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**Korenshtein et al.**

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(54) **INHERITANCE OF OBJECT'S PROPERTIES  
AND OUT OF DIFFERENT APPLICATION  
CONTEXTS IN PROPERTIES FILE OBJECTS**

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20, 2000, provisional application No. 60/205,700,  
filed on May 19, 2000.

(51) **Int. Cl.**<sup>7</sup> ..... **G06F 9/00**

(52) **U.S. Cl.** ..... **719/328; 707/3; 707/103 R**

(58) **Field of Search** ..... 719/328; 707/3-6,  
707/100-104.1

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*Primary Examiner*—Meng-Al T. An

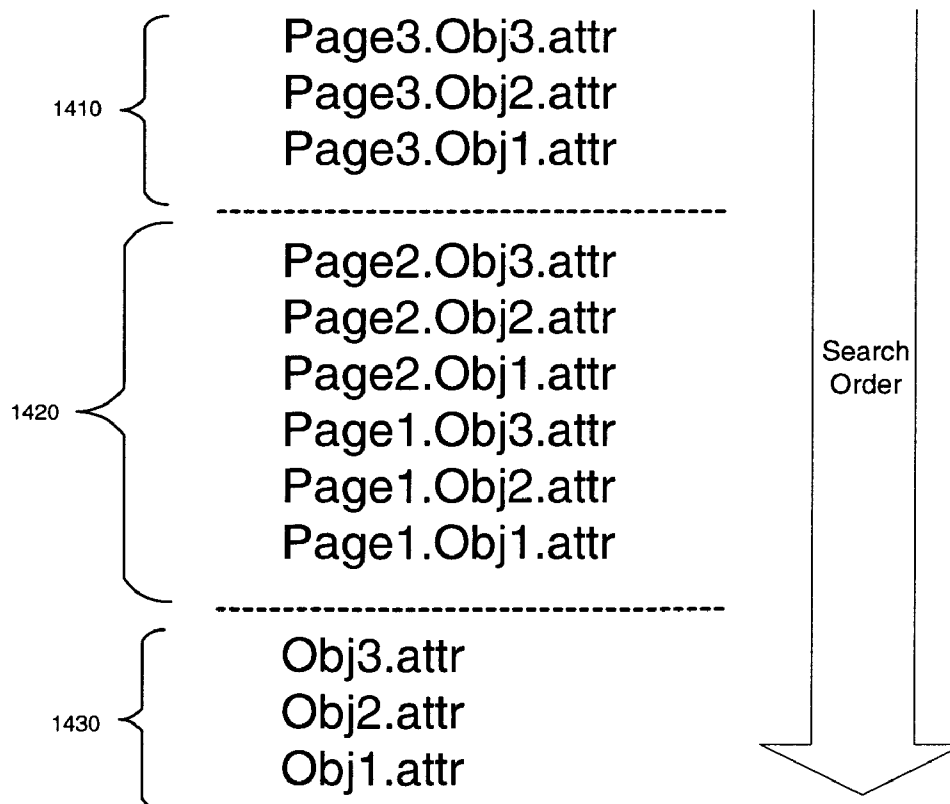
*Assistant Examiner*—Phuong N. Hoang

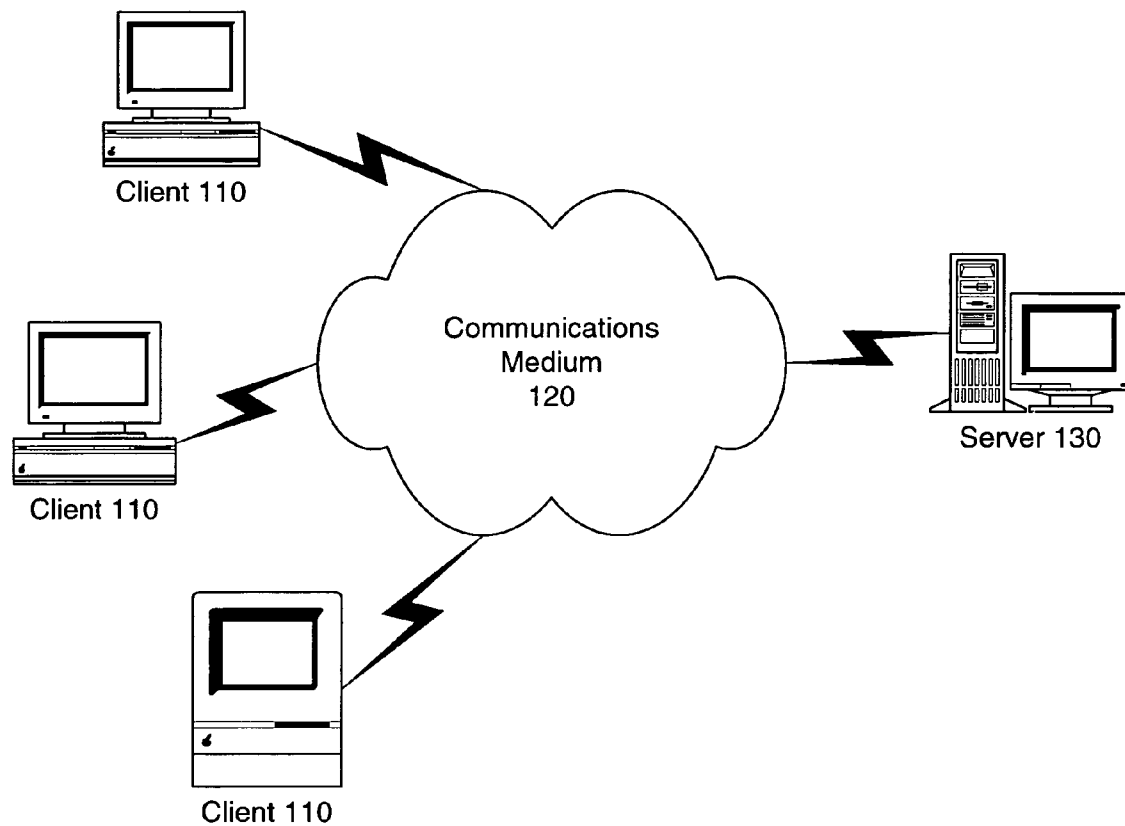
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(57) **ABSTRACT**

Apparatus and methods are provided for accessing and  
retrieving attribute name value pairs from properties data  
stores, such as properties files. According to one embod-  
iment, attribute values may be associated with properties data  
store objects. First, an attempt is made to determine a value  
of an attribute of an object by formulating and submitting a  
first query against the properties data store based upon a  
combination of a current context identifier, an object iden-  
tifier associated with the object, and an attribute identifier  
associated with the attribute. If the first query is unsuccessful  
at locating the value, then the value is determined by  
formulating and submitting a second query against the  
properties data store based upon a combination of the object  
identifier and the attribute identifier.

**14 Claims, 20 Drawing Sheets**



100**Figure 1**

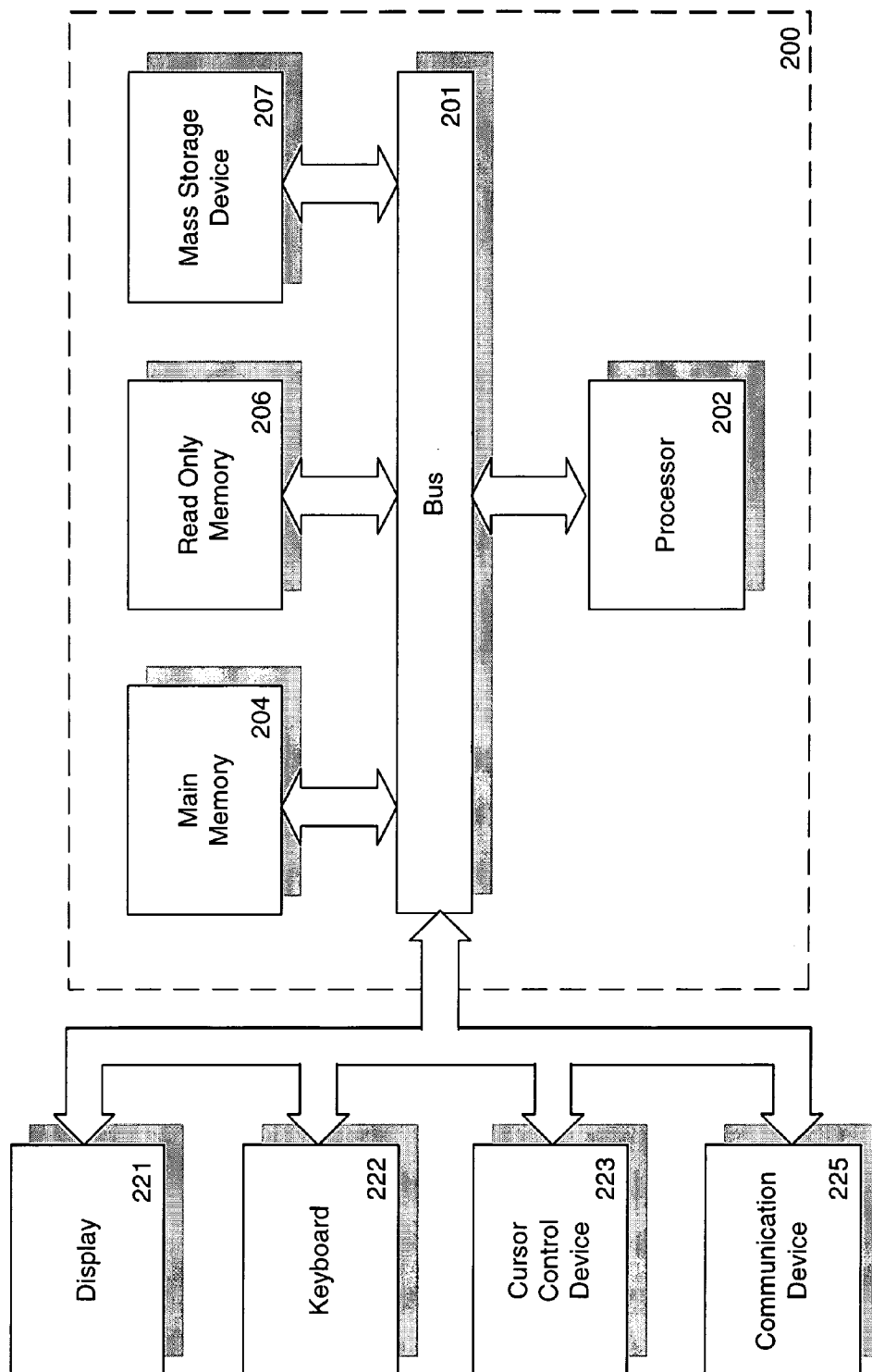
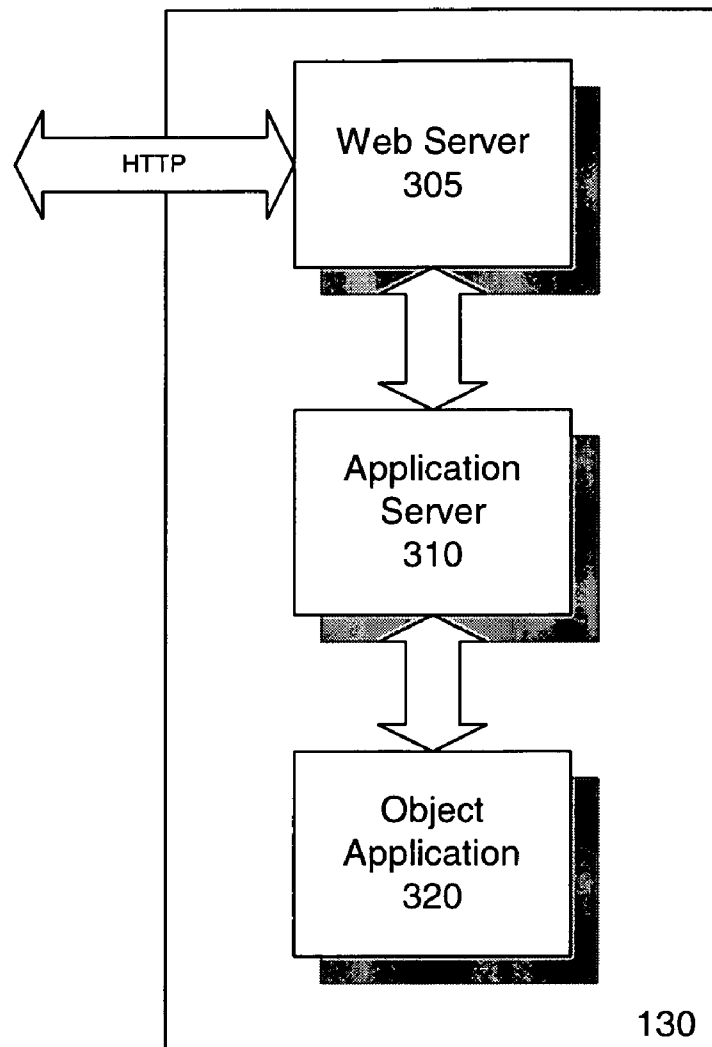


Figure 2

**Figure 3**

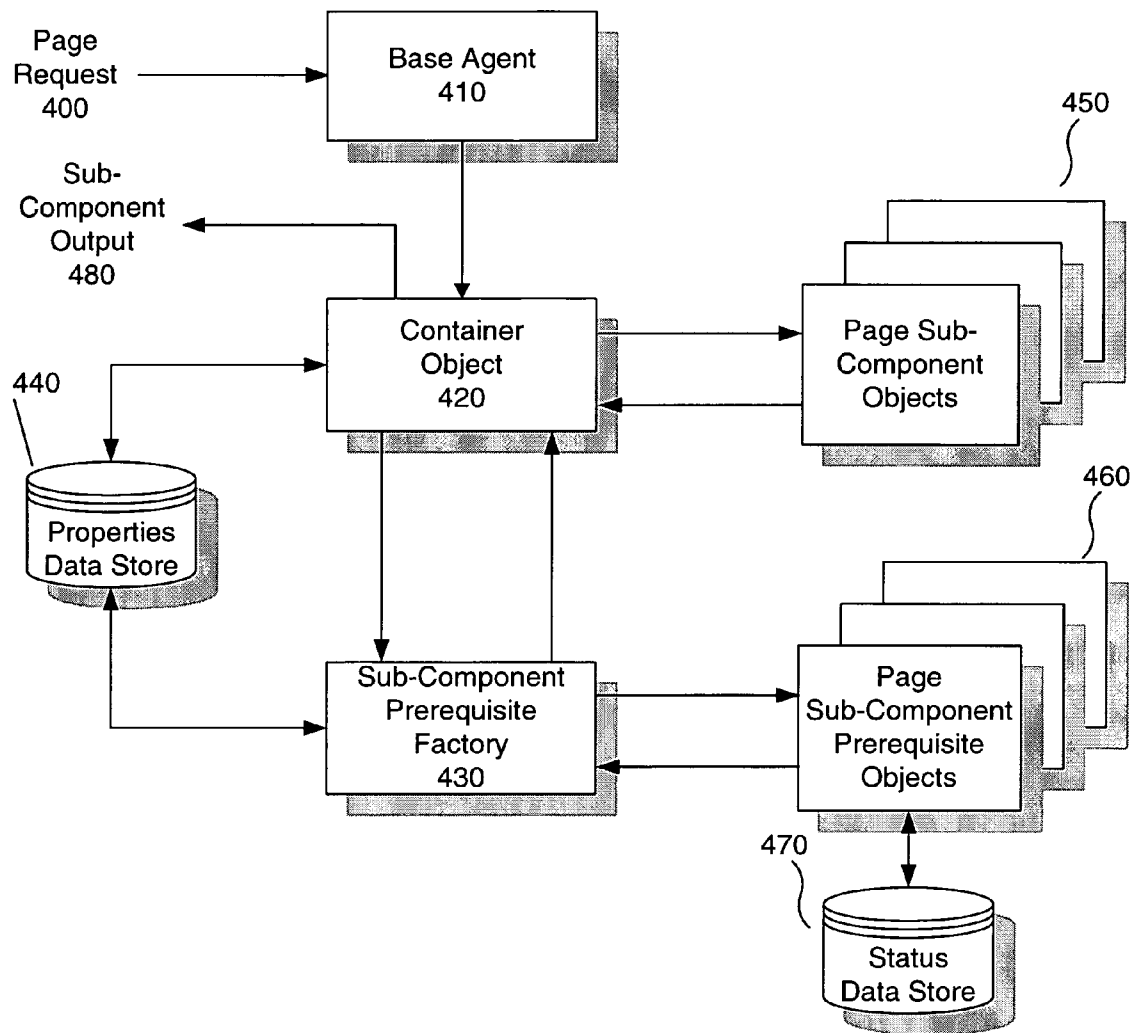
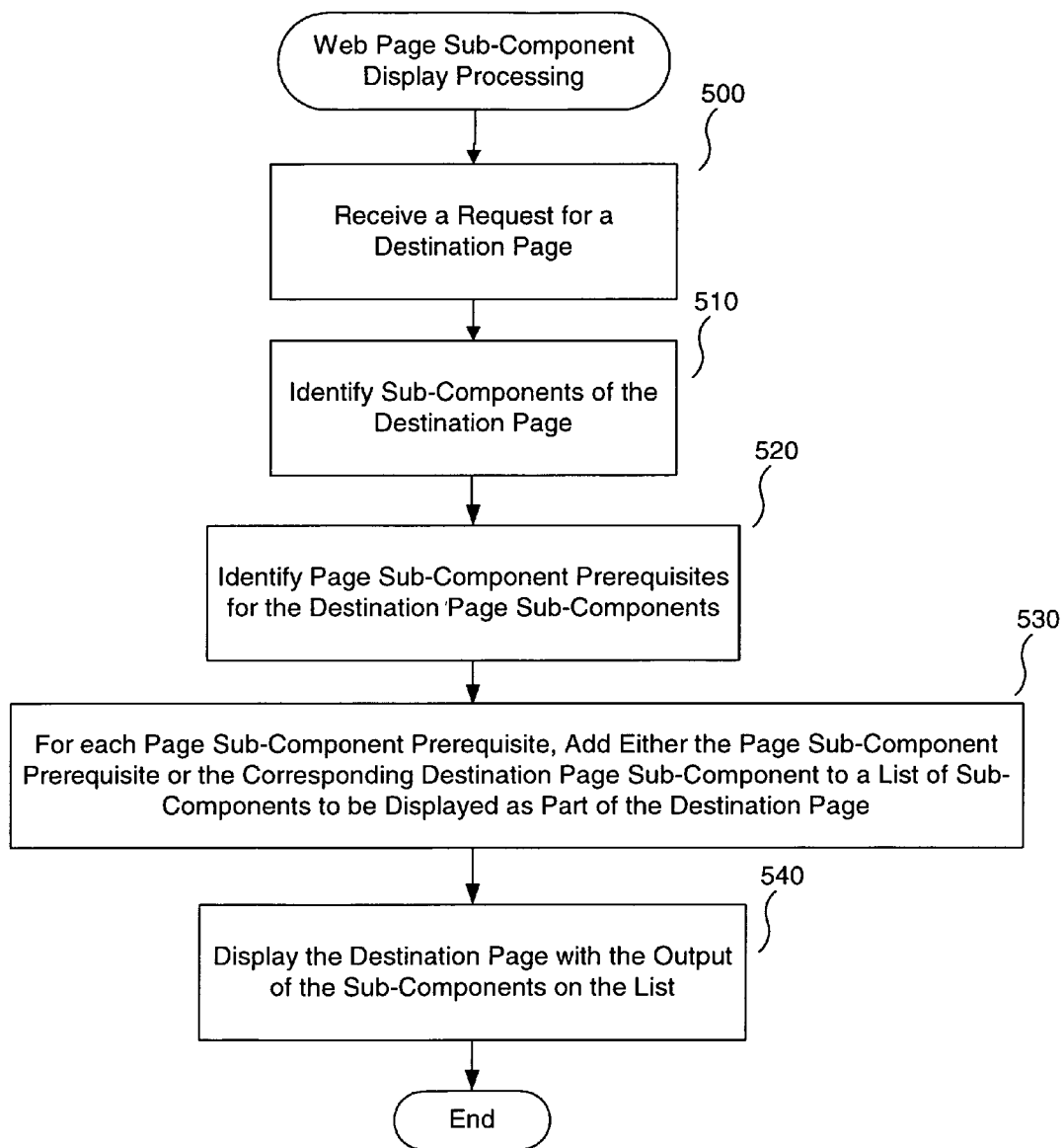


Figure 4

**Figure 5A**

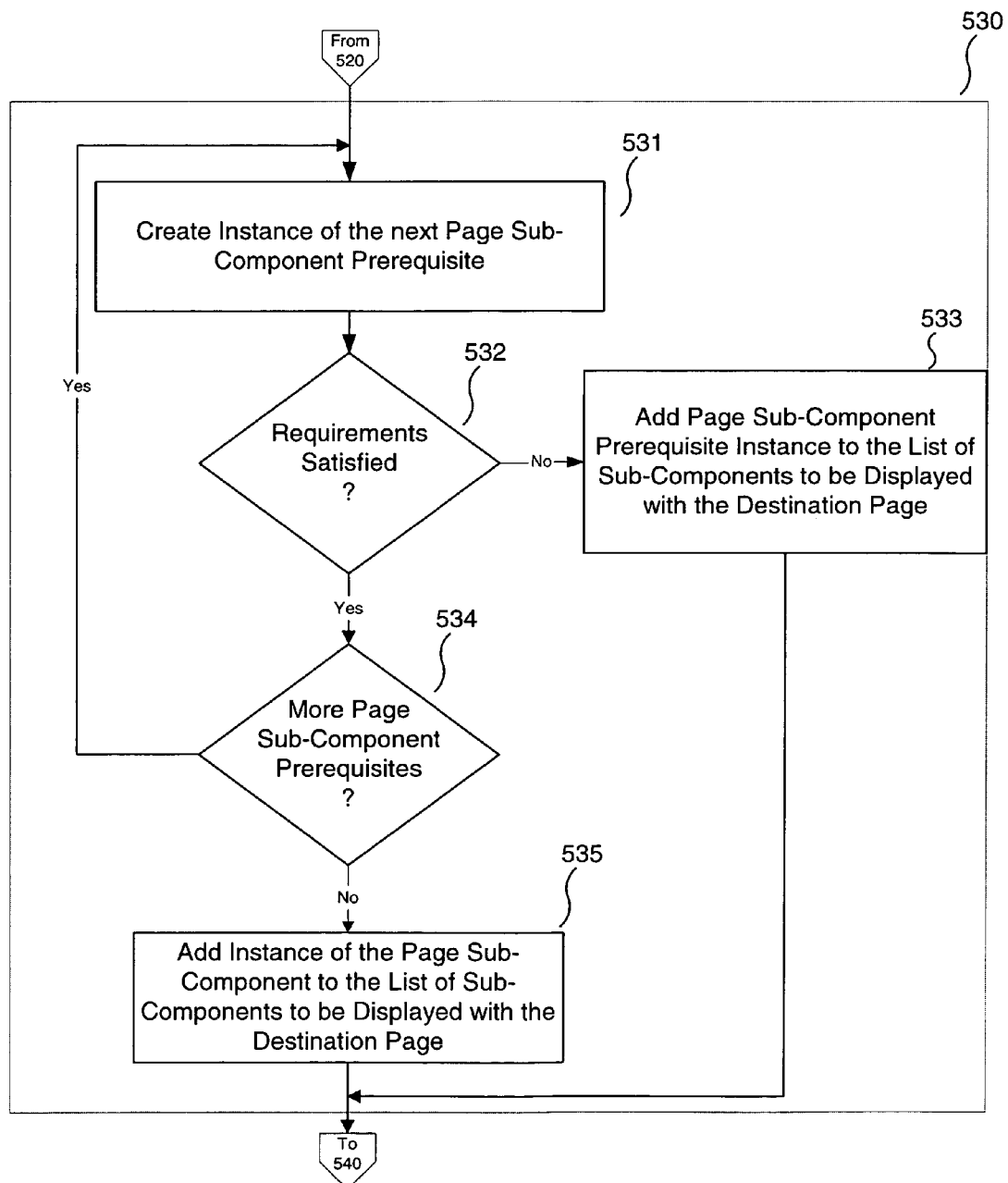
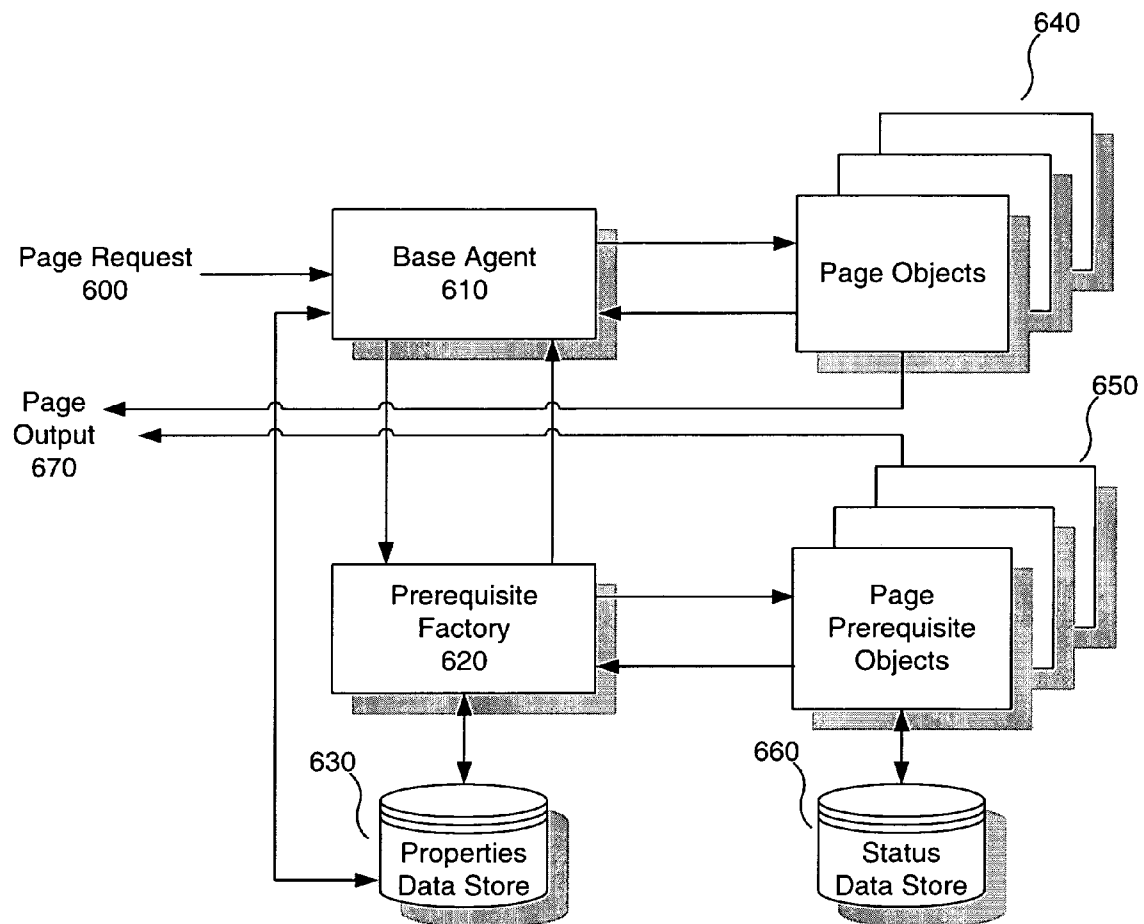
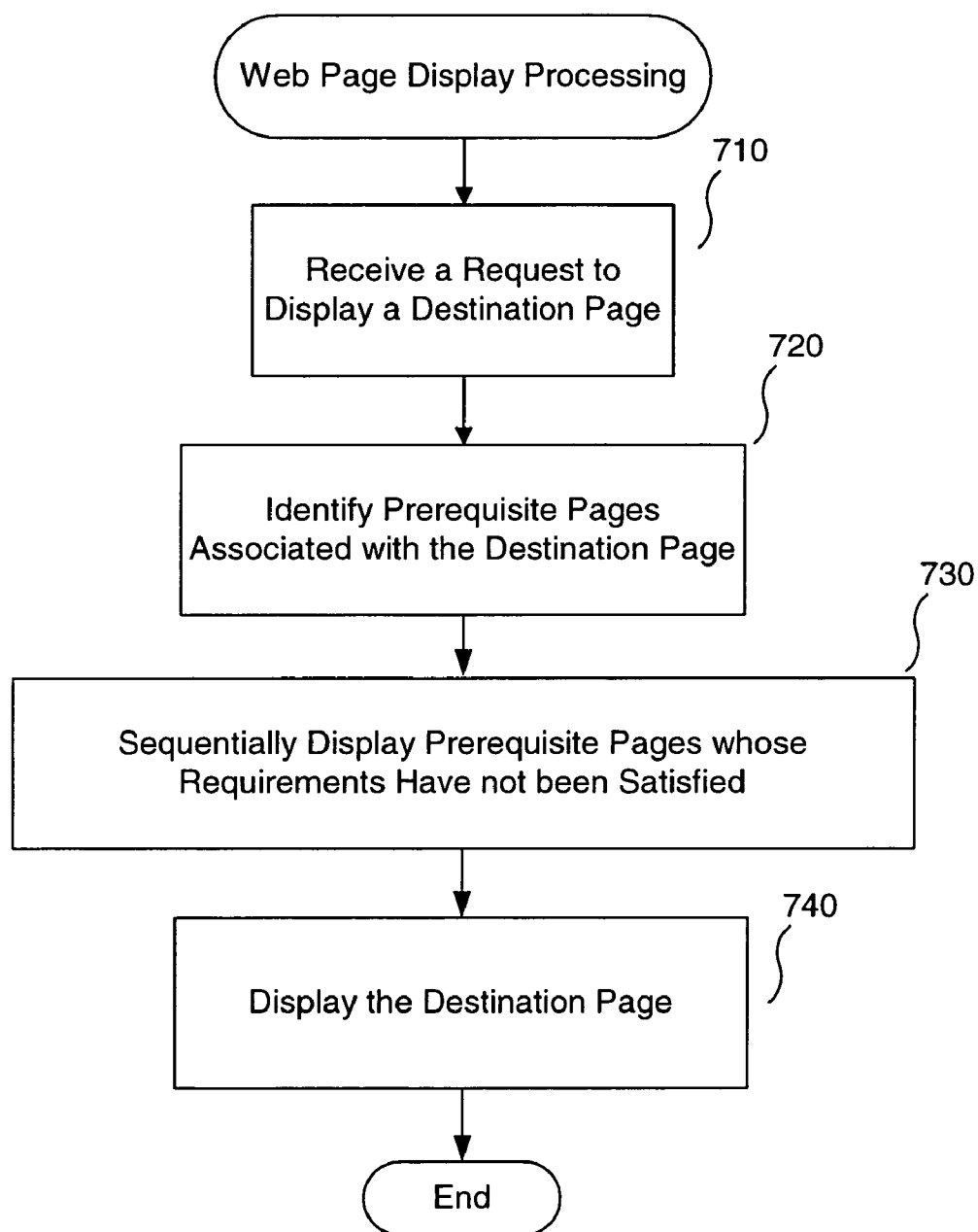


Figure 5B

**Figure 6**



**Figure 7A**

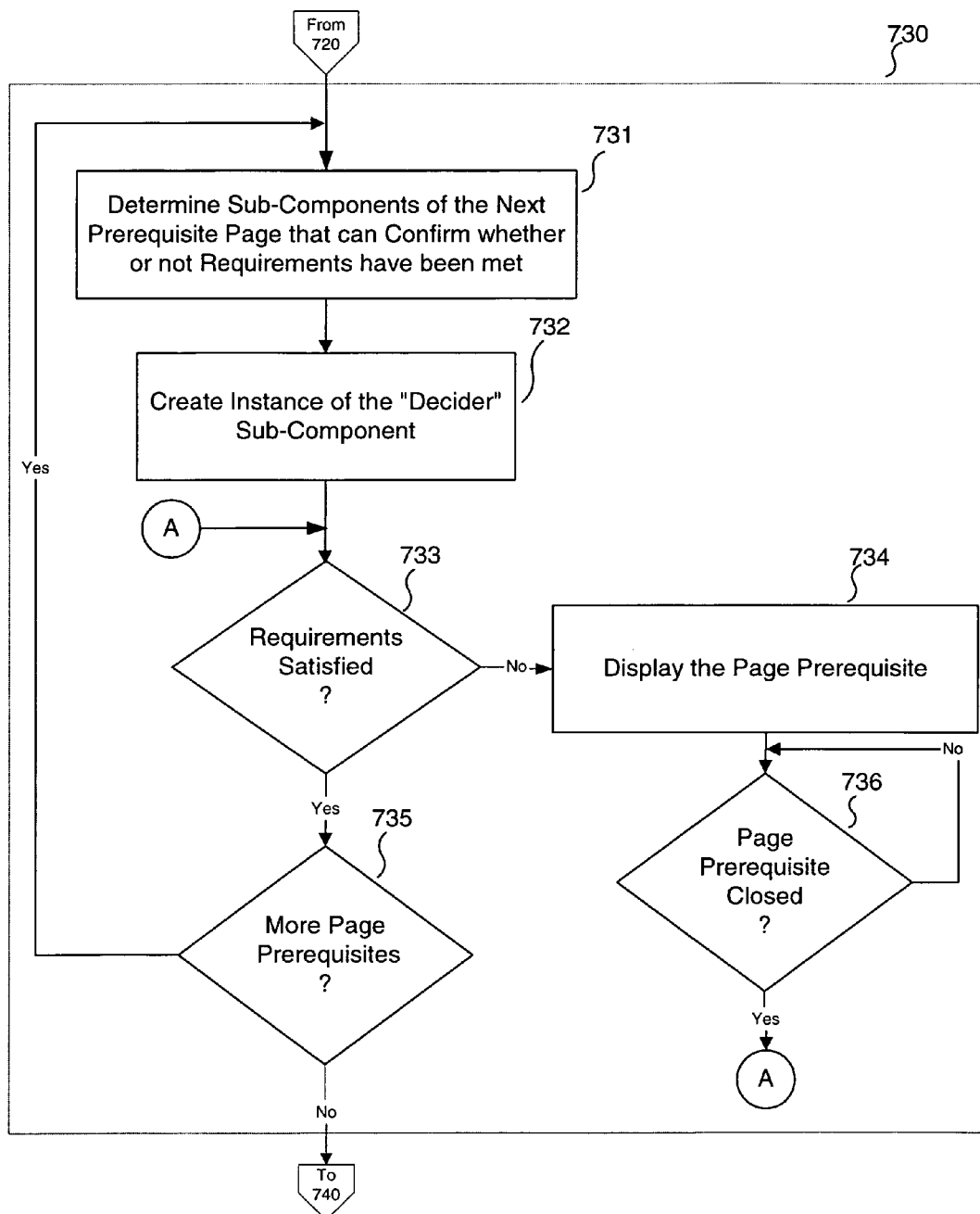



Figure 7B


$\langle \text{Attribute} \rangle = \langle \text{Value} \rangle$  810  
prompt1 = please enter your name 820


**Figure 8 (Prior Art)**


$\langle \text{Object} \rangle . \langle \text{Attribute} \rangle = \langle \text{Value} \rangle$  910  
Obj1.attr1 = val11 920  
Obj1.attr2 = val12 930  
Obj2.attr1 = val21 940  
Obj2.attr3 = val23 950  
Trading.prompt1 = please enter your name 960


**Figure 9**


<Object>.extends = <anotherObject>  1010

Obj1.attr1 = val11  1020


Obj1.attr2 = val12  1030


Obj2.extends=Obj1  1040


Obj2.attr2 = val22  1050


Obj2.attr3 = val23  1060

**Figure 10**


<Context>.<Object>.<Attribute> = <Value>  1110


Obj1.attr1 = val11  1120


Obj1.attr2 = val12  1130


Page1.Obj1.attr2 = val112  1140


**Figure 11**


<Context>.extends = <anotherContext>  1210

Obj1.attr1 = val11  1220

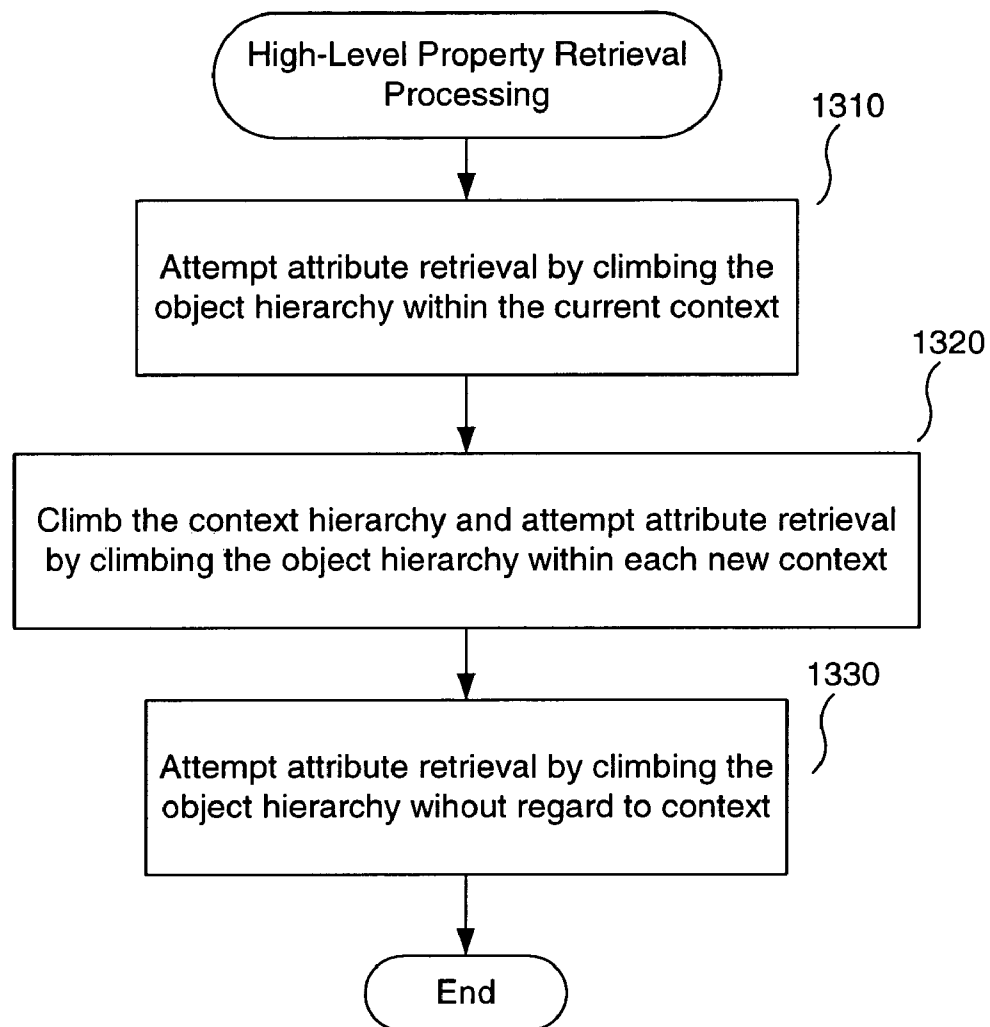
Obj1.attr2 = val12  1230

Page1.Obj1.attr2 = val112  1240

Page2.extends = Page1  1250

Page2.Obj1.attr2 = val212  1260

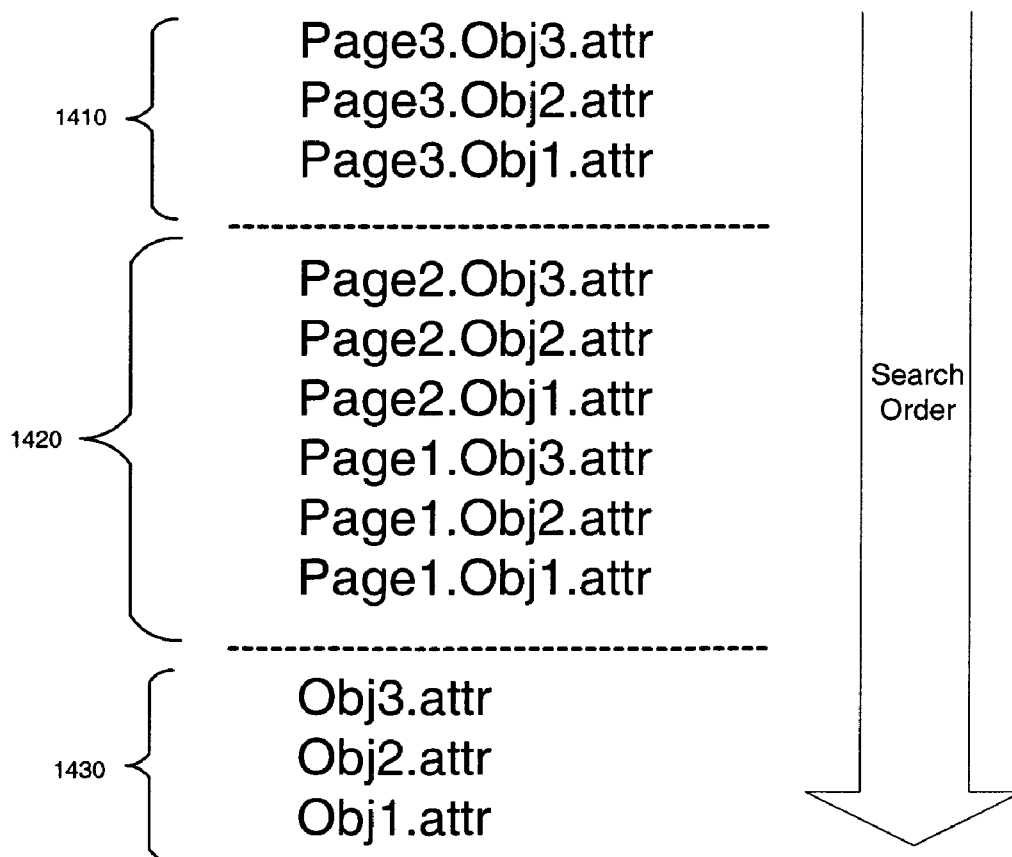
**Figure 12**

**Figure 13**

Page2.extends=Page1  
Page3.extends=Page2

Obj2.extends=Obj1  
Obj3.extends=Obj2

**Figure 14A**



**Figure 14B**

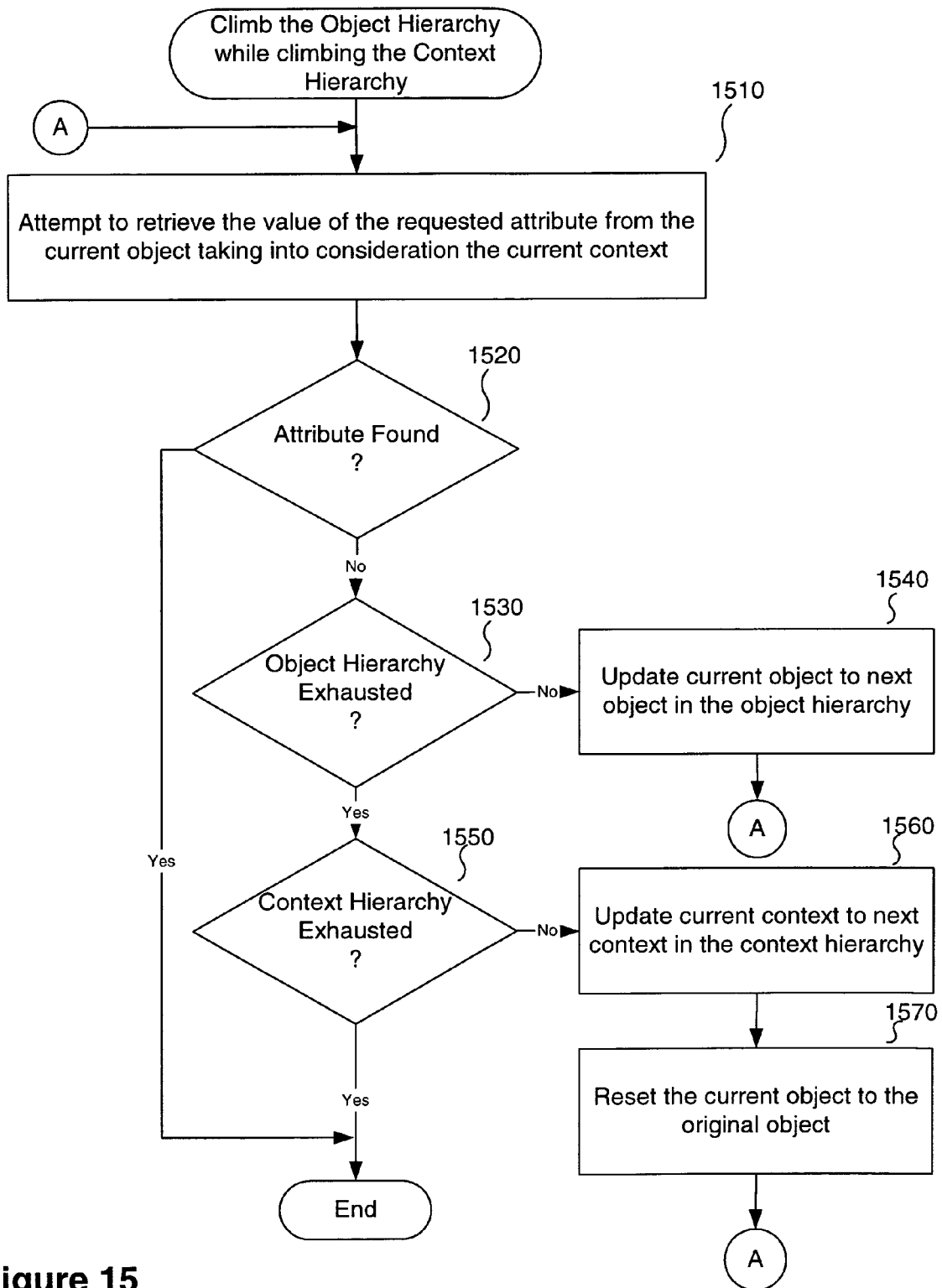
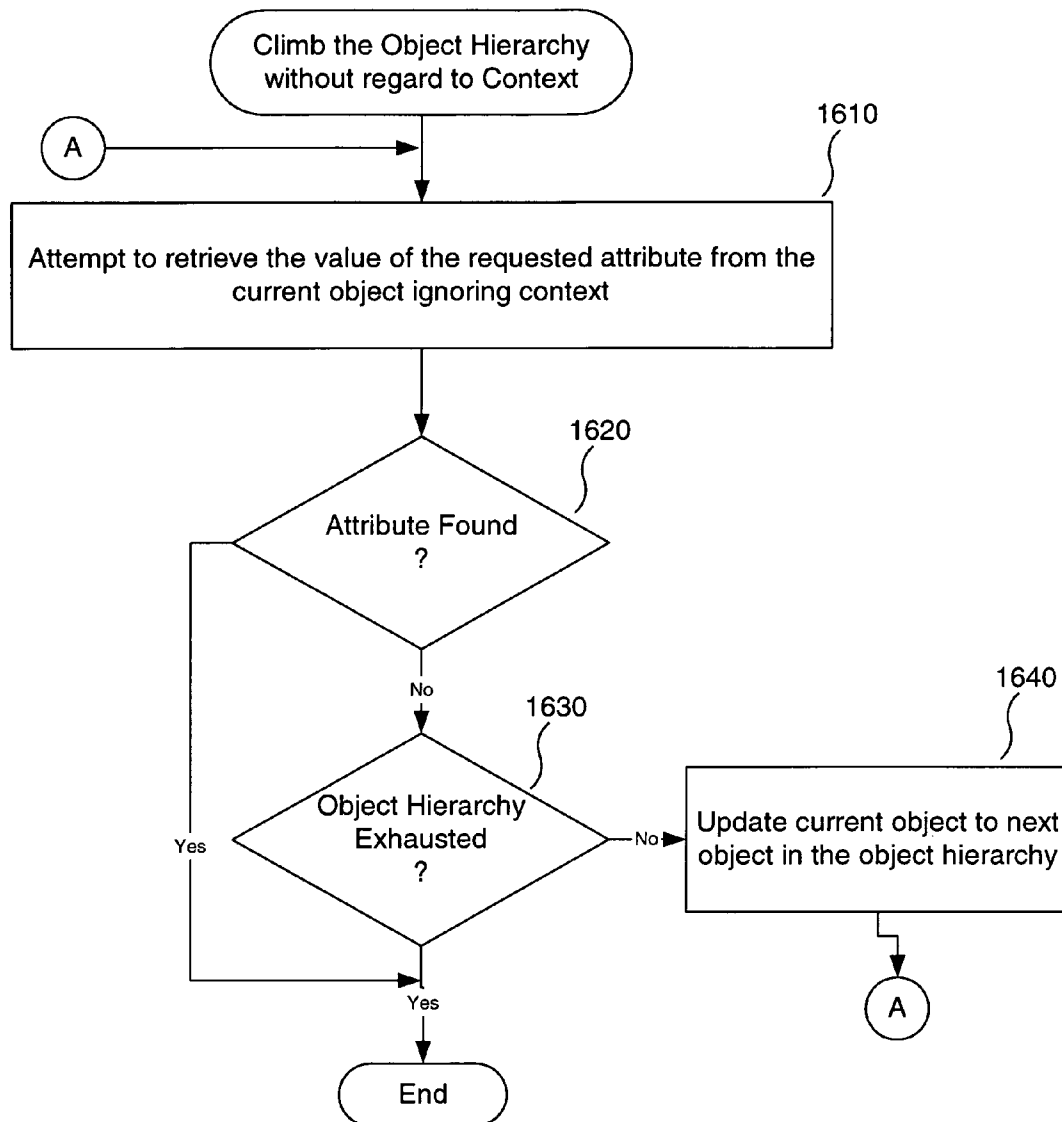


Figure 15

**Figure 16**



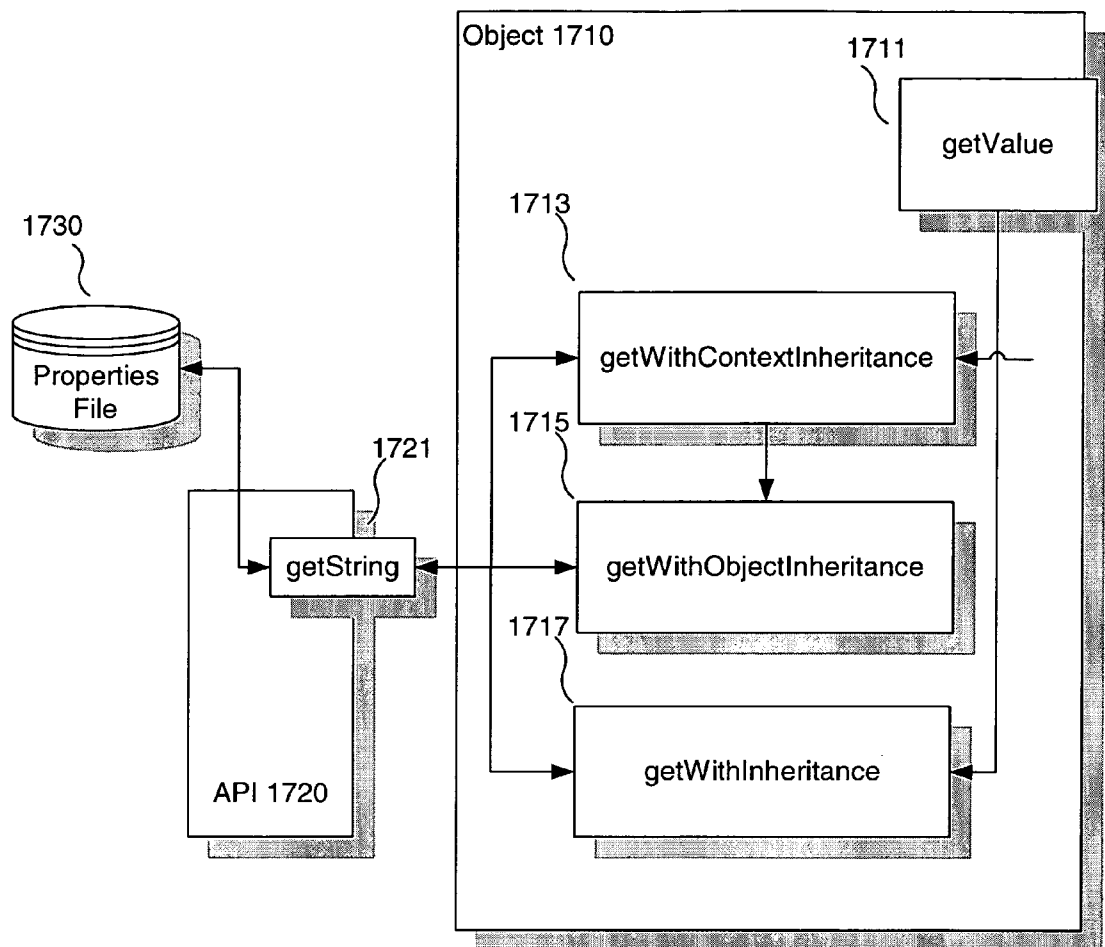


Figure 17

```
1.  String getValue( String attrib ) {  
2.  
3.      // get the container name of this object  
4.      String context = getContextName();  
5.  
6.      // get the name of the class of this executing object  
7.      String object = getClass().getName();  
8.  
9.      // check to see if within this context a value is defined for the  
10.     // specified attribute for objects of the currently executing object's  
11.     // type, or for any of its parent objects  
12.  
13.     String result = getWithContextInheritance( context, object, attrib );  
14.  
15.     if (result == null) { // if it's null it didn't find it.  
16.  
17.         // now try to find the value of the attribute of the object  
18.         // by ignoring the context  
19.  
20.         // this will look for the attribute in all objects that are extended by  
21.         // the current object  
22.  
23.         result = getWithInheritance( object, attrib );  
24.  
25.     } // end if  
26.  
27.     return result;  
28.  
29. } // end getValue
```

Figure 18

```
1.  String getWithContextInheritance(  
2.      String context, String object, String attrib) {  
3.  
4.      // check if the attrib is found in the current context by climbing up  
5.      // the object hierarchy if necessary  
6.      String result = getWithObjInheritance( context, object, attrib );  
7.  
8.      if (result == null) { //didn't find it in the current context  
9.          // check if this context extends another context  
10.         context = resourceBundle.getString( context + ".extends" );  
11.  
12.         //context now contains the name of the parent context, if any  
13.         if (context != null) // found a parent context  
14.             // this is a recursive call that looks for the attribute  
15.             // and climbs up the context hierarchy  
16.             result = getWithContextInheritance( context, object, attrib );  
17.  
18.         } //end if  
19.  
20.         return result;  
21.  
22.     } // end getWithContextInheritance
```

Figure 19

```
1.  String getWithObjInheritance( String context, String object, String attrib ) {  
2.      // concatenate context, ".", the object, ".", and the attrib  
3.      String lookFor = context + "." + object + "." + attrib;  
4.  
5.      // check if the combined attribute is found in the resource bundle  
6.      String result = resourceBundle.getString( lookFor );  
7.  
8.      if (result == null) { // didn't find it in the current object  
9.          // check if object extends another object, meaning  
10.         // it has a parent.  
11.         object = resourceBundle.getString( object + ".extends" );  
12.  
13.         //object now contains the name of the parent, if any  
14.         if (object != null) // found a parent object  
15.             // this is a recursive call that climbs up the  
16.             // object's hierarchy while keeping the context unchanged.  
17.             result = getWithObjInheritance( context, object, attrib );  
18.  
19.         } // end if  
20.  
21.         return result;  
22.  
23.     } // end getWithObjInheritance
```

Figure 20

```
1.  String getWithInheritance( String object, String attrib ) {  
2.      // concatenate the object, ".", and the attrib  
3.      String lookFor = object + "." + attrib;  
4.  
5.      // check if the combined attribute is found in the resource bundle  
6.      String result = resourceBundle.getString( lookFor );  
7.      if (result == null) { //didn't find it in the current object  
8.          // check if object extends another object, meaning  
9.          // it has a parent.  
10.         object = resourceBundle.getString( object + ".extends" );  
11.  
12.         // object now contains the name of the parent, if any  
13.         if (object != null) // found a parent object  
14.             // this is a recursive call. Look for the attribute  
15.             // in the parent or its parents  
16.             result = getWithInheritance( object, attrib );  
17.  
18.         } // end if  
19.  
20.         return result;  
21.  
22.     } // end getWithInheritance
```

Figure 21

## 1

# INHERITANCE OF OBJECT'S PROPERTIES AND OUT OF DIFFERENT APPLICATION CONTEXTS IN PROPERTIES FILE OBJECTS

This application claims the benefit of U.S. Provisional Application Nos. 60/198,718 and 60/205,700, filed Apr. 20, 2000 and May 19, 2000, respectively, both of which are incorporated herein by reference.

## COPYRIGHT NOTICE

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## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The invention relates generally to apparatus and methods for accessing and retrieving attribute name value pairs from properties data stores, such as properties files. More particularly, the invention relates to syntax enhancements and mechanisms for extending existing flat properties data stores to allow definition and access of properties on an object-by-object basis, allow implementation of inheritance of properties through some hierarchy of objects, and allow specification and overriding of properties of objects as they are used in different contexts.

### 2. Description of the Related Art

Java has a special built in mechanism for handling internationalization. One use of this mechanism encourages putting locale specific properties in "properties files" (e.g., properties files). This file contains attribute name value pairs. The normal syntax of the properties files are lines containing:

```
<attribute_name>=<value>
```

The "=" separates the key from the value in the properties file. The existing Java properties file mechanism allows an application to request the value of a specific attribute from a specific properties file and Java returns the value of that attribute as specified in the named file. This is done by loading a specified properties file into an object of type ResourceBundle and then querying a specified attribute. The following example illustrates this. Suppose the file details.properties contains the following two lines:

```
nameString=name
prompt=please enter your full address
```

The application, using the Java application programming interface (API), can query the value of the "prompt" property in the properties file named "details.properties" and get the result "please enter your full address". This is how it is done:

```
ResourceBundle
resourceBundle=ResourceBundle.getBundle("de-
tails");
String      promptValue=ResourceBundle.getString
("prompt").
```

Several limitations of existing properties files and their respective syntaxes have become apparent to the assignee of the present invention. First, in the case of Java, the properties file and the resource bundle are both flat, non-object oriented collections of key-value (attribute-value) pairs. Consequently, attributes may not be specified on an object-

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by-object basis. Second, there is no way to perform inheritance. Third, no mechanism is provided to specify and/or override properties of objects as they are used in different contexts. As a result, programmers do not have the ability to define default values of objects that may be customized or overridden when the objects are running in a particular context. These and other limitations of the Java properties file syntax and usage model, make the specification of attributes both cumbersome and time consuming.

## BRIEF SUMMARY OF THE INVENTION

Apparatus and methods are described for accessing and retrieving attribute name value pairs from properties data stores, such as properties files. According to one embodiment, attribute values may be associated with properties data store objects. First, an attempt is made to determine a value of an attribute of an object by formulating and submitting a first query against the properties data store based upon a combination of a current context identifier, an object identifier associated with the object, and an attribute identifier associated with the attribute. If the first query is unsuccessful at locating the value, then the value is determined by formulating and submitting a second query against the properties data store based upon a combination of the object identifier and the attribute identifier.

Other features of the present invention will be apparent from the accompanying drawings and from the detailed description that follows.

## BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings and in which like reference numerals refer to similar elements and in which:

FIG. 1 is an example of a client-server system in which one embodiment of the present invention may be implemented.

FIG. 2 is an example of a computer system upon which one embodiment of the present invention may be implemented.

FIG. 3 is a block diagram of a software architecture for a prerequisite enforcing framework according to one embodiment of the present invention.

FIG. 4 is a block diagram of a software architecture for an object application according to one embodiment of the present invention.

FIG. 5A is a flow diagram illustrating web page sub-component display processing according to one embodiment of the present invention.

FIG. 5B is a flow diagram illustrating processing block 530 of FIG. 5A according to one embodiment of the present invention.

FIG. 6 is a block diagram of a software architecture for an object application according to another embodiment of the present invention.

FIG. 7A is a flow diagram illustrating web page display processing according to one embodiment of the present invention.

FIG. 7B is a flow diagram illustrating processing block 730 of FIG. 7A according to one embodiment of the present invention.

FIG. 8 illustrates prior art properties file syntax.

FIG. 9 illustrates an improved properties file syntax that enables definition and access of properties on an object-by-object basis according to one embodiment of the present invention.

FIG. 10 illustrates an improved properties file syntax that enables inheritance of properties according to one embodiment of the present invention.

FIG. 11 illustrates an improved properties file syntax that enables the specification and/or overriding of object properties as they are used in different contexts according to one embodiment of the present invention.

FIG. 12 illustrates an improved properties file syntax that enables inheritance of contexts according to one embodiment of the present invention.

FIG. 13 is a high-level flow diagram that conceptually illustrates property retrieval processing according to one embodiment of the present invention.

FIG. 14A is an exemplary context and object hierarchy.

FIG. 14B illustrates property retrieval processing according to the object and context hierarchy of FIG. 14A and the processing of FIG. 13.

FIG. 15 is a flow diagram illustrating processing associated with traversal of an object hierarchy and a context hierarchy according to one embodiment of the present invention.

FIG. 16 is a flow diagram illustrating processing associated with traversal of an object hierarchy without regard to context according to one embodiment of the present invention.

FIG. 17 is a block diagram that conceptually illustrates software architectural components that enable processing of an improved properties file syntax according to one embodiment of the present invention.

FIG. 18 illustrates exemplary code for the `getValue` method of FIG. 17 according to one embodiment of the present invention.

FIG. 19 illustrates exemplary code for the `getContextInheritance` method of FIG. 17 according to one embodiment of the present invention.

FIG. 20 illustrates exemplary code for the `getWithObjInheritance` method of FIG. 17 according to one embodiment of the present invention.

FIG. 21 illustrates exemplary code for the `getWithInheritance` method of FIG. 17 according to one embodiment of the present invention.

### DETAILED DESCRIPTION OF THE INVENTION

Apparatus and methods are described for accessing and retrieving attribute name value pairs from properties data stores, such as properties files. According to one embodiment, a properties data store defines the relationships between prerequisite and destination pages and/or destination page sub-components. Advantageously, in this manner, the relationships may be modified using an editor and without requiring recompilation.

In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be apparent, however, to one skilled in the art that the present invention may be practiced without some of these specific details. In other instances, well-known structures and devices are shown in block diagram form.

The present invention includes various steps, which will be described below. The steps of the present invention may be performed by hardware components or may be embodied

in machine-executable instructions, which may be used to cause a general-purpose or special-purpose processor or logic circuits programmed with the instructions to perform the steps. Alternatively, the steps may be performed by a combination of hardware and software.

The present invention may be provided as a computer program product that may include one or more machine-readable mediums having stored thereon instructions, which may be used to program a computer (or other electronic devices) to perform a process according to the present invention. The machine-readable medium may include, but is not limited to, floppy diskettes, optical disks, CD-ROMs, and magneto-optical disks, ROMs, RAMs, EPROMs, EEPROMs, magnetic or optical cards, flash memory, or other type of media/machine-readable medium suitable for storing electronic instructions. Moreover, the present invention may also be downloaded as a computer program product, wherein the program may be transferred from a remote computer (e.g., a server) to a requesting computer (e.g., a client) by way of data signals embodied in a carrier wave or other propagation medium via a communication link (e.g., a modem or network connection). Accordingly, herein, a carrier wave shall be regarded as comprising a machine-readable medium.

Importantly, while embodiments of the present invention will be described with reference to web page processing and Java properties files, the apparatus and methods described herein are equally applicable to various other types of user interfaces and mechanisms for maintaining property/attribute information.

### Network Overview

The present invention may be included within a client-server system **100** such as that illustrated in FIG. 1. According to the embodiment depicted in FIG. 1, a server **130** may be communicatively coupled to clients **110** through a communications medium **120**, such as a local area network (LAN) or a wide area network (WAN). A representative data connection between the clients **110** and the server **130** includes a direct-dial, bi-directional data connection, which may be telephone (POTS, i.e., "plain old telephone service"), Integrated Services Digital Network (ISDN), digital subscriber line (DSL) or other similar type of connection. Various other data connections between the clients **110** and the server **130** are possible. For example, the connection may be via a network interface card or via a modem pool (not shown) such as that conventionally known in the art for providing access to the Internet and private networks. Alternatively, the connection may be established through an Internet service provider (ISP) that allows the clients **110** to exchange information with the server **130**.

The server **130** includes a novel prerequisite enforcing framework (not shown) that manages, tracks and controls page and/or page sub-component prerequisites. As will be discussed further below, the server **130** may access a properties data store (not shown), such as a Java properties file, that includes information defining the relationships between prerequisites and destination pages and/or destination page sub-components. Various exemplary software architectures of the prerequisite enforcing framework and preferred syntax and representations of the information in the properties database are described below.

### Computer System Overview

A computer system **200** in which features of the present invention may be implemented will now be described with reference to FIG. 2. Computer system **200** comprises a bus or other communication means **201** for communicating

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information, and a processing means such as processor **202** coupled with bus **201** for processing information. Computer system **200** further comprises a random access memory (RAM) or other dynamic storage device **204** (referred to as main memory), coupled to bus **201** for storing information and instructions to be executed by processor **202**. Main memory **204** also may be used for storing temporary variables or other intermediate information during execution of instructions by processor **202**. Computer system **200** also comprises a read only memory (ROM) and/or other static storage device **206** coupled to bus **201** for storing static information and instructions for processor **202**.

A data storage device **207** such as a magnetic disk or optical disc and its corresponding drive may also be coupled to bus **201** for storing information and instructions. Computer system **200** can also be coupled via bus **201** to a display device **221**, such as a cathode ray tube (CRT) or Liquid Crystal Display (LCD), for displaying information to a computer user. Typically, an alphanumeric input device **222**, including alphanumeric and other keys, may coupled to bus **201** for communicating information and/or command selections to processor **202**. Another type of user input device is cursor control **223**, such as a mouse, a trackball, or cursor direction keys for communicating direction information and command selections to processor **202** and for controlling cursor movement on display **221**.

A communication device **225** is also coupled to bus **201** for accessing remote servers or other servers via the Internet, for example. The communication device **225** may include a modem, a network interface card, or other well-known interface devices, such as those used for coupling to an Ethernet, token ring, or other types of networks. In any event, in this manner, the computer system **200** may be coupled to a number of clients and/or servers via a conventional network infrastructure, such as a company's Intranet and/or the Internet, for example.

#### Exemplary Prerequisite Enforcing Framework

FIG. **3** is a block diagram of a software architecture for a prerequisite enforcing framework according to one embodiment of the present invention. In the embodiment depicted, the software architecture includes a web server **305**, an application server **310**, and an object application **320**. In one embodiment, the web server **305** acts as a HyperText Transfer Protocol (HTTP) interface between the clients **110** and the application server **310**.

The application server **310** appropriately routes requests received from the web server **305** to the object application **320** and conveys output of the object application **320** to the web server **305**. For example, in response to page or page subcomponent requests, e.g., Uniform Request Locator (URL) requests, the application server **310** (1) determines the appropriate base agent of the object application **320**, i.e., the base agent associated with the requested page or page subcomponent, (2) creates an instance of the base agent, (3) transfers control to the object application **320** by invoking an execute method of the instantiated base agent, and (4) transfers streamed data, received from the object application **320** that has been generated by a page, page subcomponent, page prerequisite, or page subcomponent prerequisite, to the web server **305**.

The object application **320** provides an abstraction for objects, such as containers and components. According to one embodiment, an object may be thought of conceptually as a hierarchy of potentially nested sub-objects to any number of levels of nesting. The objects and nested sub-objects may be components or containers. Components are

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leaf nodes in the hierarchy. Containers are non-leaf nodes in the hierarchy and may contain one or more other containers or components. In the embodiments described herein, containers typically represent pages and components of containers represent the pages' subcomponents, such as charts, tables, scroll lists, data entry forms, etc.

#### Architecture of an Exemplary Object Application

Having briefly described an exemplary environment in which the present invention may be employed, a software architecture of the object application **320**, according to one embodiment, will now be described with reference to FIG. **4**. The architecture depicted seeks to facilitate the management, tracking and controlling of page sub-component prerequisites.

According to this example, the software architecture of the object application **320** includes a base agent **410**, a container object **420**, and a sub-component prerequisite factory **430**. The base agent **410** includes logic to instantiate and execute the container object **420** that corresponds to a page associated with the base agent **410**. In one embodiment, the base agent **410** is instantiated by the application server **310** in response to a URL request for the page associated with the base agent **410**. Then, the application server **310** causes the requested page to be displayed by invoking the base agent's execute method. The base agent's execute method, in turn, calls the execute method of the container object **420**.

The container object **420** includes logic to instantiate and execute its sub-objects and determine prerequisites of its sub-objects. The execute method of the container object **420** first determines its sub-objects (e.g., containers and/or components) with reference to a properties data store **440**, such as a Java properties file (e.g., "<name>.properties"). Then, for each component, the container object **420** determines what the next prerequisite is for the component by consulting with a special sub-component prerequisite factory object, such as the sub-component prerequisite factory **430**. As discussed further below, either the next prerequisite or the component will be added to the container object's list of sub-objects to be displayed. If the container object **420** includes nested containers, when the execute method of the nested containers is invoked, and the nested containers will instantiate and execute their components. When the leaf-level of the hierarchy of objects is reached, those of the components added to the container object's list of sub-objects to be displayed calculate their individual results and stream out these results to the base agent **410**.

According to one embodiment, the sub-component prerequisite factory **430** includes a method called "getNextPreReq" that returns either the next prerequisite sub-component object for a specified destination sub-component or null. First, the sub-component prerequisite factory **430** determines what, if any, prerequisite sub-component objects have been associated with the specified destination sub-component. In the example depicted, this operation is accomplished by retrieving information from the properties data store **440**, such as the value of a "prereq" property. Second, for each of the prerequisite sub-component objects, the sub-component prerequisite factory **430** determines if the requirements for the prerequisite sub-component have been satisfied. As described further below, in one embodiment, this determination is made by calling a "metReqs" method of the prerequisite sub-component object. In any event, if the sub-component prerequisite factory **430** returns a non-null object, it means the destination sub-component is associated with a prerequisite managed by the prerequisite sub-com-



ponent object that has not yet been satisfied; and rather than displaying the destination sub-component, the prerequisite sub-component object should be displayed to the user. If a null value is returned by the sub-component prerequisite factory **430**, it means that either the specified destination sub-component has no prerequisites or that all the prerequisites for the sub-component have been fulfilled and therefore the destination sub-component may be displayed. Advantageously, according to this novel architecture, the container object **420** is abstracted from the task of prerequisite processing. In alternative embodiments, the container object **420** may be even further abstracted from this process by removing its interface with the properties data store **440** and requiring all access to the properties data store **440** be by way of the sub-component prerequisite factory **430**.

The software architecture of the present example also includes page sub-component objects **450**, page sub-component prerequisite objects **460**, and a status data store **470**. The page sub-component objects **450** are each associated with one or more container objects **420**. Importantly, the page sub-component objects **450** and the page sub-component prerequisite objects **460** may be coded independently of each other and do not even need to be aware of each other. That is, the page sub-component objects **450** have no knowledge regarding their prerequisites and include no code relating to determining whether or not such prerequisites have been met. Advantageously, by decoupling the sub-component objects from the sub-component prerequisite objects, reusability of the page sub-component objects **450** is greatly enhanced.

The page sub-component prerequisite objects **460** ensure that the conditions for which they are responsible are met. Typically, page sub-component prerequisite objects **460** display information to the user and/or collect some information from the user and ensure the correctness of the collected information. In the embodiment depicted, the page sub-component prerequisite objects **460** store and retrieve the state of their requirements to/from the status data store **470**. For example, once a required disclosure is displayed to the user that is a precondition to display of a particular page sub-component object, the associated page sub-component prerequisite object may record that fact in the status data store **470**. Then, subsequently, when the particular page sub-component object is requested, its output will be seen rather than that of its page sub-component prerequisite object.

#### Page Sub-Component Display Processing

FIG. **5A** is a flow diagram illustrating web page sub-component display processing according to one embodiment of the present invention. In one embodiment, the processing blocks described below may be performed under the control of a programmed processor, such as processor **202**. However, in alternative embodiments, the processing blocks may be fully or partially implemented by any programmable or hardcoded logic, such as Field Programmable Gate Arrays (FPGAs), TTL logic, or Application Specific Integrated Circuits (ASICs), for example.

In the example illustrated, display processing begins at processing block **500** where a request for a destination page, such as an HTTP request, is received by the web server **305** and conveyed to the object application **320** by way of the application server **310**.

At processing block **510**, the sub-components of the destination page are identified. According to one embodiment, this is accomplished by the container object **420** querying the properties data store **440**. In alternative

embodiments, the sub-component prerequisite factory **430** may query the properties data store **440**.

At processing block **520**, the page sub-component prerequisites for the destination page sub-components are identified. As above, depending upon the implementation, this may be accomplished by the sub-component prerequisite factory **430** querying the properties data store **440**. In alternative embodiments, the container object **420** may query the properties data store **440**. Advantageously, by defining the relationships between prerequisites and destination pages in a data store, no compilation is required when the system administrator modifies those relationships. Rather, if the data store is a text file, it may simply be modified by an editor.

At processing block **530**, an appropriate sub-component object (either a page sub-component objects or a page sub-component prerequisite object **460**) is added to the destination page's list of sub-component objects to display for each sub-component identified in processing block **510**. According to one embodiment, the container object **420** calls the "getNextPreReq" method for each of the page sub-components of the destination page and adds the either the object returned (a page sub-component prerequisite object) or the page sub-component object to the destination page's list for subsequent display. According to one embodiment, the "getNextPreReq" method sequentially checks page sub-component prerequisites of the specified page sub-component in an order indicated by the properties data store and returns the first page sub-component prerequisite that has one or more requirements that are not satisfied. Advantageously, in this manner, hierarchical relationships of prerequisites may be defined easily.

Finally, at processing block **540**, the destination page is displayed with the appropriate page sub-component outputs and appropriate page sub-component prerequisite outputs by causing each of the sub-component objects on the destination page's list to stream its output to the base agent **410**.

FIG. **5B** is a flow diagram illustrating processing block **530** of FIG. **5A** according to one embodiment of the present invention. In this example, the goal is to find the first page sub-component prerequisite object associated with the specified page sub-component object that has one or more unmet requirements. At processing block **531**, an instance of the next page sub-component prerequisite object is created by the sub-component prerequisite factory **430**. Then, the sub-component prerequisite factory **430** determines if the page sub-component prerequisite object's requirements have been satisfied, at decision block **532**, by invoking a method of the newly created instance, such as a "metReqs" method that all page sub-component prerequisite objects may implement. If all the page sub-component prerequisite object's requirements have been met, then flow continues with decision block **534**; otherwise processing branches to processing block **533**.

At processing block **533**, since it has been determined that one or more requirements of the page sub-component prerequisite object has not been met, the instance of the page sub-component prerequisite object is returned by the sub-component prerequisite factory **430** and added to the destination page's list. In this example, after the first page sub-component prerequisite object has been found with one or more unsatisfied requirements (i.e., after processing block **533**), control returns to processing block **540**.

At decision block **534**, a determination is made whether or not there are more page sub-component prerequisites. If so, processing continues with processing block **531**. If not, no page sub-component prerequisite objects have been

found that have unmet requirements; and processing continues with processing block 535. At processing block 535, because either the specified page sub-component has no page sub-component prerequisites or all have been satisfied, an instance of the specified page sub-component is added to the destination page's list.

#### Architecture of Another Exemplary Object Application

FIG. 6 is a block diagram of a software architecture for an object application according to another embodiment of the present invention. The architecture depicted seeks to facilitate the management, tracking and controlling of page prerequisites. According to this example, the software architecture of the object application 320 includes a base agent 610, a prerequisite factory 630, page objects 640, page prerequisite objects 650, a properties data store 630, and a status data store 660.

The base agent 610 includes logic to determine which page object is responsible for streaming out the content of the destination page based upon predetermined properties stored in the properties data store 630 and/or the specified URL. According to one embodiment, when the user requests the destination page by selecting a link or specifying a URL, for example, in the client browser, the request is passed to the application server 310 via the web server 305. Then, the application server 310 determines the appropriate base agent 610 for the specified URL, creates an instance of the base agent 610, and calls the execute method of the base agent 610. After the base agent 610 has determined the appropriate page object associated with the URL, it consults with the prerequisite factory 620 to determine what the next prerequisite is for the page object. If there are no prerequisites or all the prerequisites have been satisfied then the base agent 610 creates an instance of the page object and executes it to cause the object to stream its output to the display. However, if a prerequisite is returned by the prerequisite factory 620, then the base agent 610 instead executes the page prerequisite object causing the prerequisite object to stream its output to the display.

According to one embodiment, the prerequisite factory 620 includes a method called "getNextPreReq" that returns either the next page prerequisite object for a specified destination page or null. First, the prerequisite factory 620 determines what, if any, page prerequisite objects 650 have been associated with the specified destination page. In the example depicted, this operation is accomplished by retrieving information from the properties data store 630, such as the value of a "prereq" property. Second, for each of the page prerequisite objects identified, the prerequisite factory 620 determines if the requirements for the page prerequisite object have been satisfied. As described further below, in one embodiment, this determination is made by calling a "metReqs" method of a "decider" component of the page prerequisite object. Because pages may have multiple sub-components, it is preferable to designate one as a decider component that can be used to determine whether or not the conditions for which it is responsible have occurred. In any event, if the prerequisite factory 620 returns a non-null object, it means the destination page is associated with a prerequisite managed by the page prerequisite object that has not yet been satisfied; and rather than displaying the destination page, the page prerequisite object should be displayed to the user. If a null value is returned by the prerequisite factory 620, it means that either the specified destination page has no prerequisites or that all the prerequisites for the destination page have been fulfilled and therefore the destination page may be displayed. Advanta-

geously, according to this novel architecture, the base agent 610 is abstracted from the task of prerequisite processing. In alternative embodiments, the base agent 610 may be even further abstracted from this process by removing its interface with the properties data store 440 and requiring all access to the properties data store 630 be by way of the prerequisite factory 620.

As above, the page objects 640 and the page prerequisite objects 650 may be coded independently of each other and do not even need to be aware of each other. Thus, reusability is enhanced because the page objects 640 and the page prerequisite objects 650 are decoupled thereby allowing page objects 640 to be easily taken out of the current context and placed unchanged into a new context.

The page prerequisite objects 650 ensure that the conditions for which they are responsible are met. Typically, page prerequisite objects 650 display information to the user and/or collect some information from the user and ensure the correctness of the collected information. In the embodiment depicted, the page prerequisite objects 650 store and retrieve the state of their requirements to/from the status data store 660. For example, once a required disclosure is displayed to the user that is a precondition to display of a particular page object, the associated page prerequisite object may record that fact in the status data store 660. Then, subsequently, when the particular page object is requested, its output will be seen rather than that of its page prerequisite object.

Importantly, the exemplary software architectures depicted in FIGS. 4 and 6 are not mutually exclusive. Rather, it is anticipated that depending upon the particular implementation either or both page sub-component prerequisites and page prerequisites may be used in the context of the same user interface for purposes of achieving the desired objectives.

#### Page Display Processing

FIG. 7A is a flow diagram illustrating web page display processing according to one embodiment of the present invention. In one embodiment, the processing blocks described below may be performed under the control of a programmed processor, such as processor 202. However, in alternative embodiments, the processing blocks may be fully or partially implemented by any programmable or hard-coded logic, such as Field Programmable Gate Arrays (FPGAs), TTL logic, or Application Specific Integrated Circuits (ASICs), for example.

In the example illustrated, display processing begins at processing block 710 where a request for a destination page, such as an HTTP request, is received by the web server 305 and conveyed to the object application 320 by way of the application server 310.

At processing block 720, the page prerequisite objects for the destination page are identified. According to one embodiment, this is accomplished by the base agent 610 calling the "getNextPreReq" method of the prerequisite factory 620, which, in turn, queries the properties data store 630. Again, the advantage of defining relationships between prerequisites and destination pages in a data store is the fact that no compilation is required when the system administrator modifies those relationships.

At processing block 730, prerequisite page objects that have one or more requirements that are not fulfilled are displayed sequentially until all prerequisite page objects' requirements are satisfied. According to one embodiment, the "getNextPreReq" method sequentially checks page prerequisite objects associated with the destination page in an order indicated by the properties data store 630 and returns

the first page prerequisite object that has one or more requirements that are not satisfied thereby facilitating definition of hierarchical relationships among page prerequisite objects and page objects.

Finally, after all the page prerequisite objects' requirements have been satisfied at processing block 740, the destination page is displayed.

FIG. 7B is a flow diagram illustrating processing block 730 of FIG. 7A according to one embodiment of the present invention. In this example, the goal is to find the first page prerequisite object associated with the specified page object that has one or more unmet requirements. At processing block 731, the "decider" sub-component of the next page prerequisite object is determined. Again, the decider is the sub-component of the page prerequisite object that is responsible for communicating whether or not the page prerequisite object's requirements have been met. According to one embodiment, the decider sub-component is determined by the prerequisite factory 620 querying the properties data store 630 for the "decider" property of the page prerequisite object.

At processing block 732, an instance of the "decider" sub-component is created. According to one embodiment, a special method is made available to allow creation of the page prerequisite object for the purpose of checking if the requirements have been met. Alternatively, the standard create method may be called with a control flag indicating the purpose of the create call, e.g., check prerequisites vs. true creation. At any rate, at decision block 733, the prerequisite factory 620 determines if the page prerequisite object's requirements have been satisfied by invoking a method of the newly created instance, such as a "metReqs" method that preferably all "decider" sub-components implement. If all the page prerequisite object's requirements have been met, then flow continues with decision block 735; otherwise processing branches to processing block 734.

At decision block 735, a determination is made whether or not there are more page prerequisite objects associated with the destination page. If so, processing continues with processing block 731. If not, no page prerequisite objects have been found that have unmet requirements; and processing continues with processing block 740.

At processing block 734, since it has been determined that one or more requirements of the page prerequisite object has not been met, the output of the prerequisite page is streamed to the display. Therefore, in this example, after the first page prerequisite object has been found with one or more unsatisfied requirements that page is displayed rather than the destination page selected by the user. In one embodiment, because the decider sub-component has already been instantiated, an optimization involves the framework saving the decider object created during the metReqs call so that it does not have to be recreated when the prerequisite page object is executed.

At decision block 736, a determination is made whether or not the page prerequisite has been closed. If so, control branches to decision block 733. If not, control loops back to decision block 736 thereby preventing the destination page from being displayed until the requirements of the prerequisite page object have been fulfilled.

#### Properties File Syntax Enhancements

Before describing various improvements to existing properties file syntax, it may be instructive to briefly discuss the current usage model of such files with reference to FIG. 8. As discussed above, Java has a special built-in mechanism for handling internationalization. Locale specific properties/

attributes are placed in files having a ".properties" extension (herein referred to as a "properties file"). The properties file contains one or more lines of attribute name value pairs (hereinafter "attribute-value pairs") in the general form represented by expression 810. The first portion of the attribute-value is an attribute name, such as "prompt1". The attribute name is followed by an equal sign. The final portion of the attribute value pair comprises a string value, such as "please enter your name", to be associated with the particular attribute. In the Java framework, properties files may be loaded into objects of type "ResourceBundle". Then, the resulting resource bundle objects may be queried to determine a value associated with a particular attribute of interest. For example, if a properties file contained the line:

```
15   Abc.def.gh_I=j
```

then invoking the appropriate resource bundle object's get method, e.g., resourceBundle.getString("Abc.def.gh\_I") would return the string value "j". In this manner, applications can query the value of an attribute during run time. However, one limitation of this prior art syntax is that both properties files and the corresponding internal resource bundle representations are flat, non-object oriented collections of key-value pairs. In connection with an object-oriented implementation of page sub-component prerequisites, page prerequisites, and/or other applications, the assignee of the present invention has found it to be advantageous to (1) allow properties/attributes to be defined and accessed on an object-by-object basis; (2) enable inheritance of properties/attributes through some hierarchy of objects; (3) specify and override properties/attributes of objects as they are used in different contexts; and (4) enable inheritance of contexts.

#### Definition and Access of Properties on an Object-by-Object Basis

FIG. 9 illustrates an improved properties file syntax that enables definition and access of properties on an object-by-object basis according to one embodiment of the present invention. According to the embodiment depicted, a properties data store, such as a properties file, may include attribute-value pairs according to the general form represented by expression 910. The first portion of the attribute-value pair is a string value representing an attribute name, such as "prompt1". Expression 910 further includes a string value representing an object name, followed by a delimiter, such as '.'. As above, the attribute name is followed by an equal sign. Finally, a value to be associated with the particular object attribute is specified in the form of a string value. While preferably, for readability, the delimiter that separates the object name and the attribute name is a non-alphanumeric printable ASCII character, in alternative embodiments other single or multiple character delimiters may be employed.

The syntax represented by expression 910 allows one or more attribute-value pairs to represent what is referred to herein as a "properties file object" or simply an object. For example, attribute-value pairs 920 and 930 together define a properties file object called "Obj1" having two attributes, attr1 and attr2. Similarly, attribute-value pairs 940 and 950 specify a properties file object named "Obj2" that also includes two attributes, attr1 and attr3. Attribute-value pair 920 associates the value, val11, with the attribute named attr1 of object, Obj1. Likewise, attribute-value pairs 930, 940, 950, and 960, associate val12, val21, val23, and "please enter your name" with attr2, attr1, attr3, and prompt1 of Obj1, Obj2, Obj2, and Trading, respectively.

Importantly, this improved syntax is fully compliant with standard Java properties files thereby making this syntax enhancement transparent to Java. To Java, the attribute-value pairs **920**, **930**, **940**, and **950** have no additional meaning. Rather, Java will interpret them as simply representing four independent attribute-value pairs. For example, Java interprets the attribute-value pair **920** as the value, val11, being associated with an attribute named "Obj1.attr1". Similarly, attribute-value pairs **930**, **940** and **950**, respectively, are interpreted as the value, val12, being assigned to "Obj1.attr2", the value, val21, being assigned to an attribute named "Obj2.attr1", and "Obj2.attr3" being associated with a value of val23. Consequently, as described further below, the syntax enhancements discussed herein may be implemented on top of standard Java properties file semantics by supplying the standard Java Application Programming Interfaces (APIs) and/or resource bundle methods with attribute names that include appropriate delimiters to separate the object name from the attribute name.

#### Inheritance of Properties

Currently, inheritance is not supported by the flat, non-object oriented structure of properties files. Therefore, the concept of a base object (e.g., an object upon which other objects may be built) does not exist. If common attributes are required in a properties file, they must be replicated as many times as necessary. Unfortunately, such replication becomes problematic when changes become necessary to the common attributes since each change must be accurately performed for each of the replicated attributes.

FIG. 10 illustrates an improved properties file syntax that enables inheritance of properties according to one embodiment of the present invention. In this example, a special attribute-value pair having the form of expression **1010** is provided. A first portion of the special attribute-value pair representing an object name is separated from a special attribute name, "extends", by a delimiter. The "extends" attribute is used to specify inheritance from the object specified on the right hand side of the equal sign.

As illustrated by attribute-value pairs **1020**, **1030**, **1040**, **1050**, and **1060**, this mechanism allows attributes and values of objects to be inherited by other objects; and the other objects may each override the value of an inherited attribute as well as add its own attributes and values. In the present example, two "properties file objects" are defined, Obj1 and Obj2. Obj1 and its associated attributes and values are defined by attribute-value pairs **1020** and **1030**. Obj2 and its associated attributes and values are defined by attribute-value pairs **1040**, **1050**, and **1060**. The use of the special attribute name "extends" in attribute-value pair **1040** causes Obj2 to extend Obj1. That is, Obj2 inherits all the attributes of Obj1. Additionally, in this example, attribute-value pair **1050** overrides the value of attr2 of Obj2 with val22. Finally, attribute-value pair **1060** specifies that Obj2 has an attribute, attr3, in addition to those specified for Obj1, which is assigned the value val23.

Advantageously, this novel inheritance syntax saves time for the person specifying attributes. For example, in a system in which two or more objects have many attributes and values in common, the common attributes need only be specified once in a base object. Then, extending objects need only specify overridden values or new attributes and values. Thus, by employing the inheritance mechanism described herein, time savings proportionate to the commonality of attributes among objects of a system can be achieved during specification of the attributes.

This notation also facilitates maintainability of properties files in which it is employed. Rather than replicating common attributes among many objects as would be required in a non-hierarchical environment that lacks a mechanism for inheritance, such as that imposed by current properties file syntax, the notation of FIG. 11 facilitates modification of object attributes and/or attribute values by allowing common attributes to be specified in base objects. As a result, a change to a particular common attribute is localized to the base object that specifies that common attribute; and semantically this change is automatically accomplished for all sub-objects (e.g., extending objects) that inherit from the modified base object.

While the special attribute name "extends" has been chosen to enhance the readability and understandability of the properties file, the invention is not limited to any particular naming convention. Thus, in alternative embodiments, the name "extends" may be replaced with other names, such as "inheritsfrom", "is a", or other arbitrary string values.

#### Specification and/or Overriding of Object Properties in Different Contexts

FIG. 11 illustrates an improved properties file syntax that enables the specification and/or overriding of object properties as they are used in different contexts according to one embodiment of the present invention. In this example, the syntax of an attribute-value pair may include a context name, an object name, and an attribute name as illustrated by expression **1110**. The context may represent a current state of a system, a top level container, a sub-container, a page, or other objects or circumstances useful for interpreting a particular object. In the examples described herein, the context is typically a user interface screen, such as a web page.

Importantly, this enhanced syntax provides for context sensitive overriding of properties file object attributes. In the present case, attribute-value pairs **1120** and **1130** define an object, Obj1, having attr1 and attr2. The value of attr1 is always val11. However, as a result of the attribute-value pair **1140**, the value of attr2 is val12 except when Obj1 is running in the context of Page1 in which case the value of attr2 is val12. Therefore, assuming an object has the ability to determine its context, a mechanism is provided by the syntax of expression **1110** for context sensitive overriding of attributes of objects.

While, in the examples illustrated herein, the context name, object name, and attribute name appear in a specific order relative to each other within attribute-value pairs, the invention is not limited to any particular ordering of these names. Consequently, in other embodiments, alternative orderings of these names may be used.

#### Inheritance of Contexts

FIG. 12 illustrates an improved properties file syntax that enables inheritance of contexts according to one embodiment of the present invention. The concept enabled by this syntax enhancement is similar to that of FIG. 10 with reference to which inheritance of attributes of properties file objects was illustrated. However, here, the properties file object is a context. Since a context is just a properties file object, any context may be extended and any contexts' attributes may be overridden or added as discussed earlier.

In the present example, properties files may include attribute-value pairs having the form of expression **1210**, which includes a context name, a special attribute name, "extends", and an indication of the context to be extended (e.g., the context from which to inherit objects and/or

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attributes). Attribute-value pairs **1220** and **1230** indicate that normally, or by default, the value of attribute attr2 of Obj1 is val12. However, attribute-value pair **1240** overrides the definition of attr2 of Obj1 when Obj1 is running in the context of Page1. Attribute-value pairs **1250** and **1260** specify a context, Page2, that includes all the objects and attributes of Page1 but overrides the value of attr2 of Obj1 when Obj1 is running in the context of Page2. Thus, the value of attr2 of Obj1 may have one of three values depending upon its current context. For example, when the context is Page1, attr2 is val112; when the context is Page2, attr2 is val212; otherwise, attr2 is val12.

#### Property Retrieval Processing

FIG. **13** is a high-level flow diagram that conceptually illustrates property retrieval processing according to one embodiment of the present invention. For simplicity the present example has been broken down into three stages: (1) a first stage in which the object hierarchy is traversed for a fixed context, (2) a second stage in which both context hierarchy traversal and object hierarchy traversal are performed, and (3) a third stage in which context is disregarded during object hierarchy traversal.

In the embodiment depicted, the property retrieval process begins at processing block **1310**. Processing block **1310** is representative of the first stage of the three stages. During processing block **1310**, an attempt is made to retrieve a specified attribute by climbing a specified object hierarchy (presumably created by the inheritance mechanisms described earlier) with which the attribute is thought to be associated. If a value for the specified attribute is located during this stage, processing is complete; otherwise processing proceeds with processing block **1320** (the second stage). At processing block **1320**, the context is no longer held fixed as in processing block **1310**. Rather, the context hierarchy is climbed to search parent contexts. Within each context, every level of the specified object hierarchy is also searched until the desired value is located or the levels are exhausted. Again, if the desired value is found, processing may cease at this point; otherwise, a final attempt is made to retrieve the value of the specified attribute in processing block **1330**. During processing block **1330** (the third stage), context is ignored; and a final search is made for the desired value by climbing the object hierarchy without regard to the current context.

FIG. **14A** is an exemplary context and object hierarchy. In this example, the properties file defines the following object hierarchy: Obj3 extends Obj2 which extends Obj1, and the following context hierarchy Page3 extends Page2 which extends Page1.

FIG. **14B** illustrates property retrieval processing according to the object and context hierarchy of FIG. **14A** and the processing of FIG. **13**. Suppose an object of type Obj3 running in the context of Page3 wants to get the value of its attribute, attr. According to the search approach described with reference to FIG. **13**, the object will look for a value of attr in the order shown in FIG. **14B**. The retrieval process will stop as soon as one of the requested attributes is located in the properties file or resource bundle representation.

First, the object will attempt to locate the value of attr by searching a first group of attribute-value pairs **1410**. More specifically, the object will first look in its current context, e.g., by calling its `getValue()` method with the string value "Page3.Obj3.attr". If the value of attr for Obj3 is not overridden by Page3, then the object will begin climbing its hierarchy. In this example, the object will look to its parent, Obj2, to see if a value has been associated with attr, e.g., by

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making the call `getValue("Page3.Obj2.attr")`. If this retrieval is unsuccessful, e.g., returns a null value, then a final attempt within the current context will be made to retrieve the desired value from Obj1.

Assuming the desired value was not found during the first stage. The search continues into a second group of attribute-value pairs **1420**. The search of the second group **1420** represents the second stage where an attempt is made to locate the object's attribute by climbing the object's hierarchy in the parent context, Page2, until a level is found in which the attribute is assigned a value or until the levels are exhausted. The search proceeds as above, climbing the object hierarchy within the current context, Page2. Once the object hierarchy has been exhausted, however, the search continues with the parent of the current context, Page1.

Again, assuming the desired value was not located by a previous stage, the search enters a final stage in which context is disregarded and the object hierarchy is traversed. First, the object determines if it has defined a value for attr, e.g., by making the call `getValue("Obj3.attr")`. If this call is unsuccessful, then a subsequent retrieval is made with reference to the object's parent, Obj2. If that call fails, a final attempt to retrieve the desired value will be made with reference to Obj2's parent, Obj1, e.g., by calling `getValue("Obj1.attr")`.

FIG. **15** is a flow diagram illustrating processing associated with traversal of an object hierarchy and a context hierarchy according to one embodiment of the present invention. According to this embodiment, the first and second stages of the search processing are combined into a single stage. At processing block **1510**, an initial attempt is made to retrieve the value of the requested attribute from the current object while taking into consideration the current context. At decision block **1520**, a determination is made whether or not the attribute has been found. If not processing continues with decision block **1530**; otherwise the search is complete.

At decision block **1530**, a determination is made whether or not the object hierarchy has been exhausted. If the current object has a parent, then another level in the object hierarchy exists. However, if the current object does not have a parent, then the object hierarchy has been exhausted. At any rate, assuming the object hierarchy has been exhausted, processing continues with processing block **1540** during which the current object is updated to be the next object in the object hierarchy, i.e. its parent, and processing returns to processing block **1510**.

Returning to decision block **1530**, if the object hierarchy has been exhausted, processing proceeds to decision block **1550**. At decision block **1550** a determination is made whether or not the context hierarchy has been exhausted. If there is no parent of the current context (context hierarchy exhausted), then the current stage of the search is complete. Otherwise, if the current context has a parent (context hierarchy not exhausted), then processing continues with processing block **1560**.

At processing block **1560**, the current context is updated to the next context (i.e., the parent of the current context). Then, at processing block **1570**, the current object is reset to the original object to restart object hierarchy traversal in the new context.

It is worth mentioning at this point that while the processing blocks of a flow diagram illustrating a particular embodiment are presented and described in a particular order, there should be no implication that the present invention is limited by that particular ordering. Rather, it is contemplated that in alternative embodiments, the ordering

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of the processing blocks may be changed while preserving the core functionality. For example, in FIG. 15, at least the ordering of processing blocks 1560 and 1570 may be reversed without any effect.

FIG. 16 is a flow diagram illustrating processing associated with traversal of an object hierarchy without regard to context according to one embodiment of the present invention. At processing block 1610, an initial attempt to retrieve the desired value is made by ignoring the current context. A determination is made regarding whether the retrieval was successful at decision block 1620. If the attribute value has successfully been located search processing is complete; otherwise, processing continues with decision block 1630. At decision block 1630, a determination is made whether or not the object hierarchy is exhausted. If so, this third stage of processing is complete. Otherwise, processing proceeds to processing block 1640. At processing block 1640, the current object is updated to reflect the next object in the object hierarchy; and then processing returns to processing block 1610.

Importantly, while the flow diagrams described above imply a simple, linear, non-recursive algorithm, it is contemplated that in an actual code implementation it may be desirable to implement one or more of the methods as recursive procedures/functions.

Software Architecture for Processing an Improved Properties File Syntax

FIG. 17 is a block diagram the conceptually illustrates software architectural components that enable processing of an improved properties file syntax according to one embodiment of the present invention. According to this example, an object 1710 exposes a `getValue()` method 1711 which in turn may call a `getContextInheritance()` method 1713 and/or a `getWithInheritance()` method 1717. In alternative embodiments, the `getValue()` method 1711 may be private (i.e., not exposed outside of the object 1710).

According to one embodiment, object 1710 inherits logic from a base object that serves as an abstraction for the interface to API 1720. In this manner, object 1710 automatically has the ability to retrieve the value of any of its attributes without needing knowledge of the underlying interface to the properties data store, e.g., properties file 1730. Additionally, inheritance of this logic saves design and development time.

In one embodiment, the functionality of the `getContextInheritance()` method and `getWithObjectInheritance()` method are represented by the processing described with reference to FIG. 15; and the functionality of the `getWithInheritance()` method is represented by the processing described with reference to FIG. 16.

Importantly, while, for sake of generality, the properties file 1730 is shown as being accessed by API 1720, it is appreciated that the properties file 1730 may be internally represented with a `resourceBundle` object as described above. Also, if this is the case, the API 1720 would be the `resourceBundle`'s exposed methods.

Exemplary Methods Accessible by the Objects

For the sake brevity, in the code examples of FIGS. 18-21, it is assumed that there exists a `getContextName()` method in every object that returns a string value containing the context/container name. Every object also is assumed to know how to figure out its name. In Java this is done by performing the call: `getClass().getName()`. Subsequently, the left sub-parts of the name are removed to reveal the object name. In the following examples, this left sub-part

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removal (or alternatively, right sub-part extraction) is assumed to be performed by `getName()`. Therefore, "pkg1.sub2.Obj3" would result in the object name of "Obj3". In the exemplary implementation every object is additionally assumed to extend some base object that implements a `getValue()` method, which returns the value of a key-value pair corresponding to a specified key. Therefore, every sub-component inherits the logic in the method `getValue()`.

FIG. 18 illustrates exemplary code for the `getValue` method of FIG. 17 according to one embodiment of the present invention. In this example, the method returns the value of the requested attribute of the currently executing object, taking the current context into consideration.

FIG. 19 illustrates exemplary code for the `getWithContextInheritance` method of FIG. 17 according to one embodiment of the present invention. In this example, this method looks for the value of attribute, `attrib`, of an object named object as it is running in the context, `context`. If the specified attribute is not found in the specified context, the method looks in the parent context. Importantly, as it looks for the attribute in a given context, it also examines the object's hierarchy. The method uses recursion that terminates when (1) the desired value is found or (2) the whole hierarchy has been examined and the specified attribute cannot be found.

FIG. 20 illustrates exemplary code for the `getWithObjInheritance` method of FIG. 17 according to one embodiment of the present invention. In this example, this method looks for the value of attribute, `attrib`, of an object named object as it is running in the context, `context`. If the specified attribute is not found associated with the object running in the current context, then the method looks for the attribute in the object's parent running in the same context. That is, the method continues to climb up the object hierarchy while keeping the context fixed. The method uses recursion that terminates when (1) the desired value is found or (2) the whole hierarchy has been examined and the specified attribute cannot be found.

FIG. 21 illustrates exemplary code for the `getWithInheritance` method of FIG. 17 according to one embodiment of the present invention. In this example, this method looks for the value of attribute, `attrib`, of an object named object. If the specified attribute is not found, then the method looks for the attribute in the object's parent and continues to climb the object hierarchy until the method terminates. The method uses recursion that terminates when (1) the desired value is found or (2) the whole hierarchy has been examined and the specified attribute cannot be found.

Importantly, while not shown in the exemplary code fragments, a memory cache may be implemented to avoid repeating lookups for attributes. Briefly, when an object needs to calculate the value of some property it first checks if it is available in the cache. If it is, the value is retrieved from the cache; otherwise, the value may be retrieved from the properties file (via the `resourceBundle` and algorithms described above or the exemplary code of FIGS. 18-21). If the value is found in the properties file, a copy may be stored in the cache to avoid future file lookups and related processing.

In the foregoing specification, the invention has been described with reference to specific embodiments thereof. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.

What is claimed is:

1. A computer implemented method of determining a value of an attribute of an object comprising:

attempting to determine the value by  
formulating a first query to retrieve the attribute from a 5  
properties data,

store based upon a combination of a current context  
identifier, an object identifier associated with the  
object, and an attribute identifier associated with the  
attribute,

submitting the first query through an application program-  
ming interface (API) associated with the properties data  
store without having knowledge of an underlying inter-  
face to the properties data store, and

receiving results associated with the first query, and 15  
if the first query is unsuccessful at locating the value, then  
determining the value by

formulating a second query to retrieve the attribute  
from the properties data store based upon a combi-  
nation of the object identifier and the attribute identifier 20  
without specifying the current context identifier,

submitting the second query through the API, and  
receiving results associated with the second query,  
wherein the value is determined based on the object  
identifier and the attribute identifier by ignoring the  
current context identifier.

2. The computer implemented method of claim 1, wherein  
the properties data store comprises one or more Java prop-  
erties files.

3. The computer implemented method of claim 2, wherein  
the second query is compliant with standard Java properties  
files, and wherein the second query includes a string value  
representing the object identifier, the attribute identifier, and  
a delimiter to separate the object identifier and the attribute 35  
identifier.

4. The computer implemented method of claim 1, wherein  
the first query is compliant with standard Java properties  
files, and wherein the first query includes a string value  
representing the current context identifier, the object identifier,  
the attribute identifier, and delimiters separating the  
identifiers from each other.

5. A computer implemented method of determining a  
value of an attribute of an object stored in a Java properties  
files, the method comprising:

attempting to determine the value by initiating a first  
attribute retrieval stage that formulates and applies a  
first set of queries that traverse an object hierarchy  
associated with the object within a fixed context to a  
properties data store, each query of the first set of 50  
queries including a current context identifier, an object  
identifier associated with an object of the object hier-  
archy, and an attribute identifier associated with the  
attribute; and

if the first attribute retrieval stage is unsuccessful, 55  
attempting to determine the value by initiating a second  
attribute retrieval stage that formulates and applies a  
second set of queries that traverse both the object  
hierarchy and a context hierarchy associated with a  
current context, each query of the second set of queries 60  
including a context identifier associated with a context  
of the context hierarchy, an object identifier associated  
with an object of the object hierarchy, and the attribute  
identifier; and

if the second attribute retrieval stage is unsuccessful, 65  
attempting to determine the value by initiating a third  
attribute retrieval stage that formulates and applies a

third set of queries that traverses the object hierarchy  
without regard for the current context, each query of the  
third set of queries including an object identifier asso-  
ciated with an object of the object hierarchy and the  
attribute identifier.

6. The computer implemented method of claim 5, wherein  
the object inherits the attribute from a base object defined in  
the Java properties files.

7. The computer implemented method of claim 6, wherein  
the object overrides the value assigned to the attribute in  
connection with the base object.

8. The computer implemented method of claim 7, wherein  
the object represents a prompt of a graphical user interface.

9. The computer implemented method of claim 5, wherein  
the current context inherits the attribute from a base context.

10. The computer implemented method of claim 9,  
wherein the current context overrides the value assigned to  
the attribute in connection with the base context.

11. The computer implemented method of claim 10,  
wherein the current context represents a particular page of a  
website.

12. A system for maintaining attribute-value pairs com-  
prising:

a Java properties file having stored therein values of a  
plurality of attributes associated with one or more  
objects, the one or more objects represented in an  
improved properties file syntax that is compliant with  
standard Java properties files semantics thereby making  
the existence of the one or more objects transparent to  
Java;

a Java application programming interface (API) to receive  
and apply queries for attribute values to the Java  
properties files; and

a syntax enhancement layer residing above the Java API  
that is able to receive and parse queries formulated  
according to the improved properties file syntax and  
issue appropriate queries to the Java API, the syntax  
enhancement layer encapsulating the Java API such  
that an originator of the queries does not have to know  
about the Java API,

wherein the syntax enhancement layer determines a value  
of an attribute of an object stored in the Java properties  
file by employing at least a first attribute retrieval stage,  
a second attribute retrieval stage, and a third attribute  
retrieval stage,

wherein the first attribute retrieval stage formulates and  
applies a first set of queries that traverse an object  
hierarchy associated with the object within a fixed  
context to the Java properties file via the Java API, each  
query of the first set of queries including a current  
context identifier, an object identifier associated with an  
object of the object hierarchy, and an attribute identifier  
associated with the attribute,

wherein the second attribute retrieval stage is responsive  
to unsuccessful completion of the first attribute  
retrieval stage and formulates and applies a second set  
of queries that traverse both the object hierarchy and a  
context hierarchy associated with a current context,  
each query of the second set of queries including a  
context identifier associated with a context of the  
context hierarchy, an object identifier associated with  
an object of the object hierarchy, and the attribute  
identifier, and

wherein the third attribute retrieval stage is responsive to  
unsuccessful completion of the second attribute

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retrieval stage and formulates and applies a third set of queries that traverses the object hierarchy without regard for current context, each query of the third set of queries including an object identifier associated with an object of the object hierarchy and the attribute identifier.

13. A machine-readable medium having stored thereon data representing sequences of instructions, the sequences of instructions which, when executed by a processor, cause the processor to:

attempt to determine a value of an attribute of an object by,

formulating a first query to retrieve the attribute from a properties data store based upon a combination of a current context identifier, an object identifier associated with the object, and an attribute identifier associated with the attribute,

submitting the first query through an application programming interface (API) associated with the properties data store without having knowledge of an underlying interface to the properties data store, and

receiving results associated with the first query, and if the first query is unsuccessful at locating the value, then attempt to determine the value by

formulating a second query to retrieve the attribute from the properties data store based upon a combination of the object identifier and the attribute identifier without specifying the current context identifier,

submitting the second query through the API, and receiving results associated with the second query, wherein the value is determined based on the object identifier and the attribute identifier by ignoring the current context identifier.

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14. A machine-readable medium having stored thereon data representing sequences of instructions, the sequences of instructions which, when executed by a processor, cause the processor to:

attempt to determine a value of an attribute of an object stored in a Java properties file by initiating a first attribute retrieval stage that formulates and applies a first set of queries that traverse an object hierarchy associated with the object within a fixed context to a properties data store, each query of the first set of queries including a current context identifier, an object identifier associated with an object of the object hierarchy, and an attribute identifier associated with the attribute;

attempt to determine the value by initiating a second attribute retrieval stage in response to unsuccessful completion of the first attribute retrieval stage that formulates and applies a second set of queries that traverse both the object hierarchy and a context hierarchy associated with a current context, each query of the second set of queries including a context identifier associated with a context of the context hierarchy, an object identifier associated with an object of the object hierarchy, and the attribute identifier; and

attempt to determine the value by initiating a third attribute retrieval stage in response to unsuccessful completion of the second attribute retrieval stage that formulates and applies a third set of queries that traverses the object hierarchy without regard for context, each query of the third set of queries including an object identifier associated with an object of the object hierarchy and the attribute identifier.

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