file, particular embodiments of the LOAD handler may set the values of the various structure fields according to the following guidelines:

comp__name	for elements and attributes, this field stores the name of the relevant data component
comp__value	initialized to NULL by the LOAD handler at the beginning of the load. May be set to the value contained in the document if the corresponding data component is contained in the document
comp__type	elements (0), attributes (1), namespaces (2), and comments (3).
comp__id, comp__parent and comp__level	
comp__namespaceURI	can be specified if the document contains a namespace URI; otherwise may be left NULL or set to a null string ("")
comp__IsRepeating	set to TRUE if the element repeats; set to FALSE otherwise

[0064] With respect to the STORE handler, #FILE may be used to specify the name of the file to which the XML document may be written (see reference numeral **516**). #DATA may be used to specify the array of structures that define the components of the XML document to be created. #repeating_element_index may be used on the STORE of a repeating element and specifies the element's index in the array of structures. Special notes on the use of structure fields for the STORE handler is as follows:

comp__name	required for elements, attributes, and comments; namespace prefix name for namespaces
comp__value	optional for elements; required for attributes; ignored for namespaces and comments
comp__type, comp__id, comp__parent and comp__level	all required
comp__namespaceURI	ignored for elements, attributes, and comments; required for namespaces
comp__NS__Prefix	optional for elements, attributes, and namespaces; ignored for comments
comp__IsCDATA	may be specified as TRUE if the element value is to be wrapped in CDATA delimiters. May be set to FALSE or left NULL otherwise
comp__IsRepeating	set as TRUE if the element repeats; set to FALSE otherwise

[0065] After the generation of example script **500**, mapper module **102** (**FIG. 1**) stores example script **500** in internal database **114** for later execution by server **106**. Script manager **104** may later schedule example script **500** for execution by server **106**. When server **106** is ready to execute example script **500**, it calls on XML interface **600** as shown and described below in conjunction with **FIG. 6**.

Repeating Elements—Additional Information

[**0066**] As described above, XML Object definitions may have an additional "repeating" property added to an element in an XML Object definition (for example, Car element in XML file format **352**). This property is used to indicate if a particular element (and its children) in the XML Object definition has data that repeats in the associated XML document. The repeating property of the element is later used when the XML Object definition is added to a program (see, e.g., repeating element definition **408** in **FIG. 4**) to create "repeating element" XML definitions for each element with the "repeating" property. Repeating element XML definitions in a program provide the means of accessing a particular repeating element and its children for structure assignments in a script and processing distinct LOAD and STORE operations inside a program. This feature may provide the necessary control and flexibility in the program to handle special LOAD/STORE processing required for the repeating data.

[**0067**] In particular embodiments of ADT **101**, all elements in the XML definition except for the document root and any second level elements may be defined as repeating. The repeating property is not applicable to attributes, namespaces, and comments. The repeating property may be designated on child elements that are designated as repeating and so forth down the hierarchy as needed. A user may specify if an element is repeating or non-repeating in the XML Object Definition dialog (e.g., dialog **350** in **FIG. 3B**). The user may specify the repeating property from an XML Component dialog or directly from the element component in the XML Object Definition dialog via a context menu.

[**0068**] Moreover, in particular embodiments of ADT **101**, the following rules may govern the use of repeating elements:

[**0069**] 1) Root and second level elements can not be designated as repeating. Consequently, second level element names are assigned unique.

[**0070**] 2) Element names for third or lower level elements do not have to be unique as long as they are not designated as repeating.

[**0071**] 3) Elements designated as repeating are assigned unique names for a given parent element.

[**0072**] 4) XML Object definitions can only have a single second level element if that second level element includes one or more "repeating" elements. By contrast, multiple second level elements may be supported for XML objects without repeating elements.

[**0073**] The main element (such as main element **406** in **FIG. 4**) and repeating-element (such as the repeating Car element **408** in **FIG. 4**) XML palette objects are considered a single entity for LOAD and STORE processing. That is, a single XML definition structure is used in the script to set/get values in common memory for LOAD and STORE processing of the XML document stream.

[**0074**] Each repeating-element definition may allow operations to be performed such as mappings, user constraints and process order specification and may follow the existing rules consistent with other objects on the palette such as tables, records, and views. When user drags and drops the XML object definition containing elements with the repeating property onto a program palette, the main XML definition **406** and all the associated repeating-element definitions **408** are shown, as illustrated in **FIG. 4**.

[**0075**] The name of the palette objects for repeating-element definitions may be derived from the name of the main XML definition. For example, "PersonCars" main XML Object definition is the name of the XML object in the illustrated example. The repeating-element definition may use the element name for the repeated-element definition followed by the parent elements up to the document root in the main XML Object definition with a period "." separating each name.

[**0076**] For example, "Car.Person_Record.PersonCar_Document" is the name derived for the repeating-element definition for the repeating Car element shown in **FIG. 4**. If the final name is not unique for the palette object, a number may be appended to the element name to make it unique (e.g., Car2.Person_Record.PersonCar_Document). In particular embodiments, the name of the palette objects regardless of type (tables, records, views, Reusable Transformations, Lookups, etc.) will be unique in a given program. The unique palette name is used to identify the object to processing steps (LOAD, STORE, INVOKE) in a program.

[**0077**] In the "Car.Person_Record.PersonCar_Document" repeating-element definition **408**, the fully qualified path for the Car element to Person_Record (parent) **408** and Person-Cars_Document (grand parent) is shown in the palette object name. The fully qualified path uniquely identifies a repeating-element definition such that the user may differentiate between two or more repeated-element definitions having the same element name but different parents. In particular embodiments, the user may be prevented from creating mappings and user constraints to/from the parent component for Car in the parent element of the repeating-element definition in this example. That is, in such embodiments, mappings and user constraints may not be created on the Car element in the Person_Cars palette instance, they may be create on the Car element in the Car.Person_Record.Person-Car_Document repeating-element definition.

[**0078**] The format for repeating-element definitions is considered separate but implicitly associated with the repeating-element definitions in the related main XML definition and may be visible in the program palette. That is, the format maintained in the main XML definition is used to define the corresponding repeating element definitions on the program palette and "appear" as separate addressable palette objects (**406** and **408**) from the user's perspective. This approach keeps all the formats in a single location in the metadata store for the repeating-element structure and reduces the amount of duplicated data that would be needed in an approach that uses separate repeating-element XML object metadata definitions in the metadata store.

[**0079**] When a user makes a modification to a main XML Object definition (such as by using the XML Object editor shown in **FIG. 3B**), the program palette objects are updated to reflect the new structure. The program synchronization routines may recreate/restructure the main/repeating element definitions while trying to maintain existing mappings and preserve existing repeating element definitions if possible. Synchronization of the XML Object definitions occurs on program open, program import, and when XML objects are edited while programs are open.

[0080] The use of "repeating-element" XML Object definitions is important to allow the user to graphically see the implied DO WHILE loops that may be generated in the script. In addition, this construct may allow the user to control how each "repeating-element" XML Object definition may be processed in program and resulting script. Handling of multiple repeating elements in a single XML definition may require having separate LOAD/STORE loops for each repeating element. The user may create as many repeating-element XML definitions as necessary to correctly processing the XML definition.

[0081] In particular embodiments, the LOAD and STORE calls generated in the script may have additional parameters and structures to uniquely identify each part of the XML definition (main or repeating-element) being processed for a particular LOAD and STORE call. This may be handled by passing the index of the "repeating element" to be processed as an additional parameter to the LOAD or STORE statements (for example, using #repeating_element_index parameter as shown at reference numeral **514**). A single profile may be used for the main and repeating-element XML Object definitions on the program palette since they use the same script structure and memory for the "related" LOAD or STORE statements in the script. However, the "PersonCars" (main) and "Car.Person_Record.PersonCars_Document" (repeating-element) XML Object definitions from above are handled using separate LOAD or STORE operations in the script.

[0082] An XML interface **600** may save/stage the data for repeating child elements to cache both on LOAD and STORE calls in the script. In particular embodiments, STORE statements for repeating-element definitions always stage the data to the memory. When the main record is STOREd then all of its data, including the staged repeating elements, gets written to the XML target file. The LOAD process begins with the LOAD of the entire record. All of the non-repeating data for the root record is returned, while the data for repeating child elements is staged to a cache. On subsequent LOADs for the child portions, this data is extracted from cache and returned.

[0083] **FIG. 6** is a block diagram illustrating XML interface **600** according to one embodiment of the invention. In the illustrated embodiment, XML interface **600** includes a plurality of communication handlers **602**, a parser **604**, a plurality of function calls **606**, and a cache **608**. The present invention contemplates more, fewer, or different components than those shown in **FIG. 6**.

[0084] As described above, rather than passing data through a structure in which each structure field translates to a table column or file field, XML interface **600** may pass an array structure, and each element of the array may correspond to an XML component. The array structure may contain the information required to format an XML file, and may be derived from the XML file format **351** as described above (**FIG. 3B**).

[0085] For the STORE handler, XML interface **600** may simply traverse the array structure and write out the structure to the file in XML format. For the LOAD handler, XML interface **600** may first parse a given XML object until locating an element corresponding to the root node of the record passed in. XML interface **600** may then parse the XML file and try to map the components encountered to their corresponding fields in the array. In one embodiment, XML components that have no corresponding field may be discarded. Array fields that have no counterpart in the XML file may be left NULL.

[0086] Communication handlers **602** generally provide a common function set that enables Server **106** to interact with different databases or data formats. Communication handlers **602** may establish and terminate connections, issue queries and other suitable commands, and move data to and from a database or other suitable data repository. A particular interface converts these common script functions into database-specific code. In the illustrated embodiment, communication handlers **602** include a CONNECT handler **610**, a SEND handler **612**, a LOAD handler **614**, a STORE handler **616**, and a DISCONNECT handler **618**.

[0087] Generally, CONNECT handler **610** allows the connection to XML interface **600** in order to connect with source files and target files when server **106** desires to execute a script. SEND handler **612** prepares XML interface **600** for a LOAD call by passing initial information to parser **604**. This call may initialize the "XML file" object, and prepare the XML file to be a source file. LOAD handler **614** works in conjunction with parser **604** and may iteratively parse each successive element until the end of a record is reached. At that point, parsing may wait and the array described above may be returned with the data portion filled in. STORE handler **616** may cause the passed array of element structures to be written to the XML file format or cache **608** depending on the type of element being processed. The structure may contain the field names, hierarchy information, and the data. XML interface **600** may run this structure and generate the indicated XML to the XML file associated with the profile. DISCONNECT handler **618** writes out any element tags that are still pending, frees any parser resources, closes the source and target files, and disconnects server **106** from XML interface **600**.

[0088] Parser **604** may be any suitable computer program operable to read one data line at a time during the LOADing of data from a source file. Parser **604** makes particular calls to function calls **606** based on the data read in order to perform its functions. For example, function calls **606** may include a comments-process function call **620**, a namespace-process function call **622**, a CDATA-process function call **624**, a start element function call **626**, and an end element function call **628**.

[0089] Cache **608** may be any suitable storage unit or database and may take the form of volatile or non-volatile memory including, without limitation, magnetic media, optical media, random access memory, read-only memory, removable memory, or any other suitable local or memory component. In the illustrated embodiment, cache **608** includes a stack **630**, a component list **632**, and a repeating component list **634**. Stack **630** functions to keep track of where parser **604** is in an XML tree structure when XML interface **600**. Component list **632** temporarily caches data from a particular source file or target file during a LOAD call and repeating component list **634** temporarily caches data for the repeating elements during a particular LOAD call. This is described in further detail below in conjunction with **FIGS. 7A and 8** below.

[0090] To support STORing of repeating elements, repeating records, and nested repeating records, example script **500** stores the repeating data first followed by the non-repeating data. First, example script **500** determines what type of data is being processed, e.g., a repeating record, repeating element or non-repeating data. Example script **500** determines this by using a repeating index passed on the STORE call from example script **500**. Next, if example script **500** determines that a repeating record is being processed then the size of the record (that is, the start and end indexes of the record) is calculated.

[0091] Repeating component list **634** maintains the list of all active repeating records being processed. Any time a repeating record is parsed, the parsing routines add a new reference to repeating component list **634**. When a repeating component is parsed, repeating component list **634** is scanned to determine if the record is a member of this list (has been processed before). If so, XML interface **600** identifies the parent of the repeating component from repeating component list **634**. On STORE of the main component, the non-repeating data is recorded in component list **632**. A call is subsequently made to STORE handler **616** to write out the XML record.

[0092] While processing a repeating record, a check for nested repeating record scans for any nestings of repeating data. All repeating data may have their own LOADs, which may each cause a new in-memory cache data area to be added in the component. Parsing routines, while building the list, will save the component data in the in-memory cache and LOAD handler **614** will then process the data if the Component Ids match a Component Id that is to be processed next.

[0093] **FIGS. 7A-7B** and **8** illustrate example operation of XML interface **600** in executing a transformation script such as the one shown in **FIGS. 5A-5C**. In particular, **FIG. 7A** illustrates example operation of XML interface **600** in executing an example script to transform input data stored in rows from a database table into an XML output file, while **FIG. 8** illustrates example operation of XML interface **600** in executing another example script to transform input data stored in an XML-format source file to rows in a database table. In general, however, XML interface **600** may be configured to transform input data from an XML-format source file into a target file of any appropriate format. As indicated above other possible target file-to-source file combinations may include, but are not limited to XML file-to-XML file, flat file-to-XML file, and XML file-to-flat-file transformations.

[0094] **FIG. 7A** is a flowchart illustrating steps that may be taken by server **106** and XML Interface **600** in executing the example script **500** shown in **FIGS. 5A-5C** to transform a portion of a particular set of database tables (referred to generically here as the "source files" for this transformation) into an XML document having a particular format (referred to generically as the "target file" in this transformation). More specifically, **FIG. 7A** illustrates the transformation of a plurality of PERSON rows from a PERSON table and a plurality of associated CAR rows from a CAR table into a plurality of XML records that each includes information about a particular person and one or more cars associated with that person.

[0095] The process begins at step **710** with server **106** initiating execution of the generated script. At step **720**, server **106** creates array **502** describing the target data definition (here, the PersonCars XML Object definition) and initializes one or more values of its various array elements. For example, using example script **500** illustrated in **FIGS. 5A-5C** as an example, during initialization server **106** creates the "PersonCars_Document" array and sets the "name, ""type,""id,""parent," and "level" of each element of the "PersonCars_Document" array based on the PersonCars XML data definition that was supplied at the time of script creation.

[0096] At step **730**, the relevant interfaces CONNECT to the source file and target file. In particular here, XML interface **600** issues a CONNECT to connect to the XML target file, while database interface **116** issues CONNECTs to the "Person" table and the "Cars" table in the relational database associated with database interface **116**. At this point, server **106** may also initialize other operational variables, clear temporary memory, and/or perform any other steps appropriate to facilitate input and output to the relevant files.

[0097] The appropriate interface then begins reading data from the source file. Here, database interface **116** begins reading data from the relevant database tables. In particular, database interface **116** transmits a SEND request to the PERSON table to request all PERSON rows at step **740**. These PERSON rows may then be buffered in temporary memory by database interface **116** until needed.

[0098] At step **750**, server **106** determines whether another PERSON row can be loaded from those stored in memory by issuing a LOAD call on the PERSON table. If server **106** determines that no more rows remain to be processed, server **106** continues operation at step **800**. If, instead, server **106** determines that additional rows remain to be processed, server **106** accesses the next remaining PERSON row and transforms the data in this PERSON row for output to the target XML file. As part of this process, server **106** may also iteratively process any repeating data elements associated with this PERSON row.

[0099] For example, in the illustrated example, server **106** transmits a SEND request to the CARS DBMS table to request the CAR rows having a particular ID value at step **760**. These CAR rows may then be buffered in temporary memory. At step **770**, server **106** determines whether any CAR repeating elements remain to be processed by issuing a LOAD on the identified CAR rows. If server **106** determines that no more CAR rows remain to be processed for this particular PERSON row, server **106** continues operation at step **790**. If, instead server **106** determines that additional CAR rows remain to be processed for this particular PERSON row, server **106** accesses the data in the next remaining CAR row and issues a STORE for the relevant CAR row at step **780**. As a result of the STORE, data from this CAR row will be cached internally by XML interface **600** along with other data previously cached for the repeating XML data component type associated with these CAR rows. In particular embodiments, this data may saved in the buffer until being written to the target XML file when the STORE for the parent data component is processed (e.g., at step **790** in this example). Additionally, in particular embodiments, server **106** may also format or otherwise modify the data extracted from the relevant CAR rows to match the target data definition associated with the target file. For example, server **106** may modify the format of a model year stored in a particular CAR row to match the target year format associated with the data definition for the target XML file.

[0100] Once the appropriate data for a particular data component in the target XML file has been buffered, including any appropriate repeating elements, XML interface **600** writes the data component to the target XML file. More specifically, in the illustrated example, XML interface **600** writes out a Person_Car XML record to the target XML file at step **790**. Operation then returns to step **750** and server **106** attempts to LOAD another PERSON row.

[0101] Once data for all of the XML data components has been LOADed from the appropriate source files, database interface **116**, XML interface **600** and server **106** may complete any steps appropriate to finalize the transformation and close the source file and target file. In the illustrated example, as part of this process, server **106** performs a write of the last remaining XML data component to the target XML file, and XML interface **600** and database interface **116** issue DISCONNECTs to the target XML file and source database tables respectively at step **800**. At step **810**, server **106** completes execution of the example script and terminates operation with respect to this particular data transformation. The target XML file may now be viewed by an appropriate XML editor.

[0102] **FIG. 7B** is an example output of the example method of **FIG. 7A** according to one embodiment of the invention. As indicated in **FIG. 7B**, an XML file **798** is illustrated in which car data for particular persons are arranged in an XML format. This data was extracted from database tables, such as source tables **404***a*, **404***b* (**FIG. 4**).

[0103] **FIG. 8**, as noted above, illustrates an example operation of XML interface **600** in executing another transformation. In particular, **FIG. 8** illustrates operation of server **106** and XML Interface **600** in executing another example script (not shown) generated to transform the data in the XML file shown in **FIG. 7B** (representing the source file for this transformation) into an arrangement of DBMS rows (representing the target files in this transformation) having a particular format. Moreover, **FIG. 8** provides additional detail for some of the high-level steps identified in **FIG. 7**, with respect to how these steps might be implemented in a particular embodiment of system **100**.

[0104] The process begins at step **900** with server **106** initiating execution of the script generated to perform this transformation. At step **910**, server **106** creates an array describing desired data that will be stored in the target files (here, the fields of the PERSONS rows and the associated CARS rows) based on the target data definition defined by the executing script. Server **106** additionally initializes one or more values of the various array elements in this array.

[0105] At step **920**, the relevant interfaces CONNECT to the source file and target file. In particular here, XML interface **600** issues a CONNECT to connect to the XML source file, while database interface **116** issues CONNECTs to the "Person" table and the "Cars" table in the relational database associated with database interface **116**. At this point, server **106** may also initialize other operational variables, clear temporary memory, and/or perform any other steps appropriate to facilitate input and output to the relevant files.

[0106] At step **930**, XML interface **600** begins parsing the XML source file **798** which includes multiple XML data records. While parsing, XML interface **600** determines at step **940** whether XML interface **600** has reached the start of an XML data component (e.g., based on the detection of a start delimiter in the parsed data). When XML interface **600** determines that it has detected the beginning of an XML data component, XML interface **600** determines, at step **950**, whether this data component should be included in the target file. In particular embodiments, XML interface **600** may determine whether to include the detected data component by traversing the array and determining whether the "Name" field of any array element matches the name of the detected XML component. If not, XML interface **600** discards the detected data component at step **960** and proceeds with parsing at step **1060**.

[0107] If, instead, XML interface **600** is able to match the name of the detected XML component to the "Name" field of one of the array elements, XML interface **600** processes the data component for inclusion in the array. As part of this process, XML interface **600** determines, at step **970**, whether the detected data component has any children components. If so, XML interface **600** parses and processes the children components, at step **980**, in a similar fashion deciding whether each should be included in the array. (Although shown, for the sake of simplicity, as a single box, this process may, depending on the hierarchy of the detected children, be an iterative process that follows a flow similar to that taken to process the detected parent component.)

[0108] XML interface **600** then determines at step **990** whether the detected data component is of a repeating component type. In particular embodiments, XML interface **600** may determine this by checking a field, such as an "IsRepeating" field of the array **502** illustrated in **FIG. 5A**. If XML interface **600** determines that the detected data component is not of a repeating component type, XML interface **600** sets a field (e.g., a "Value" field) of the matched array element to the value of the detected data component at step **1000**. As a result, data from matched data components will be stored in their corresponding array elements.

[0109] If XML interface **600** determines that the detected component is of a repeating component type, XML interface **600** stores the value of the detected component in a temporary buffer at step **1010**. XML interface **600** then determines if there are additional data components of the same component type immediately following the detected component at step **1020**. If so, XML interface **600** stores the next repeating data component in the buffer at step **1030** and adds a pointer back to the previous repeating element at step **1040**. XML interface **600** then returns to step **1020**. Once all repeating elements of that component type have been stored in the buffer, XML interface **600** adds a pointer to the last repeating element of that type to a field (e.g., a "Value" field) of the matched array element (i.e., the array element that originally matched the name of the first data component of this repeating type) at step **1050**. XML interface **600** then returns to parsing the remainder of the source XML file.

[0110] At step **1060**, the interface **108** associated with the target file, in this case data base interface **116**, issues a STORE on any non-repeating data from the currently-parsed data component, thereby writing the non-repeating data to the target file. XML interface **600** then determines whether the currently-parsed data component has any repeating children at step **1070**. If so, XML interface **600** retrieves, from the memory buffer, data from one of the repeating children and database interface **116** issues a STORE on this repeating child data, writing the data to the target file at step **1080**. XML interface **600** and database interface **116** repeat this process until all of the repeating children have been stored, returning to step **1070** until no more children remain in memory.

[0111] As one example, in the described configuration, the target files represent associated rows in the PERSONS and CARS tables. As a result, database interface **116** may write the values stored in a particular field (e.g., a "Value" field) of the array elements associated with non-repeating component types to a PERSON row in the PERSON table. Database interface **116** then accesses the memory location identified by the pointer stored in the array elements associated with any repeating component types, here the CARS data components, and writes the values stored at that location to the target files in the appropriate manner based on the type of target files. In the illustrated example, database interface **116** creates a CAR row for each CAR data component and adds it to the CARS table. Because the associated PERSON row was already created and added to the PERSONS table, database interface **116** can also incorporate an ID identifying the associated PERSON row into each of the newly-created CAR rows.

[0112] After database interface **116** stores or saves the appropriate data, XML interface **600** determines whether it has completed parsing the XML source file at step **1090**. For example, in particular embodiments, XML interface **600** may determine if it has completed parsing the last data component based on whether or not XML interface **600** has detected an end delimiter associated with the root data component. If XML interface **600** has not completed parsing the XML source file, XML interface **600** returns to step **930** and continues parsing the XML source file.

[0113] If, instead, XML interface **600** determines that it has finished parsing the XML source file, XML interface **600**, database interface **116**, and server **106** may complete any steps appropriate to finalize the transformation and close the source file and target file. As part of this process, XML interface **600** and database interface **116** issue DISCONNECTs to the target XML file and source database tables respectively at step **1100**. At step **1110**, server **106** completes execution of the example script and terminates operation with respect to this particular data transformation.

[0114] **FIGS. 9-12** illustrate the operation of particular embodiments of data transformation systems that may utilize web services in various ways to supplement the transformation functionality described above with respect **FIGS. 1-8**. **FIG. 9** illustrates the operation of a system **120** capable of generating data transformation scripts that are similar to those described above but that may be executed as web services. Meanwhile, **FIGS. 10-12** illustrate the operation of a system **160** capable of generating data transformation scripts that are also similar to those described above but that may invoke web services offered by other servers to complete requested data transformations. The incorporation of web service features into ADT systems such as these may increase the flexibility of these ADT systems and may further reduce the amount of design required of ADT users.

[0115] **FIG. 9** illustrates a system **120** that allows transformation scripts (referred to herein as "web-invoked scripts **125**") to be executed via a web service call. In general, the ability to execute such web-invoked scripts **125** as a web service may allow the existing program execution architecture of system **100** to be accessed by remote devices through a call handled by a web server **124** with execution-specific data passed in and out. Additionally such a configuration may allow system **120** to schedule the execution of a web-invoked script **125** for a future time and/or add other forms of flexibility to the transformation functionality described above. As shown in **FIG. 9**, system **120** includes ADT **121**, web server **124**, client **122**, and network **123**. Moreover, web server **124** includes network interface module **128** and messaging module **129**, while ADT **121** includes mapper module **142**, script manager **144**, server **146**, interfaces **148**, and internal database **154**. Except as explicitly noted below, mapper module **142**, script manager **144**, server **146**, interfaces **148**, and internal database **154** may, in particular embodiments, all operate in a similar fashion to that described above with respect to similarly-labeled components of ADT **101**. In addition, ADT **121** includes scheduler **138**.

[0116] In general, web server **124** receives service requests **130** from one or more clients **122** requesting data transformation service. Web server **124**, in turn, requests these data transformation services from server **146**. After server **146** completes the desired data transformation using web-invoked scripts **125**, web server **124** may also transmit a service response **131** to client **122** with the results of the requested data transformation services. Web server **124** may represent any appropriate combination of software and/or hardware suitable to provide the described functionality. For example, in particular embodiments, web server **124** may represent a server running Apache Tomcat. Additionally, in particular embodiments, web server **124** may represent the same physical component as ADT **121**. For example, ADT **121** and web server **124** may represent applications running on the same computer. Alternatively, as suggested by dotted line **127** between ADT **121** and web server **124**, in particular embodiments, ADT **121** and web server **124** may represent separate physical devices, or applications running on separate physical devices, operable to communicate with one another.

[0117] Client **122** may represent a software application executing on a suitably configured personal computer (PC), networked terminal, or any other appropriate device capable of accessing web services. Although the description below focuses on embodiment of system **120** in which client **122** is running on a separate physical device remote from ADT **121**, in particular embodiments, client **122** may represent a software application running on the same computer as ADT **121** and/or web server **124**. Network **123** may represent a local area network (LAN), portions of the Internet, or any other suitable public or private communications network. Web server **124**, server **146**, network interface module **128**, and messaging module **129** represent any appropriate combination of hardware and/or software suitable to provide the described functionality.

[**0118**] In operation, ADT **121** generates web-invoked scripts **125** to perform user-defined data transformations. A user of system **120** may define the relevant transformations and ADT **121** may generate the corresponding web-invoked scripts **125** in any appropriate manner. In particular embodiments, a GUI similar to the one described in **FIGS. 3A-3C** and **4A-4B**, may be modified for used in creating web-invoked scripts **125**. For example, the GUI of **FIG. 4** may be modified to include a "Web Services" select box that the user may select, when creating a script using the process described above with respect to **FIG. 4**, to indicate that the transformation currently being defined is intended to be provided as a web service. When the user selects the box to indicate that this script is to be executed as a web service, the GUI may enable a number of GUI inputs for defining web-invoked scripts **125**. As a result, in particular embodiments, server **146** may receive information identifying web-service-capable transformation web-invoked scripts **125** in a similar fashion to that described above with respect to scripts **115**.

[**0119**] Furthermore, web-invoked scripts **125** may also be similar in structure to scripts **115** described above with respect to **FIGS. 5A-5C** with suitable modifications made to the code to allow web-invoked scripts **125** to utilize data from web service messages as the target and source files of the relevant data transformation. For example, in particular embodiments, the LOAD and STORE functions for the XML interface described above accept a "#ws_xml" field that indicates whether the target or source file, respectively, should be retrieved from a web service request or transmitted as a web service response. For web-invoked scripts **125** this field is set true when the web-invoked script **125** is generated.

[**0120**] ADT **121** may be configured to generate web-invoked scripts **125** that accept input data from client **122** and/or provide output data to client **122**. In particular embodiments, a particular web-invoked script **125** may be configured not to accept input data from client **122** and/or not provide output data to client **122**, depending on the configuration of ADT **121** and the transformation defined for the relevant web-invoked script **125**. In such embodiments, web-invoked scripts **125** may be configured to retrieve input data from local memory and/or to store output data to local memory as an alternative to exchanging data with client **122**.

[**0121**] Additionally, once a particular web-invoked script **125** has been generated, system **120** may be configured to create a service definition **134** that can be used to provide client **122** with information regarding the appropriate manner for communicating with web server **124** to request the associated transformation as a web service. Service definition **134** may represent a Web Services Description Language (WSDL) file, and XML schema, and/or any other appropriate collection of information identifying for client **122** the appropriate inputs to use and/or outputs to anticipate when requesting the execution of the relevant web-invoked script **125** as a web service. In particular embodiments, service definition **134** may be generated by mapper module **142** when a particular data transformation is defined and a user requests the associated script be made available as a web service. In particular embodiments, when the user chooses to have service definition **134** generated, mapper module **142** may generate this service definition **134**"automatically" in the sense that mapper module **142** may generate service definition **134** based on mappings in the program palette without any additional input from the user beyond the initial request for generation of service definition **134**. Server **146**, web server **124**, or any other appropriate component of system **120** may then publish service definition **134** at an appropriate registry (e.g., in a Universal Description, Discovery, and Integration (UDDI) repository) for access by clients **122** in system **120**, transmit service definition **134** to requesting clients **122**, or otherwise make service definition **134** available to clients **122**.

[**0122**] After one or more web-invoked scripts **125** have been generated, client **122** may request data transformation services by transmitting a service request **130** to web server **124** over network **123**. Service request **130** may represent a Simple Object Access Protocol ("SOAP") message, an Electronic Business using eXtensible Markup Language ("ebXML") message, or a message of any other type or format appropriate for requesting web services. Service request **130** may include request data **132**, such as one or more XML data components; one or more DBMS table entries, rows, or columns; or any other appropriate collection of data. In particular embodiments, web server **124** may also be configured to support scheduled processing of service requests **130**, and service request **130** may also specify that the request is for a scheduled execution and supply a requested execution time **139**.

[**0123**] A network interface module **128** of web server **124** receives service request **130** and processes service request **130** to facilitate execution of the request by ADT **121**. Network interface module **128** may represent any appropriate hardware and/or software suitable to provide the described functionality. In particular embodiments, network interface module **128** comprises a Java servlet that handles initial message decoding and a Java Native Interface (JNI) for communicating with messaging module **129**.

[**0124**] Network interface module **128** performs any appropriate decoding of service request **130** and extracts request data **132**. For example, as noted above, in particular embodiments, service request **130** represents a SOAP message, and network interface module **128** performs initial SOAP decoding of service request **130** and extracts request data **132** from the service request **130**. Network interface module **128** then passes request data **132** and any other appropriate information from the service request **130**, such as the requested execution time **139**, to a messaging module **129** of web server **124**. In particular embodiments, a Java servlet of network interface module **128** passes the request data **132** to messaging module **129** using JNI.

[**0125**] Messaging module **129** receives request data **132** from network interface module **128** and interacts with server **146** to facilitate completion of the requested data transformation. In particular embodiments, messaging module **129** may interact with server **146** using threaded messages **135**. For example, in particular embodiments, web server **124** and server **146** may be operating in a system using Computer Associate's Platinum Enterprise Communicator (PEC), and threaded messages **135** may represent PEC messages transmitted between messaging module **129** and server **146**.

Additionally, threaded messages **135** may each include a thread identifier and/or a source identifier to allow both web server **124** and server **146** to coordinate communication and processing related to service request **130**.

[0126] Thus, after receiving the decoded service request **130**, messaging module **129** transmits one or more threaded messages **135** to server **146** to request transformation services. As part of one or more of the threaded messages **135**, messaging module **129** communicates the request data **132** to server **146**. In particular embodiments, server **146** may be able to identify, based on the name and/or structure of request data **132**, an appropriate web-invoked script **125** to execute from among a plurality of web-invoked scripts **125** currently stored in internal database **154**. Alternatively, messaging module **129** may also communicate additional information to server **146** to allow server **146** to determine the appropriate data transformation to be completed. For example, in particular embodiments, messaging module **129** may also include the name of a particular web-invoked script **125** to be executed by server **146** in completing the desired data transformation.

[0127] Server **146** receives threaded messages **135** from web server **124** and initiates one of web-invoked scripts **125** using request data **132** as the source file. As noted above, in particular embodiments, web-invoked scripts **125** may be generated with LOAD statements that are configured to receive input data from service requests **130** and/or with STORE statements that are configured to write output data to service responses **131**. Once server **146** has completed execution of the appropriate web-invoked script **125**, server **146** may communicate back any appropriate output, including any response data **133** generated as a result of the execution of the relevant web-invoked script **125**, to the messaging module **129** of web server **124** in one or more threaded messages **135**. Alternatively, server **146** may store any output of the executed web-invoked script **125** locally and may not communicate any response data **133** back to web server **124**. In particular embodiments, response data **133** for all scheduled data transformations may be stored local to ADT **121**, and clients **122** may not receive any response data **133** when requesting scheduled data transformation services.

[0128] Messaging module **129** receives threaded messages **135** from server **146** and forwards threaded message **135** (or information obtained from the threaded message **135**) to network interface module **128**. Network interface module **128** then determines an appropriate client **122** to which a service response **131** should be transmitted. Network interface module **128** generates a service response **131** and transmits service response **131** to the client **122** that originally transmitted the corresponding service request **130**. Service response **131** includes the response data **133** received from server **146**. As a result of this process, a remote user using client **122** may be able to remotely access and utilize the data transformation capabilities of ADT servers using web service calls.

[0129] Additionally, as suggested above, particular embodiments of web server **124** and server **146** may support scheduled execution of the data transformations requested via web service calls. More specifically, web server **124** may receive service requests **130** that include an execution time **139**. Server **146** may then execute the web-invoked script **125** corresponding to the requested transformation at a time determined based on execution time **139**. For example, particular embodiments of server **146** may include a scheduler **138**. Messaging module **129** may determine, based on the inclusion of execution time **139** in particular service requests **130**, that those requests are to be scheduled for execution at a later time. For these service requests **130**, messaging module **129** may transmit, to scheduler **138**, threaded messages **135** that include the request data **132** and execution time **139**. Scheduler **138** may then store request data **132**, execution time **139**, and any other appropriate information to allow server **146** to properly execute the desired transformation. At an appropriate time, scheduler **138** may then initiate the desired web-invoked script **125** or instruct other components of server **146** to initiate the desired web-invoked script **125**. If the service request **130** included a request data **132**, scheduler **138** may provide this to the relevant components as well.

[0130] Additionally, scheduler **138** may determine the appropriate time to begin execution of the relevant script based in any suitable manner on execution time **139**. For example, execution time **139** may represent an initiation time at which scheduler **138** will execute the web-invoked script **125**, a completion time at which the web-invoked script **125** must be completed, or a priority level that server **146** will use to order the various tasks server **146** currently has scheduled.

[0131] Thus, system **120** provides a flexible solution for data transformation solutions. As a result, system **120** may be capable of providing a variety of services to remote users using standardized interfaces. Moreover, system **120** may be configured to provide clients **122** information as to the services offered by server **146** and the proper manner for accessing those services through the use of a service definition **134**. Additionally, system **120** may be capable of timing the execution of the relevant data transformation based on the desires of the requesting user. As a result, system **120** may provide a number of operational benefits.

[0132] **FIG. 10** illustrates a system **160** that utilizes web services to provide functionality for transformation programs (referred to herein as "web-utilizing scripts **155**"). In general, system **160** allows a user to identify a web service to be called to provide all or a portion of a particular data transformation. In particular embodiments, web-utilizing scripts **155** may be identical to particular types of scripts **115** described above with respect to **FIGS. 1-8** with the added ability to invoke external web services based on a defined data transformation. The web service is identified during mapping and a particular web-utilizing script **155** is generated to perform the defined data transformation using the specified web service.

[0133] In the illustrated embodiment, system **160** includes an ADT **181**, a web server **162**, a network **163**, and a proxy server **164**. ADT **181** includes server mapper module **182**, script manager **184**, server **186**, interfaces **188**, and internal database **194**. Except as explicitly noted below, mapper module **182**, script manager **184**, server **186**, interfaces **188**, and internal database **194** may, in particular embodiments, all operate in a similar fashion to that described above with respect to similarly-labeled components of ADT **101**. In addition, ADT **181** includes service interface module **183**.

[0134] Service interface module **183** is responsible for receiving input parameters from server **186** during execution of a web-utilizing script **155**, packaging input parameters, invoking the web service, and un-packaging output parameters. Although the description below focuses on examples in which ADT **181** transmits input data to the requested web service and receives particular output data back from the web service, particular web services may be configured to receive no input data and/or to transmit no output data back to ADT **181**. In particular embodiments, service interface module **183** includes a dynamically-linked C++ library capable of receiving appropriate input data (as described further below), structuring the input data in an appropriate manner for the particular web service to be invoked, and communicating the data to a SOAP tool, which in turn transmits a SOAP message containing the data to the designated web server **162**. In particular, the dynamically-linked library may support a generic web execution function capable of calling any web service identified by function parameters **174** received by the generic web execution function. In general, however service interface module **183** may represent any suitable hardware and/or software appropriate to communicate with web servers and utilize web services.

[**0135**] Web server **162** may represent any appropriate component providing any functionality (generically referred to herein as "web services **175**") that can be utilized through the transmission of a suitably-structured request and the receipt of a corresponding response. For example, in particular embodiments, web server **162** may comprise an Apache Axis or Microsoft NET server supporting web services **175**. In general, however, web server **162** may represent any appropriate combination of software and/or hardware suitable to provide the described functionality.

[**0136**] In operation, mapper module **182** receives information defining a data transformation that utilizes a web service **175** and generates a web-utilizing script **155** that invokes the relevant web service **175** to execute the defined transformation. Web-utilizing scripts **165** may be similar in content and operation to scripts **115** described above with respect to **FIGS. 1-8**, but with the addition of web service calls to, in part, transform data extracted from source data files into data to be written into target data files. An example of a particular web-utilizing script **165** is shown in **FIG. 12** and discussed below.

[**0137**] More specifically, mapper module **182** allows a user to design a transformation program to transform data via mappings from one or more source files to one or more target files utilizing one or more specified web services. In particular embodiments, the mapping may be defined via a GUI having a program palette (as shown in **FIG. 11**) in which a user is allowed to select a source object definition, a target object definition, and a web service definition **178**. In particular embodiments, web service definition **178** may comprise information defining inputs expected by and outputs transmitted by the corresponding web service **175**. The user may then drag and drop data components from a graphical representation of the source object definition into a graphical representation of the web service definition **178**, and then drag and drop outputs of web service definition **178** into a graphical representation of the target object definition in order to define the desired transformation.

[**0138**] As part of the information the user provides the define the transformation, the user may identify a source object definition, a target object definition, and a web service definition **178** that will be utilized as part of the transformation. With respect to the web service, the user may identify such information as the web service Uniform Resource Indicator (URI) location, the method to invoke for the web service, a proxy server to contact, and/or any other appropriate information to facilitate communication between the web-utilizing script **155** and the relevant web service **175**.

[**0139**] The user may also provide a web service definition **178** to be displayed in a GUI associated with ADT **181**. Web service definition **178** defines the inputs and outputs associated with a particular web service **175** and any additional information service interface module **183** may need to request web services from a particular web server **162**. The user may provide web service definition **178** to ADT **181** in any suitable manner. In particular embodiments, ADT **181** may be capable of parsing a WDSL, XML schema, or other suitable description of a web service to automatically generate web service definition **178**. In alternative embodiments, the user may provide web service definition **178** to ADT **181** manually, identify a previously-saved web service definition **178**, or provide web service definition **178** to ADT **181** in any appropriate manner.

[**0140**] After the user has provided one or more source object definitions, one or more target object definitions, and one or more web service definitions **178**, the user specifies mappings between source file components and target file components, between source file components and web service inputs, and/or between web service outputs and target file components. Once the user has provided the appropriate information to define the transformation, mapper module **182** generates a web-utilizing script **155** to perform the defined data transformation. This web-utilizing script **155** will include calls to the identified web service **175** through service interface module **183**.

[**0141**] Web-utilizing scripts **155** may be stored by mapper module **182** until a user requests the corresponding data transformation be executed. When a particular web-utilizing script **155** is executed, server **186** will execute that web-utilizing script **155** and as part of this process will perform data transformations that utilize web services. More specifically, in particular embodiments, web-utilizing script **155** will include a call to service interface module **183** that will transfer various function parameters **174** to service interface module **183** for use in generating a service request **166**. The exact data that is included in function parameters **174** may depend on the configuration of server **186**, web server **162**, and/or service interface module **183**. In particular embodiments, function parameters **174** includes the URI for the relevant web service, the method to be invoked by that web service, any input data **168**, and/or empty output data structures to be filled with the results of the web service. Input data **168** may represent data of any appropriate format including, but not limited to, one or more XML data components, one or more database rows, or any portion of a flat file. Similarly, the output data structures may represent empty XML data components, empty rows, empty variables, or any other suitable structure for holding data. Particular data transformations may not require input data or return output data, and the web service calls executed by web-utilizing scripts **155** may be tailored to reflect this fact.

[0142] After receiving function parameters **174** from server **186**, service interface module **183** invokes the designated web service **175**. In particular embodiments, this process includes connecting to the URI specified in the function parameters **174**, transferring the input data **168** into a service request **166**, and transmitting service request **166** to a particular web server **162** associated with the specified URI. In particular embodiments, service request **166** represents a SOAP message that contains input data **168**. Alternative embodiments may use other appropriate communication protocols to request web services and otherwise interact with web server **162**.

[0143] Web server **162** receives service request **166** and unpacks data included in service request **166**. Web server **162** identifies the appropriate method to invoke based on information in the received service request **166** and invokes the identified method with respect to input data **168**, if any, that is included in service request **166**. After the method has been invoked, web server **162** transmits output data **169**, if any, back to service interface module **183** as part of a service response **167**.

[0144] Service interface module **183** receives service response **167** and completes the data transformation requested by the user. In particular, service interface module **183** receives service response **167**, performs any appropriate unpacking of service response **167**, and transfers output data **169**, if any, into the empty data structures passed to service interface module **183**. Service interface module **183** then transmits the output data **169** back to server **186** for use in completing execution of web-utilizing script **155**. In particular embodiments, service interface module **183** transmits the output data **169** to server **186** as the return value of the generic web execution function originally called by service interface module **183**.

[0145] In addition, particular embodiments of service interface module **183** may support the use of proxy servers **164** (e.g., for use with firewalls) to communicate with web server **162**. More specifically, in particular embodiments of system **160**, function parameters **174** passed to service interface module **183** may include information that allows service interface module **183** to identify a proxy server **164** to use when invoking a particular web service. This information may include a proxy server host name, an appropriate port number to use when communicating with the designated proxy server **164**, a user identifier recognized by the designate proxy server **164**, a password associated with the designated proxy server **164**, and/or any other suitable information to facilitate communication between server **186** and proxy server **164**. Alternatively, some or all of this type of information may be stored in a proxy profile, and function parameters **174** may identify the appropriate profile to use when invoking the relevant web service. Server **186** may then direct any communication with web server **162** through proxy server **164**. This may allow users to utilize publicly-available web services **175** for data transformations without compromising the security of their own systems.

[0146] Thus, system **160** provides additional flexibility and user ease with respect to the execution of data transformations. By allowing a user to access and utilize available web services, system **160** may further reduce the amount of programming and/or design the user must complete. Automated parsing of web service definitions may improve ease-of-use even further in some embodiments. Additionally, particular embodiments may be configured to interact with web service through a proxy server, thereby making web-service functionality available for data transformations without compromising security.

[0147] **FIG. 11** illustrates an example screen shot **1200** illustrating functionality of a GUI that may be used, in particular embodiments of system **160**, to define a data transformation that utilizes one or more web services. In particular, **FIG. 11** illustrates a program palette **1202** that allows a user to design a desired data transformation from one or more source files to one or more target files using one or more web services. The illustrated embodiment includes a graphical representation of a source object definition **1204**, a target object definition **1206**, a reusable transformation **1207**, and a web service definition **1208**. Although **FIG. 11** and the description below focus, for purposes of illustration, on a particular type of GUI that allows a user to enter certain information in a specific manner, system **160** may utilize any appropriate form of GUI to facilitate interaction with a user. Moreover, particular embodiments of system **160** may include no GUI and users may enter information manually, instruct system **160** to retrieve saved information, and/or provide information to system **160** in any other suitable manner. Furthermore, **FIG. 11** illustrates, for purposes of example, a scenario in which a web service is utilized to transform portions of a source database table into a target database table. Nonetheless, the described techniques may be utilized with target and source files of any appropriate format including XML files and flat files.

[0148] With respect to the particular GUI illustrated in **FIG. 11**, a user may begin entering information by dragging and dropping of object definitions **1204** and **1206**, reusable data transformation **1207**, and web service definition **1208** into program palette **1202**. For example, in the illustrated example, a user has dragged a source object definition **1204** named “StockCompanies” and a target object definition **1206** named “StockQuotes” into program palette **1202**. Additionally, the user has dragged a web service definition **1208** named “GetQuoteWS” and a reusable data transformation **1207** named “GetCurrentTime” into program palette **1202**. The “GetQuoteWS” web service definition **1208** in the illustrated example is associated with a web service **175** that provides stock prices for specified stock symbols. In addition, particular embodiments of ADT **181** may support scripted, reusable functionality, such as one or more reusable data transformations **1207**, that provide data transformations and/or custom outputs that may be used to execute frequently-used data transformations or to generate frequently-used data outputs. Here reusable data transformation **1207** provides the current time as output **1218***b*.

[0149] Once the appropriate object definitions **1204** and **1206**, any reusable transformations **1207**, and any web service definitions **1208** have been introduced to program palette **1202**, the user may define connections **1210** between specific data components **1212** of source object definitions **1204** and target object definitions **1206** and particular inputs **1216** and outputs **1218** of web service **175**. In particular embodiments, the user may do this by dragging and dropping components of source object definition **1204** onto inputs **1216** of web service definition **1208** or reusable data transformation **1207** or onto components of target object definition **1206**, and by dragging and dropping outputs **1218** of web service definition **1208** or reusable data transformation **1207** onto components of target object definition **1206**.

[**0150**] For example, in the illustrated scenario, the user has dragged the "Stock Symbol" data component **1212***b* from the "StockCompanies" source object definition **1204** to the "symbol" input **1216** of "GetQuoteWS" web service definition **1208** forming connection **1210***a*. The user has also dragged the "Stock Symbol" data component **1212***b* from the "StockCompanies" source object definition **1204** to the "StockSymbol" data component **1212***c* of the "StockQuotes" target object definition **1206** forming connection **1210***b*. Additionally, the user has dragged the "Result" output **1218***a* of the "GetQuoteWS" web service definition **1208** to the "StockPrice" data component **1212***e* of the "StockQuotes" target object definition **1206** forming connection **1210***c*. The user also has dragged the "timestamp" output **1218***b* of the "GetCurrentTime" reusable transformation **1207** to the "QuoteDateTime" data component **1212***d* of the "StockQuotes" target object definition **1206** to create connection **1210***d*.

[**0151**] After moving the relevant object definitions **1204** and **1206**, web service definitions **1208**, and reusable data transformations **1207** to program palette **1202** and creating the appropriate connections **1210**, the user may then utilize system **160** to generate a web-utilizing script **155** to implement the defined transformation. In particular embodiments, the GUI for defining the transformation may additionally include a "Generate Script" button or other input the user can use to request a web-utilizing script **155** be generated from the mappings the user has created on program palette **1202**. Alternative embodiments may use any appropriate mechanism for the user to request script generation.

[**0152**] **FIGS. 12A and 12B** collectively illustrate an example of a web-utilizing script **155** that may be generated by a particular embodiment of system **160** based on the transformation defined in **FIG. 11**. Although **FIGS. 12A and 12B** illustrate one example of a particular web-utilizing script **155** that may be generated to implement the transformation defined in **FIG. 11**, alternative embodiments of system **160** may generate other types of web-utilizing scripts **155** to implement the illustrated transformation based on the configuration and capabilities of system **160**. For purposes of description, the web-utilizing script **155** is broken into multiple sections **1310**.

[**0153**] Section **1310***a* identifies a code fragment that defines various variables and structures to be used during execution of web-utilizing script **155**. Section **1310***b* generates the array that will be used to pass XML data from server **186** to service interface module **183** as part of function parameters **174**. This array will store any input data that will be transmitted by service interface module **183** to the appropriate web service **175**. ser. Section **1310***c* constructs the data structure that will be used to pass information about the relevant web service to service interface module **183** as another part of function parameters **174**. Section **1310***d* constructs the empty data structure that will be filled with output data **169** and passed to service interface module **183** as yet another part of function parameters **174**. Section **1310***e* sets the input values that will be sent to service interface module **183** as part of function parameters **174**. In the illustrated example, section **1310***e* is defined by connection **1210***a* in the associated mapping shown in **FIG. 11**. Section **1310***f* calls service interface module **183** using function parameters **174**. Section **1310***g* verifies that the call to service interface module **183** was successful. Section **1310***h* processes output data **169** received back from service interface module **183**. In the illustrated example, section **1310***h* is defined by connection **1210***c* in the associated mapping shown in **FIG. 11**.

[**0154**] Although the present invention has been described with several embodiments, a myriad of changes, variations, alterations, transformations, and modifications may be suggested to one skilled in the art, and it is intended that the present invention encompass such changes, variations, alterations, transformations, and modifications as fall within the scope of the appended claims.

What is claimed is:

1. A method of transforming data:

receiving information defining a transformation of an input data object to an output data object;

generating, based on the received information, a script operable when executed to implement the defined transformation;

storing the script;

receiving a service request from a remote client, wherein the service request requests a particular transformation and identifies a request data object;

identifying a script that performs the requested transformation;

generating a response data object by executing the identified script on the request data object; and

transmitting the response data object to the remote client.

2. The method of claim 1, wherein receiving a service request from a remote client comprises receiving a service request invoking a web service.

3. The method of claim 1, wherein the service request identifies a request data object by including the request data object.

4. The method of claim 1, wherein receiving a service request comprises receiving a Simple Object Access Protocol (SOAP) message from the remote client, and wherein transmitting the service response to the remote client comprises transmitting a SOAP message to the remote client.

5. The method of claim 1, wherein:

generating a script capable of implementing the defined transformation comprises:

generating a service definition describing a request data object and a response data object associated with the script; and

transmitting the service definition to the remote client;

receiving a service request comprises receiving a service request that includes a request data object that conforms with the service definition; and

generating a response data object comprises generating a response data object that conforms with the service definition.

6. The method of claim 5, wherein the service definition comprises a Web Services Description Language (WSDL) file.

7. The method of claim 1, wherein identifying a script associated with the service request comprises identifying, based on a name of the request data object, a script associated with the service request.

8. The method of claim 1, further comprising storing the response data object in memory.

9. The method of claim 1, wherein receiving information defining a transformation of an input data object to an output data object comprises

receiving, from a user, through a graphical user interface (GUI) information describing an input data object associated with the transformation;

receiving, from the user, through the GUI information describing an output data object associated with the transformation; and

receiving, from the user, through the GUI information identifying a mapping of components in the input data object to components in the output data object.

10. The method of claim 1, wherein the request data object and the response data object comprise extensible Markup Language (XML) data objects.

11. A method of transforming data:

receiving information defining a transformation of an input data object to an output data object;

generating, based on the received information, a script operable when executed to implement the defined transformation based on the received information;

storing the script;

receiving a service request from a remote client, wherein the service request requests the defined transformation and identifies a request data object and a requested execution time;

generating a response data object by executing the script on the request data object at a time determined based on the requested execution time; and

storing the response data object in memory.

12. The method of claim 11, wherein receiving a service request from a remote client comprises receiving a service request invoking a web service.

13. The method of claim 11, wherein receiving a service request comprises receiving a Simple Object Access Protocol (SOAP) message from the remote client.

14. The method of claim 11, wherein:

generating a script capable of implementing the defined transformation comprises:

generating a service definition describing a request data object and a response data object associated with the script; and

transmitting the service definition to the remote client; and

receiving a service request comprises receiving a service request that includes a request data object that conforms with the service definition.

15. The method of claim 14, wherein the service definition comprises a Web Services Description Language (WSDL) file.

16. The method of claim 11, wherein storing the script comprises storing the script in a database that includes a plurality of scripts each operable when executed to implement a different transformation; and wherein generating the response data object comprises:

identifying, in the database, a script associated with the service request, and

generating a response data object by executing the identified script on the request data object.

17. The method of claim 16, wherein identifying a script associated with the service request comprises identifying, based on a name of the request data object, a script associated with the service request.

18. The method of claim 11, wherein receiving information defining a transformation of an input data object to an output data object comprises

receiving, from a user, through a graphical user interface (GUI) information identifying an input data object;

receiving, from the user, through the GUI information identifying an output data object; and

receiving, from the user, through the GUI information identifying a mapping of components in the input data object to components in the output data object.

19. The method of claim 11, wherein the response data object comprises a database row, and wherein storing the response data object comprises storing the database row in a database table specified by the script.

20. The method of claim 11, wherein the request data object and the response data object comprise eXtensible Markup Language (XML) data objects.

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