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(54) SYSTEM AND METHOD FOR BUILDING MIXED MODE EXECUTION ENVIRONMENT FOR COMPONENT APPLICATIONS

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Publication Classification

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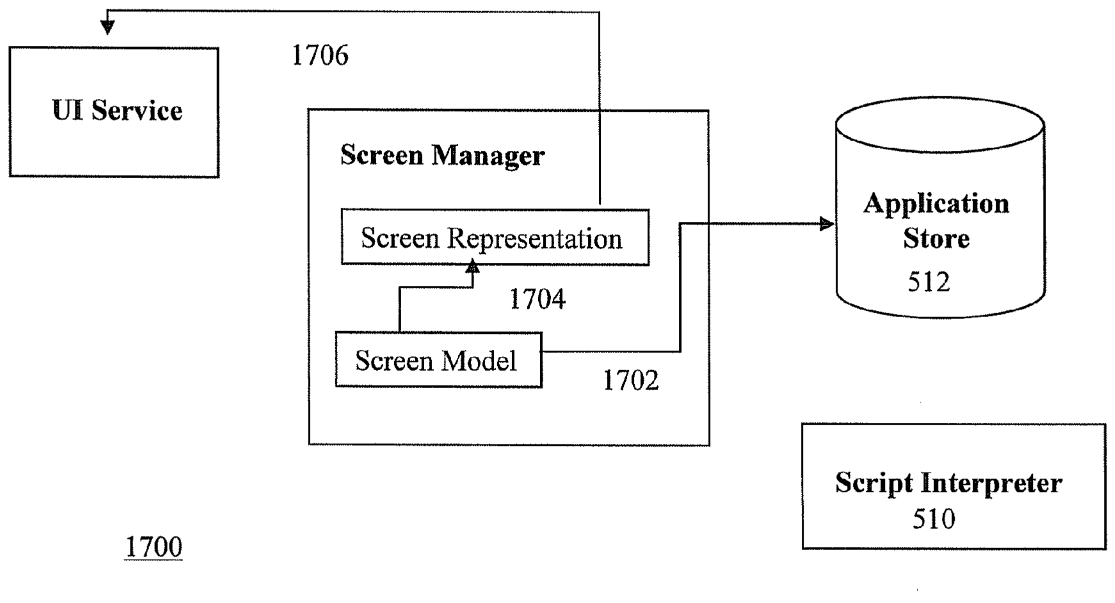
(57) **ABSTRACT**

A device runtime environment is provided for execution on a computing device. The device runtime environment provides an intelligent container for an application at runtime and comprises a plurality of services in communication with each other. The plurality of services a data manager, a screen manager, a communication service and a script interpreter. The data manager manages data components of the application including manipulation and persistence in a database of the data components. The screen manager managing screen components of the application and renders an output for display on a screen of the computing device. The communication service sends messages to external resources and receives and manages messages sent from external resources in accordance with corresponding message components.



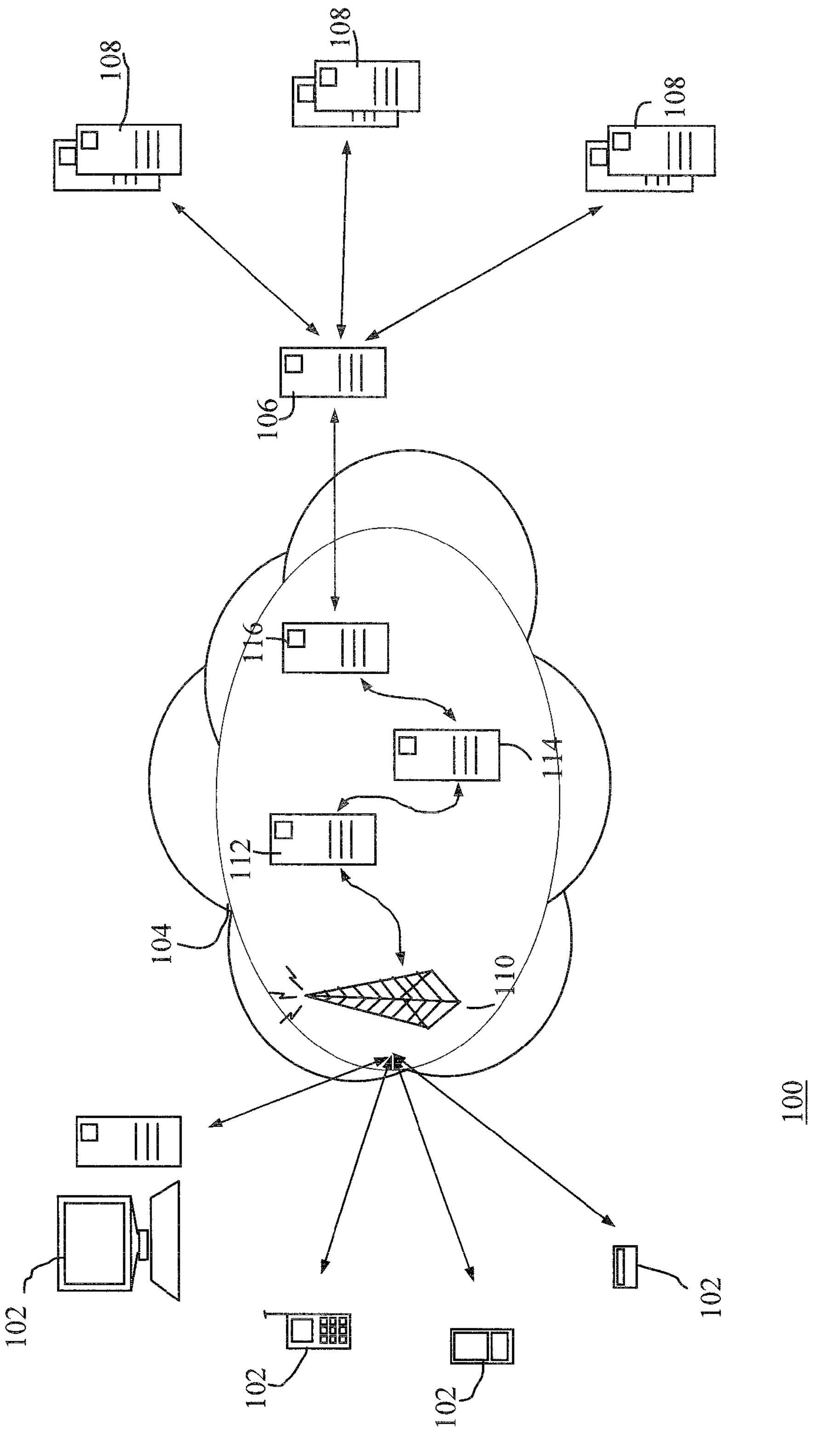


Figure 1

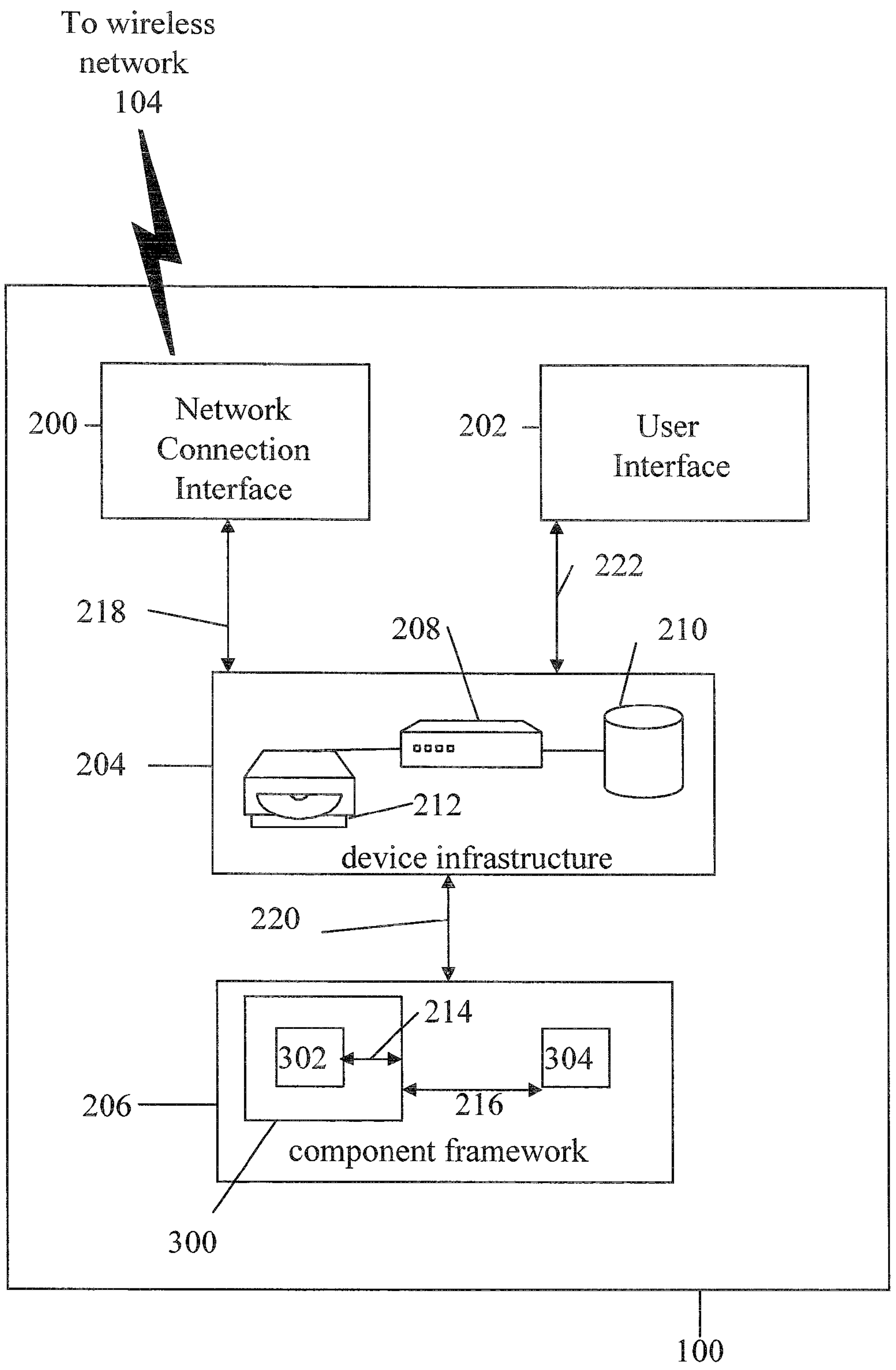

To wireless network 104
200
Network Connection Interface
202
User Interface
218
222
208
210
204
212
device infrastructure
220
214
302
304
206
216
component framework
300
100

Figure 2

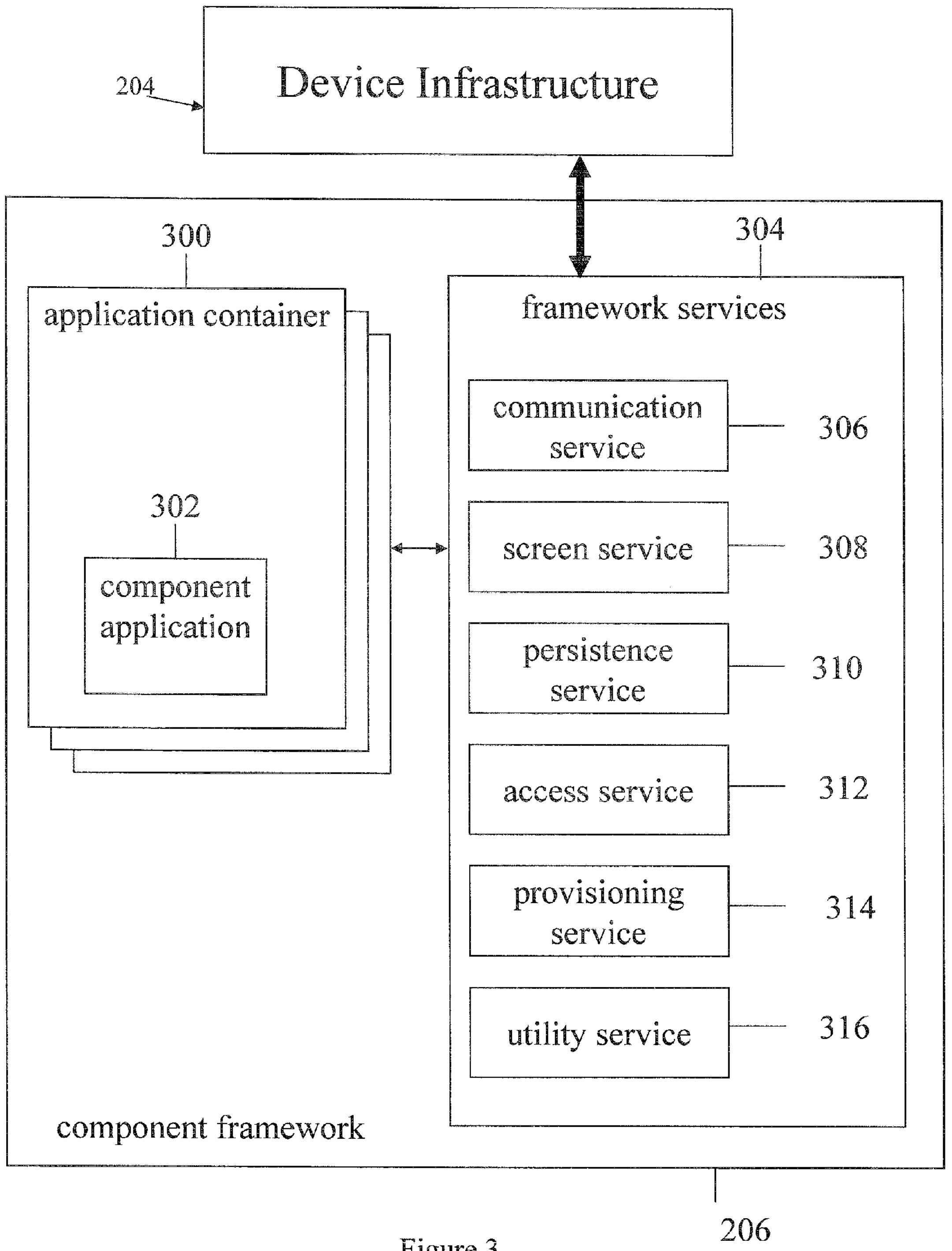

204
Device Infrastructure
300
application container
302
component application
304
framework services
communication service
306
screen service
308
persistence service
310
access service
312
provisioning service
314
utility service
316
component framework
206

Figure 3

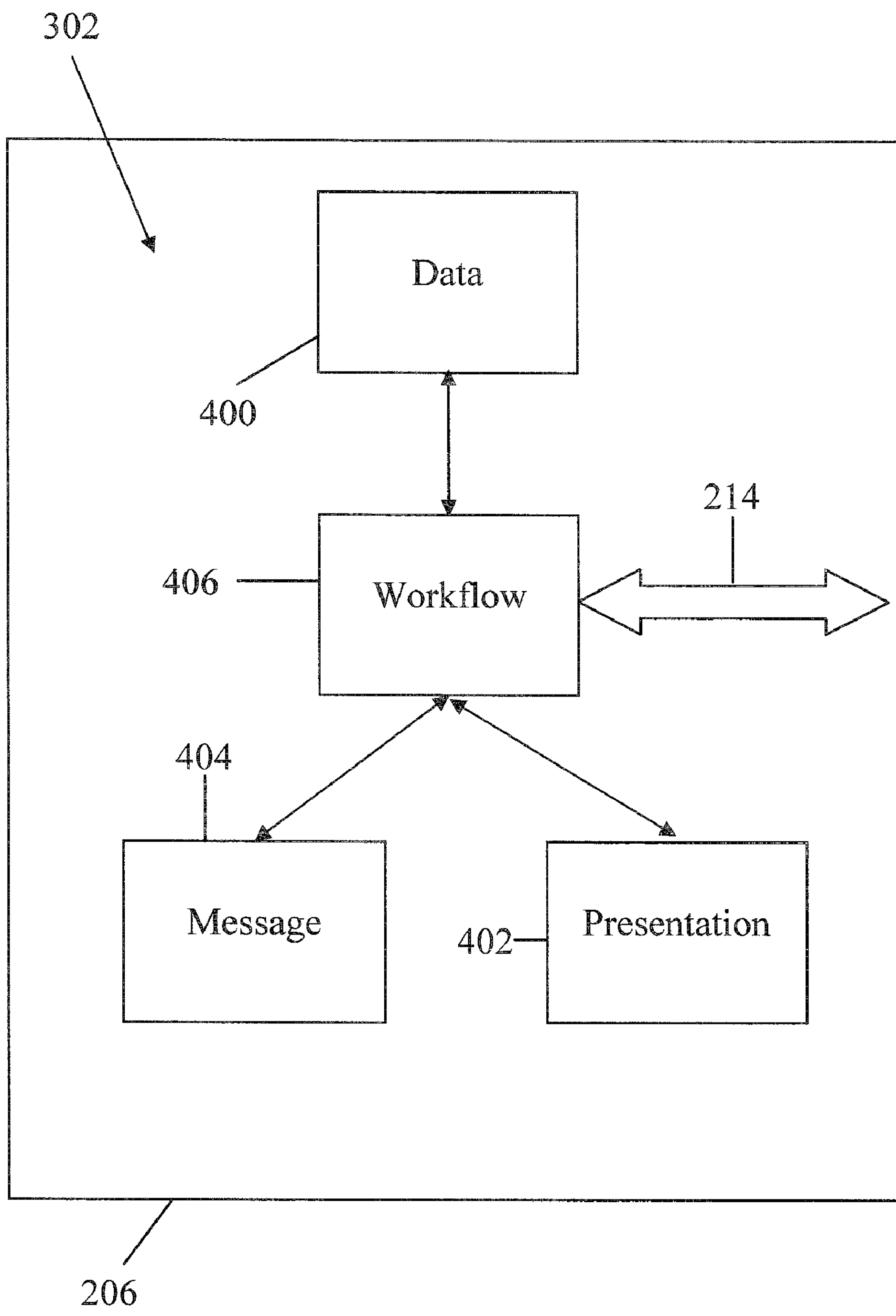

302
Data
400
214
406
Workflow
404
Message
402
Presentation
206

Figure 4

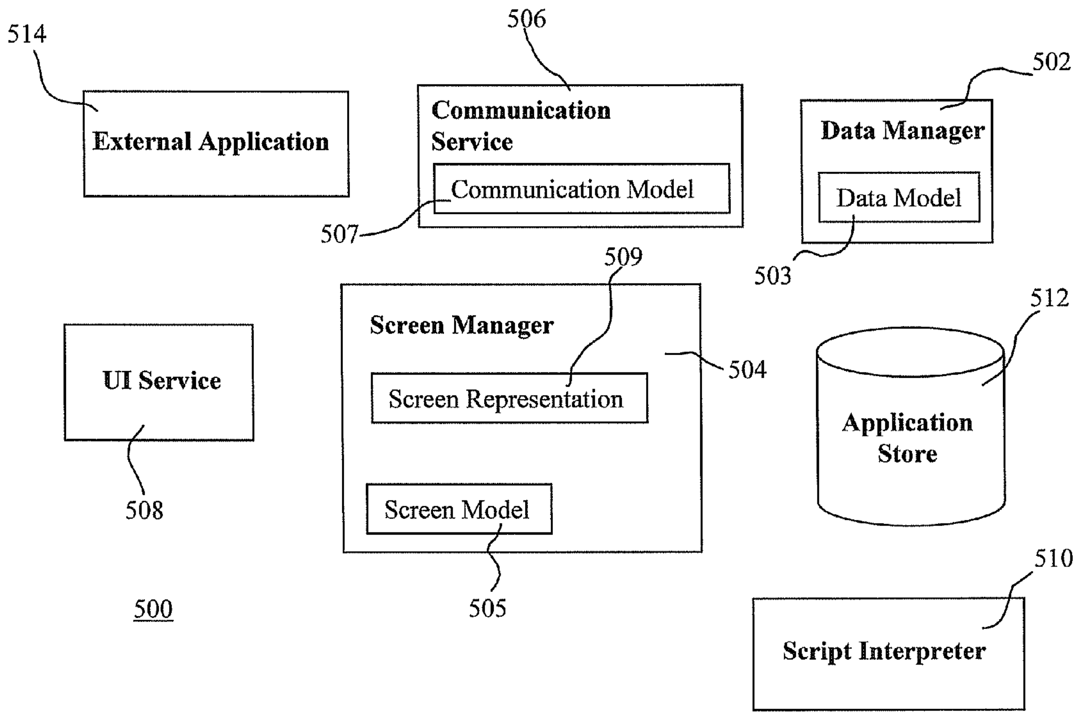
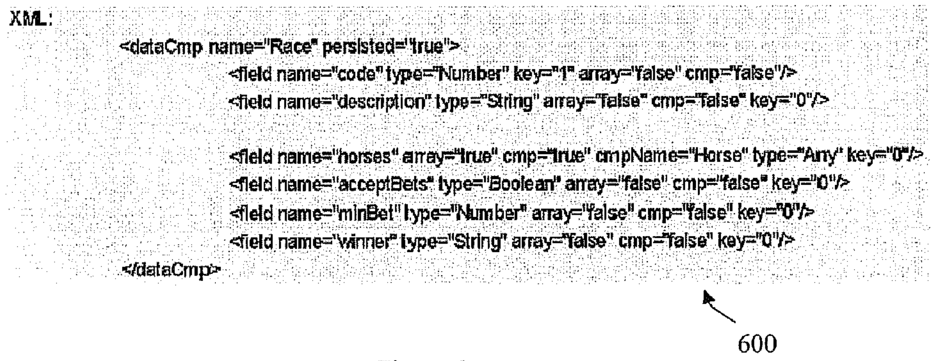


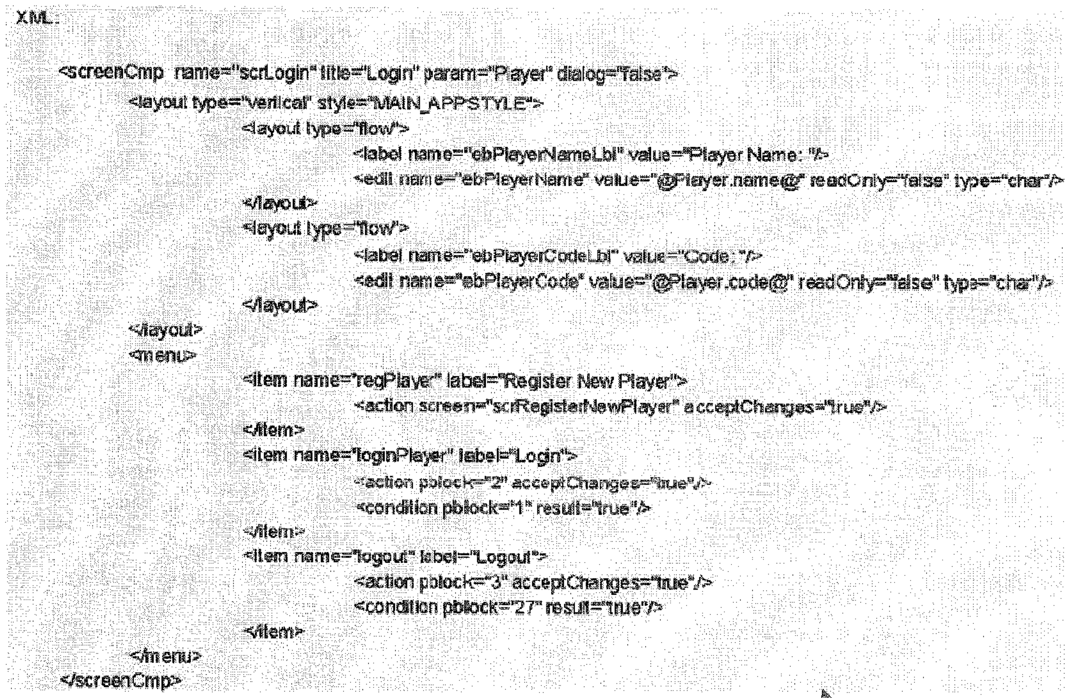
Figure 5



```
XML:
        <dataCmp name="Race" persisted="true">
                <field name="code" type="Number" key="1" array="false" cmp="false"/>
                <field name="description" type="String" array="false" cmp="false" key="0"/>

                <field name="horses" array="true" cmp="true" cmpName="Horse" type="Any" key="0"/>
                <field name="acceptBets" type="Boolean" array="false" cmp="false" key="0"/>
                <field name="minBet" type="Number" array="false" cmp="false" key="0"/>
                <field name="winner" type="String" array="false" cmp="false" key="0"/>
        </dataCmp>
```

Figure 6

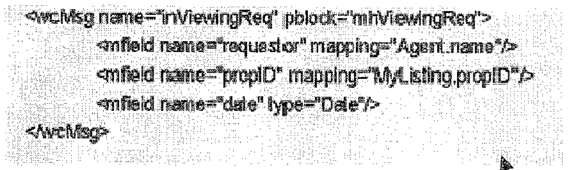


```
XML:

    <screenCmp  name="scrLogin" title="Login" param="Player" dialog="false">
            <layout type="vertical" style="MAIN_APPSTYLE">
                        <layout type="flow">
                                    <label name="ebPlayerNameLbl" value="Player Name: "/>
                                    <edit name="ebPlayerName" value="@Player.name@" readOnly="false" type="char"/>
                        </layout>
                        <layout type="flow">
                                    <label name="ebPlayerCodeLbl" value="Code: "/>
                                    <edit name="ebPlayerCode" value="@Player.code@" readOnly="false" type="char"/>
                        </layout>
            </layout>
            <menu>
                        <item name="regPlayer" label="Register New Player">
                                    <action screen="scrRegisterNewPlayer" acceptChanges="true"/>
                        </item>
                        <item name="loginPlayer" label="Login">
                                    <action pblock="2" acceptChanges="true"/>
                                    <condition pblock="1" result="true"/>
                        </item>
                        <item name="logout" label="Logout">
                                    <action pblock="3" acceptChanges="true"/>
                                    <condition pblock="27" result="true"/>
                        </item>
            </menu>
    </screenCmp>
```

700

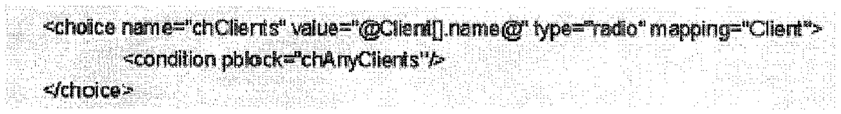
Figure 7



```
<wcMsg name="inViewingReq" pblock="mhViewingReq">
        <mfield name="requestor" mapping="Agent.name"/>
        <mfield name="propID" mapping="MyListing.propID"/>
        <mfield name="date" type="Date"/>
</wcMsg>
```

800

Figure 8



```
<choice name="chClients" value="@Client[].name@" type="radio" mapping="Client">
        <condition pblock="chAnyClients"/>
</choice>
```

900

Figure 9a

```
XML:

<screenCmp name="scrLogin" title="Login" param="Player" dialog="false">
        <layout type="vertical" style="MAIN_APPSTYLE">
                <layout type="flow">
                        <label name="ebPlayerNameLbl" value="Player Name: "/>
                        <edit name="ebPlayerName" value="@Player.name@" readOnly="false" type="char"/>
                </layout>
                <layout type="flow">
                        <label name="ebPlayerCodeLbl" value="Code: "/>
                        <edit name="ebPlayerCode" value="@Player.code@" readOnly="false" type="char"/>
                </layout>
        </layout>
        <menu>
                <item name="regPlayer" label="Register New Player">
                        <action screen="scrRegisterNewPlayer" acceptChanges="true"/>
                </item>
                <item name="loginPlayer" label="Login">
                        <action pblock="2" acceptChanges="true"/>
                        <condition pblock="1" result="true"/>
                </item>
                <item name="logout" label="Logout">
                        <action pblock="3" acceptChanges="true"/>
                        <condition pblock="27" result="true"/>
                </item>
        </menu>
</screenCmp>
```

930

Figure 9b

```
XML:
    <wcMsg name="inPropertyInfo" mapping="PropertyInfo"/>
```

960

Figure 9c

```
XML:

<layout>
   <label>Country</label>
   <choice name="choiceCountry">"Canada", "USA"</choice>
   <layout condition="choiceCountry" value="Canada">
      <label name="provinces">Provinces:</label>
      <choice name="choiceCanadaProvinces">"BRITISH COLUMBIA","YUKON",
         "NORTHWEST TERRITORIES","ALBERTA","SASKATCHEWAN","NANAVUT","MANITOBA",
         "ONTARIO","QUEBEC","NEWFOUNDLAND","NEW BRUNSWICH","NOVA SCOTIA"</choice>
   </layout>
   <layout condition="choiceCountry" value="USA">
      <label name="states">States:</label>
      <choice name="choiceUSStates">"ALABAMA","ALASKA","ARIZONA","ARKANSAS",
         "CALIFORNIA","COLORADO","CONNECTICUT","DELAWARE","D.C.",
         "FLORIDA","GEORGIA","HAWAII","IDAHO","ILLINOIS","INDIANA","IOWA",
         "KANSAS","KENTUCKY","LOUISIANA","MAINE","MARYLAND","MASSACHUSETTS",
         "MICHIGAN","MINNESOTA","MISSISSIPPI","MISSOURI","MONTANA","NEBRASKA",
         "NEVADA","NEW HAMPSHIRE","NEW JERSEY","NEW MEXICO","NEW YORK",
         "NORTH CAROLINA","NORTH DAKOTA","OHIO","OKLAHOMA","OREGON",
         "PENNSYLVANIA","RHODE ISLAND","SOUTH CAROLINA","SOUTH DAKOTA",
         "TENNESSEE","TEXAS","UTAH","VERMONT","VIRGINIA","WASHINGTON",
         "WEST VIRGINIA","WISCONSIN","WYOMING"</choice>
   </layout>
</layout>
```

1000

Figure 10

```
<layout type="vertical" placement="1,0">
        <button name="btnCPrefs" value="Client Details">
                <condition pblock="chAnyClients"/>
                <event type="onClick" screen="scrClientInfo" param="Client"/>
        </button>
        <button name="btnCWrbk" value="Client Workbook">
                <condition pblock="chAnyClients"/>
                <event type="onClick" screen="scrClientWrbk" param="Client"/>
        </button>
        <button name="btnNewClient" value="New Client">
                <event type="onClick" screen="scrNewClient"/>
        </button>
</layout>
```

Figure 11

1100

```
XML:
     <wcMsg name="inMyListing" mapping="PropertyInfo" pblock="mhMyListing"/>
     <!-- Listing of interest for registered client (pushed on outRegClientSearch or after
     outPropertyStatusChange from "pending" to "new" -->
     <wcMsg name="inListingForClient" mapping="PropertyInfo" pblock="mhListingForClient">
               <mfield name="forClient" mapping="Client.name"/>
     </wcMsg>
```

1200

Figure 12a

```
XML:
<wcScr name="scrPropDetails" title="Property Details" param="PropertyInfo">
     <!--... -->
     <refresh>
               <msg>inPropertyInfo</msg>
               <msg>inPropertyStatusChange</msg>
     </refresh>
</wcScr>
```

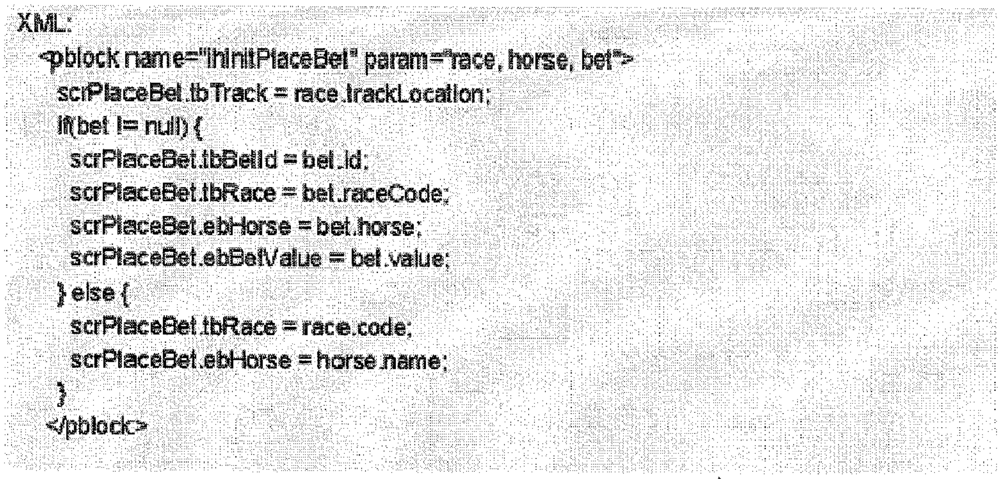
1250

Figure 12b

```
XML:
 <pblock name="ahStatusChange" param="propertyInfo">
     outPropertyStatusChange.propID = propertyInfo.propID;
     outPropertyStatusChange.status = propertyInfo.status;
     outPropertyStatusChange.price = propertyInfo.price;
     outPropertyStatusChange.send();
     scrPropDetails.display(propertyInfo);
 </pblock>
```

1300

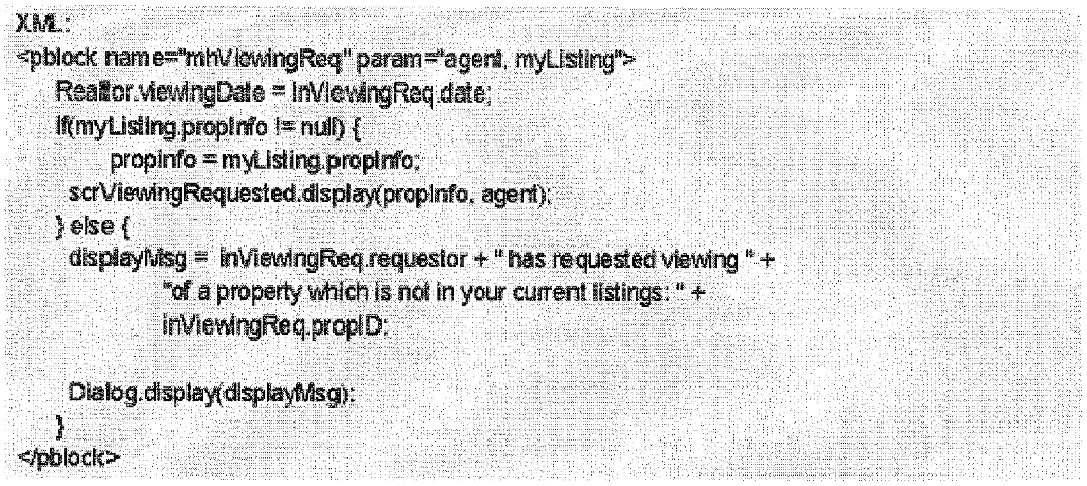
Figure 13



```
XML:
  <pblock name="lhInitPlaceBet" param="race, horse, bet">
    scrPlaceBet.tbTrack = race.trackLocation;
    if(bet != null) {
      scrPlaceBet.tbBetId = bet.id;
      scrPlaceBet.tbRace = bet.raceCode;
      scrPlaceBet.ebHorse = bet.horse;
      scrPlaceBet.ebBetValue = bet.value;
    } else {
      scrPlaceBet.tbRace = race.code;
      scrPlaceBet.ebHorse = horse.name;
    }
   </pblock>
```

1400

Figure 14



```
XML:
<pblock name="mhViewingReq" param="agent, myListing">
    Realtor.viewingDate = inViewingReq.date;
    if(myListing.propInfo != null) {
         propInfo = myListing.propInfo;
      scrViewingRequested.display(propInfo, agent);
    } else {
      displayMsg =  inViewingReq.requestor + " has requested viewing " +
                "of a property which is not in your current listings: " +
                inViewingReq.propID;

      Dialog.display(displayMsg);
    }
</pblock>
```

1600

Figure 16

```
        <wcScr name="scrStatusChange" param="PropertyInfo" title="Change Listing" dialog="true">
                <layout type="vertical">
                        <layout type="flow">
                                <label name="lbStatus" value="Status: @PropertyInfo.status@"/>
                        </layout>
                        <layout type="grid">
                                <label name="lbChStatus" value="Change to:" placement="0,0"/>
                                <label name="dummy10" value=" " placement="1,0"/>
                                <label name="dummy01" value=" " placement="0,1"/>
                                <choice name="chStatuses" mapping="PropertyInfo.status" type="radio"
placement="1,1">
                                        <entry>new</entry>
                                        <entry>active</entry>
                                        <entry>reduced</entry>
                                        <entry>suspended</entry>
                                        <entry>cond. sold</entry>
                                        <entry>sold</entry>
                                </choice>
                        </layout>
                        <layout type="flow">
                                <label name="lbNewPrice" value="New Price: $">
                                        <condition pblock="chStatusSelection"/>
                                </label>
                                <edit name="ebNewPrice" mapping="PropertyInfo.price">
                                        <condition pblock="chStatusSelection"/>
                                </edit>
                        </layout>
                        <button name="btnDone" value="Done" placement="1,0">
                                <event type="onClick" pblock="ahStatusChange" param="PropertyInfo"/>
                        </button>
                </layout>
        </wcScr>
```

1500

Figure 15

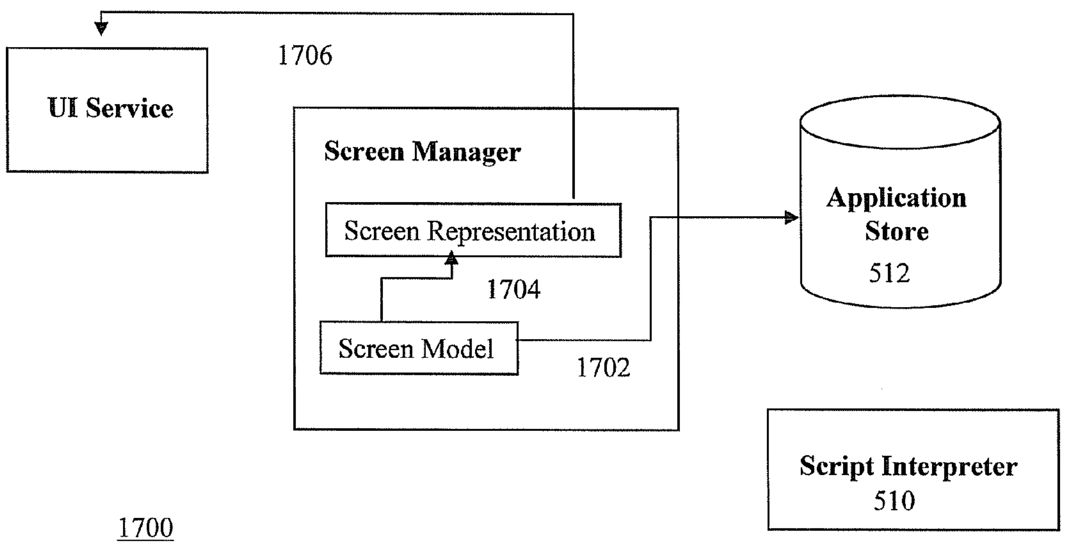


Figure 17

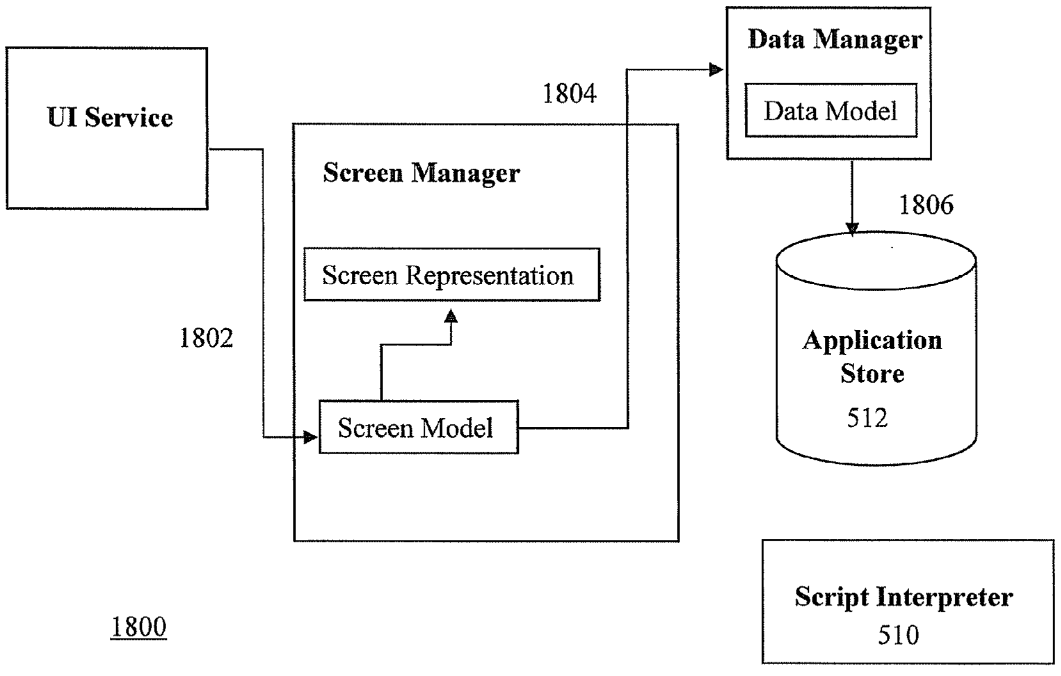


Figure 18

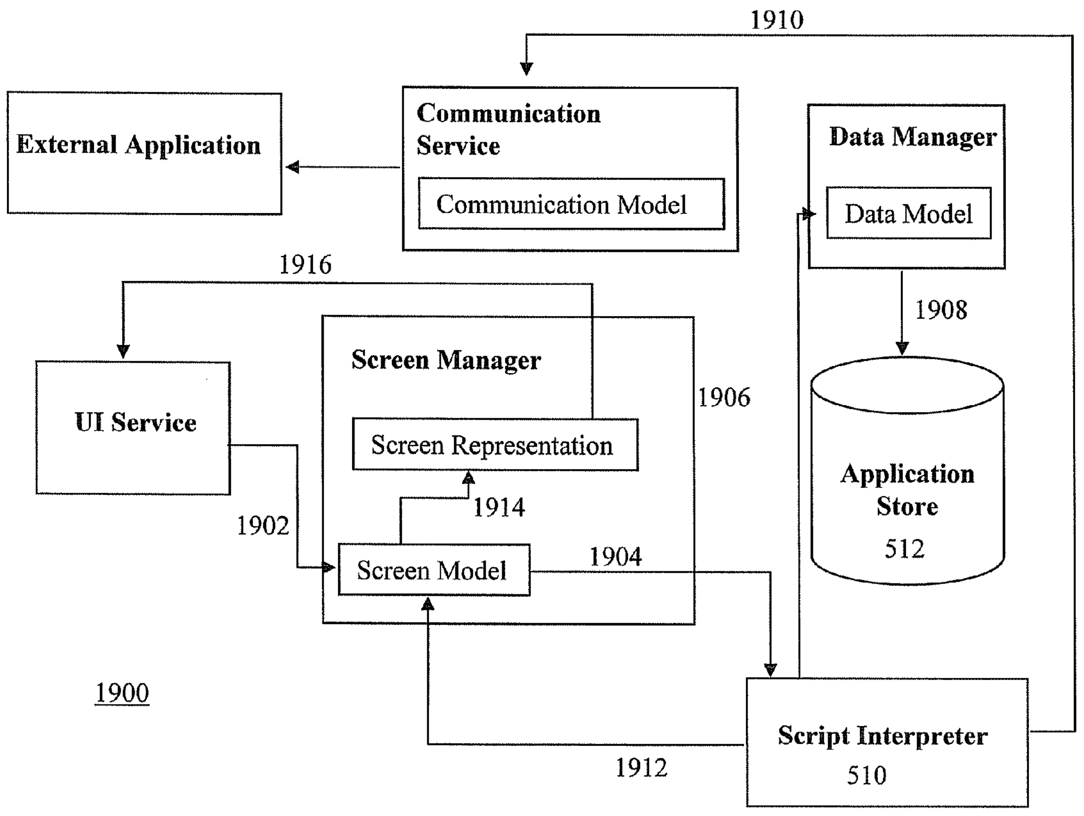


Figure 19

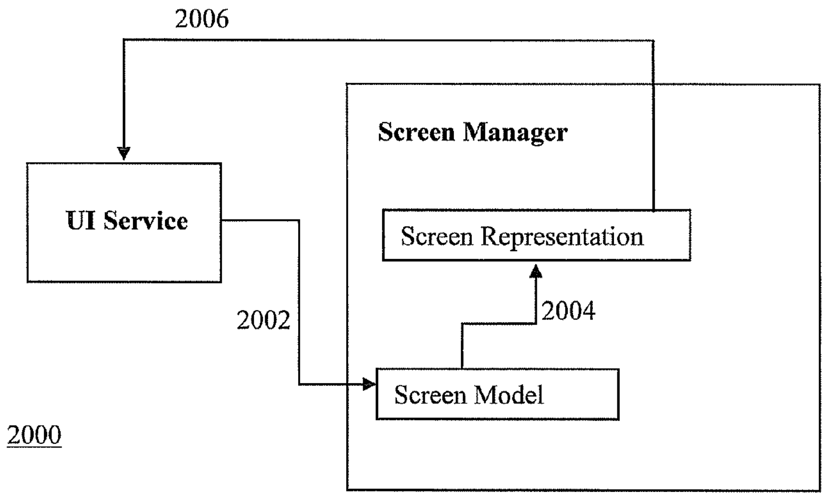


Figure 20

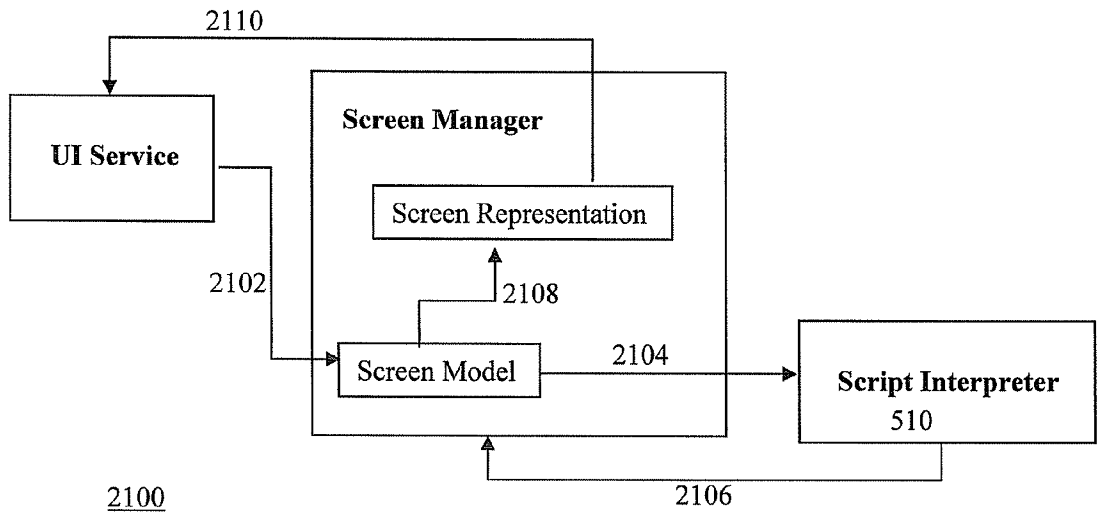


Figure 21

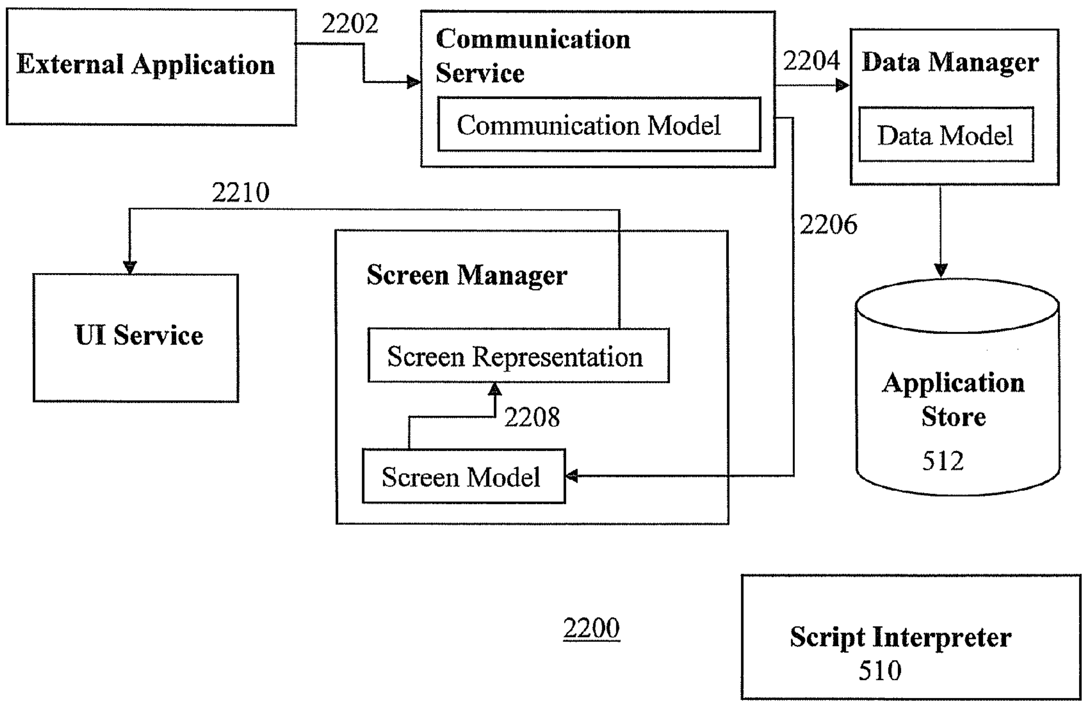


Figure 22

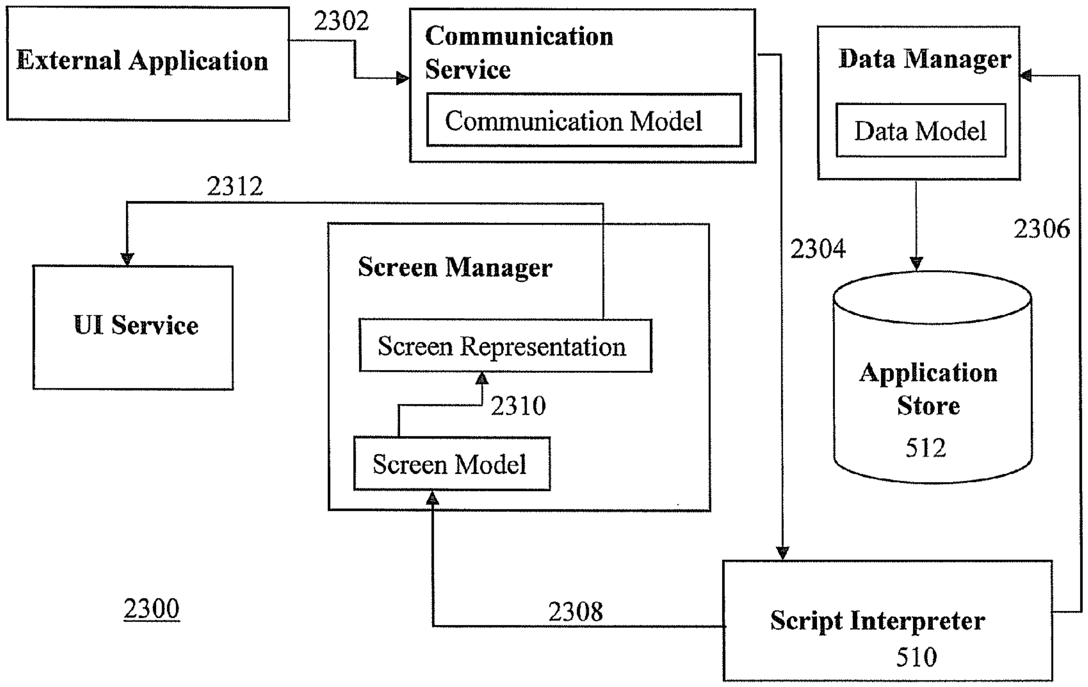

External Application
2302
Communication Service
Communication Model
Data Manager
Data Model
2312
2304
2306
Screen Manager
UI Service
Screen Representation
2310
Screen Model
Application Store
512
2300
2308
Script Interpreter
510

Figure 23

SYSTEM AND METHOD FOR BUILDING MIXED MODE EXECUTION ENVIRONMENT FOR COMPONENT APPLICATIONS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of application Ser. No. 11/066,239 filed on Feb. 25, 2005, the entire disclosure of which is hereby incorporated by reference for all purposes and claims priority from U.S. Provisional Application No. 60/548,098 filed Feb. 27, 2004.

TECHNICAL FIELD

[0002] The present disclosure relates generally to runtime environments and specifically to runtime environments capable of operating in both executable mode and interpreted mode.

BACKGROUND

[0003] Due to the proliferation of wireless networks, there are a continually increasing number of wireless devices in use today. These devices include mobile telephones, personal digital assistance (PDAs) with wireless communication capabilities, two-way pagers and the like. Concurrently with the increased availability of wireless devices, software applications running on such devices have increased their utility. For example, the wireless device may include an application that retrieves a weather report for a list of desired cities or allows a user to shop for groceries. These software applications take advantage of the ability to transmit data to a wireless network in order to provide timely and useful services to users, often in addition to voice communication. However, due to the number of different types of devices, the limited available resources of some devices, and the complexity of delivering large amounts of data to the devices, developing software applications remains a difficult and time-consuming task.

[0004] Currently, devices are configured to communicate with Web Services through Internet based browsers and/or native applications. Browsers have the advantage of being adaptable to operate on a cross-platform basis for a variety of different devices, but have a disadvantage of requesting pages (screen definitions in HTML) from the Web Service, which hinders the persistence of data contained in the screens. A further disadvantage of browsers is the fact that the screens are rendered at runtime, which can be resource intensive. However, applications for browsers are efficient tools for designing platform independent applications. Accordingly, different runtime environments, regardless of the platform, execute the same application. Unfortunately, since different wireless devices have different capabilities and form factors, the application may not be executed or displayed as desired. Further, browser based application often require significant transfer bandwidth to operate efficiently, which may be costly or even unavailable for some wireless devices.

[0005] On the other hand, native applications are developed for a specific wireless device platform, thereby providing a relatively optimized application program for a runtime environment running on that platform. However, a platform dependent application introduces several drawbacks, including having to develop multiple versions of the same application and being relatively large in size, thereby taxing memory resources of the wireless device. Further, application developers need experience with programming languages such as JAVA (Java™) and C++ to construct such native applications.

[0006] Thus it can be seen that there is a need for application programs that can be run on client devices having a wide variety of operating systems, as well as having a reduced consumption of device resources. Furthermore, it is desirable to achieve the aforementioned result while limiting the complexity for application program developers as much as possible.

[0007] Accordingly, it is an object of the present disclosure to obviate or mitigate at least some of the above-mentioned disadvantages.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] An embodiment of the disclosure will now be described by way of example only with reference to the following drawings in which:

[0009] FIG. **1** is a block diagram of a communication infrastructure;

[0010] FIG. **2** is a block diagram of a wireless device;

[0011] FIG. **3** is a block diagram illustrating a component framework;

[0012] FIG. **4** is a block diagram illustrating a component application;

[0013] FIG. **5** is a block diagram of a sample runtime environment;

[0014] FIGS. **6** to **16** are sample XML definition of various components of an application; and

[0015] FIGS. **17** to **23** are block diagrams illustrating runtime flow for several application scenarios.

DETAILED DESCRIPTION

[0016] In accordance with an aspect of the present disclosure there is provided a wireless communication device comprising: a memory for storing instructions; and a processor for executing the instructions stored in memory, when executed by the processor the instructions configuring the wireless device to provide: a runtime environment for executing an application definition defined declaratively in a plurality of component definitions, the runtime environment coordinating communication between a plurality of runtime environment components comprising: an application container for hosting an internal model of the application defined declaratively, the internal model comprising: a data model of one or more data types defined in the application defined declaratively; a screen model of one or more screen definitions defined in the application defined declaratively; and a message model of one or more messages defined in the application defined declaratively; a screen manager to render an application screen based on the screen model; a communication service to transmit and receive messages to and from an external computer based on the communication model; and a data manager for manipulating the data model to store application data.

[0017] In accordance with another aspect of the disclosure there is provided a method of executing an application on a wireless communication device, the wireless communication device comprising a memory for storing instructions and a processor for executing the instructions stored in memory, the instructions implementing the method comprising: receiving at a runtime environment an application definition defined declaratively in a plurality of component definitions; creating an internal model of the application hosted in an application container including: creating a data model of one or more data types defined in the application defined declaratively; creating a screen model of one or more screen definitions defined in the application defined declaratively; and creating a message model of one or more messages defined in the application defined declaratively; manipulating the data model using a data manager of the runtime environment to store application data; transmitting and receiving messages using a communication service to and from an external computer based on the communication model; and rendering an application screen using a screen manager based on the screen model.

[0018] For convenience, like numerals in the description refer to like structures in the drawings. Referring to FIG. **1**, a communication infrastructure is illustrated generally by numeral **100**. The communication infrastructure **100** comprises a plurality of communication devices **102**, a communication network **104**, a gateway **106**, and a plurality of backend services **108**.

[0019] The communication devices **102** include any wired or wireless device such as a desktop computer, a laptop or mobile computer, a smart phone, a personal digital assistant, such as a BLACKBERRY (Blackberry™) by Research in Motion for example, and the like. The communication devices **102** are in communication with the gateway **106** via the communication network **104**. Accordingly, the communication network **104** may include several components such as a wireless network **110**, a relay **112**, a corporate server **114** and/or a mobile data server (MDS) **116** for relaying messages between the devices **102** and the gateway **106**. The gateway **106** is further in communication with a plurality of the backend servers **108**. The types of backend servers **108** and their corresponding links will be apparent to a person of ordinary skill in the art.

[0020] Wireless application technologies need to provide means for user interaction, communication with other wired or wireless applications and data storage in the context of usually limited computing resources such as speed, power, memory, storage as well as intermittent connectivity. These limitations provide great challenges for the development of real-world, useful applications.

[0021] A desirable approach for reducing application development complexity is to define those components that individualize an application in a declarative way. Examples of such components include user interface, data and communication models. The components are presented to an intelligent container, such as the device runtime environment, as contracts and the complex but otherwise common tasks are delegated to the intelligent container to solve.

[0022] The following describes a system by which the intelligent container offers a native execution environment for applications defined by means of metadata and scripting languages. Accordingly, the burden that constitutes the wireless environment complexity is shifted from the application to the intelligent container. Thus, the only complexity that the application writer is left to solve is to clearly define a contract between the application and the intelligent container in order to ensure the desired functionality.

[0023] Referring to FIG. **2**, the communication devices **102** (also referred to simply as devices **102**) are illustrated in greater detail. The devices **102** include a network interface **200**, a user interface **202**, a core infrastructure **204**, and a component framework **206**. The network interface **200** comprises a wireless transceiver or a wired network interface card or modem, for coupling the device **102** to the network **104**. For example, the network interface **200** communicates with the wireless network **104** using either known or proprietary protocols. This feature enables the devices **102** to communicate wirelessly with each other as well as external systems, such as the network server **106**. The network **104** supports the transmission of data in the form request and response messages between devices and the backend servers **108**. Further, the network **104** may support voice communication for telephone calls between the devices **102** as well as devices external to the network **104**.

[0024] The user interface **202** comprises one or more means for communicating with the user (not shown). For example, the user interface **202** includes one or more input devices such as a keypad, trackwheel, stylus, mouse, and microphone for receiving input from the user and one or more output devices such as a display and speaker for presenting output to the user. If the display is touch sensitive, then the display can also be used as an input device. The user interface **202** is employed by the user of the device **102** to coordinate request and response messages of client application programs **201**.

[0025] The core infrastructure **204** includes a computer processor **208** and an associated memory module **210**. The computer processor **208** manipulates the operation of the network interface **200**, the user interface **202** and the component framework **206** of the communication device **116** by executing related instructions, which are provided by an operating system and client application programs (not shown) stored in the memory module **210**. Further, it is recognized that the device infrastructure **204** may further include a computer readable storage medium **212** for providing instructions to the processor or loading or updating client application programs to the memory module **210**. The computer readable medium **212** may include floppy disks, magnetic tape, optically readable media such as compact discs and digital video discs, memory cards and the like.

[0026] The component framework **206** comprises a runtime environment **216** that is capable of generating, hosting and executing client application programs from metadata definitions. Therefore, the component framework **206** provides the native client runtime environment **216** for the client application programs and acts as an interface to the processor **208** and associated operating system of the core infrastructure **204**. The component framework **206** provides the runtime environment **216** by supplying at least the minimum requirements for a controlled, secure and stable environment on the device **100**, in which the component application programs can be executed. The requirements for the runtime environment will be described throughout the description.

[0027] The runtime environment **216** can be configured so that the devices **102** operate as web clients of the web services provided by the network server **106**. It is recognized that the runtime environment **216** can also make the devices **102** clients of any other generic schema-defined services supplied by the server **108**. The runtime environment **216** is capable of generating, hosting and executing the application programs. Further, specific functions of the client runtime environment include support for different languages, coordination of memory allocation, networking, management of data during input/output (I/O) operations, coordination of graphics to an output device, and providing access to core object oriented classes and supporting files/libraries. Examples of environments on which the runtime environments **216** can be based include Common Language Runtime (CLR) by Microsoft and Java Runtime Environment (JRE) by Sun Microsystems.

[0028] The runtime environment **216** preferably supports the following functions for executable versions of the client application programs: provide communications capability for sending messages to the web services of the network server **106** or to any other generic schema defined services via the network **104**; allow data input from the user via the input device; provide data presentation or output capabilities for displaying data to the user via the output device; provide data storage services to maintain and manipulate data in the memory module **210**; and provide a script interpreter for executing scripts when required.

[0029] Referring to FIG. **3** the component framework **206** is illustrated in greater detail. The component application program **302** comprises components that are executed by the runtime environment **216**. The runtime environment **216** creates an application container **300** for each component of the component application program **302**. The application container **300** loads the components of the application program **302** and creates executable metadata, which is executed by the processor **208**. The component framework **206** therefore provides the host application containers **300** for provisioning the definitions of the components to create the actual web client specific for each respective device infrastructure **204** of the communication devices **102**. The application container can provision the component application **302** as per the template-based native execution and metadata-based execution models as described above.

[0030] Further, the component framework **206** can also provide framework services **304** to the runtime environment **216** for facilitating implementation of the components of the component application program **302**. The component application program **302** is in communications with the application container **300**, which coordinates communications **216** with the framework services **304**, as needed. The framework services **304** of the component framework **206** coordinate communications via the connection **220** with the device infrastructure **204**. Accordingly, access to the device infrastructure **204**, user interface **202** and network interface **200** is provided to the component application programs **302** by the component framework **206**. In addition, the component application programs **302** can be suitably virus-resistant, since the application containers **300** can control and validate all access of the communications of the component framework **206** to and from the client application programs **302**. It is recognized that a portion of the operating system of the device infrastructure **204** can represent the application container **300**.

[0031] Referring to FIG. **4**, a block diagram of the component application program **302** comprises data components **400**, presentation components **402** and message components **404**, which are coordinated by workflow components **406** through communications with the application container **300**. The structured definition language can be used to construct the components **400**, **402**, **404** as a series of metadata records, which consist of a number of pre-defined elements representing specific attributes of a resource such that each element can have one or more values. Each metadata schema typically has defined characteristics such as but not limited to; a limited number of elements, a name of each element, and a meaning for each element. Example metadata schemas include such as but not limited to Dublin Core (DC), Anglo-American Cataloging Rules (AACR2), Government Information Locator Service (GILS), Encoded Archives Description (EAD), IMS Global Learning Consortium (IMS), and Australian Government Locator Service (AGLS). Encoding syntax allows the metadata of the components **400**, **402**, **404** to be processed by the device infrastructure **204** (see FIG. **2**), and encoding schemes include such as but not limited to XML, HTML, XHTML, XSML, RDF, Machine Readable Cataloging (MARC), and Multipurpose Internet Mail Extensions (MIME).

[0032] The data components **400** define data entities which are used by the component application program **302**. Examples of data entities include are orders, users, and financial transactions. Data components **400** define what information is required to describe the data entities, and in what format the information is expressed. For example, the data component **400** may define an order comprising a unique identifier for the order which is formatted as a number, a list of items which are formatted as strings, the time the order was created which has a date-time format, the status of the order which is formatted as a string, and a user who placed the order which is formatted according to the definition of another one of the data components **400**. Since data elements are usually transferred by message, there is often persistence of data components **400** in a database. Data components **400** may be dynamically generated or defined by the application designer.

[0033] The message components **404** define the format of messages used by the component application program **302** to communicate with external systems such as the web service. For example, one of the message components **404** may describe such as but not limited to a message for placing an order which includes the unique identifier for the order, the status of the order, and notes associated with the order. Message component **404** definitions written in the structured definition language can uniquely represent and map to WSDL messages, and can be generated dynamically at runtime. Accordingly, the dynamic generation can be done for the component definitions for client application messages, and associated data content, from standard Web Service metadata in the definition language used to express the web service interface, such as for example WSDL and BPEL. Web Services messages are defined within the context of operation and there is defined correlations between the message components **404** in the component application program **302** definition. This correlation could be done using predefined message parameters and/or through separate workflow components **406**, as further defined below.

[0034] The presentation components **402** define the appearance and behaviour of the component application program **302** as it displayed by the user interface **202**. The presentation components **402** can specify GUI screens and controls, and actions to be executed when the user interacts with the component application **302** using the user interface **202**. For example, the presentation components **402** may define screens, labels, edit boxes, buttons and menus, and actions to be taken when the user types in an edit box or pushes a button. The majority of Web Service consumers use a visual presentation of Web Service operation results, and therefore provide the runtime environment on their devices **100** capable of displaying user interface screens.

[0035] It is recognized that in the above described client component application program **302** definitions hosting model, the presentation components **402** may vary depending on the client platform and environment of the device **100**. For example, in some cases Web Service consumers do not require a visual presentation. The application definition of the components **400**, **402**, **404**, **406** of the component application program **302** can be hosted in a Web Service registry in a metadata repository **700** as a bundle of platform-neutral data **400**, message **404**, workflow **406** component descriptors with a set of platform-specific presentation component **402** descriptors for various predefined client runtimes (i.e. specific component frameworks **206**—see FIG. **2**). When the discovery or installation request message is issued the client type should be specified as a part of this request message. In order not to duplicate data, message, and workflow metadata while packaging component application programs **302** for different client platforms of the devices **102**, application definitions can be hosted on the application server **108**, for example, as a bundle of platform-neutral component definitions linked with different sets of presentation components **403***a*, **403***b*, **403***c*, representing the different supported user interfaces **202** of the devices **102**. It is also recognized that a standard presentation component **402** can be used in the event the specific device **102** is not explicitly supported, thereby providing at least a reduced set of presentation features. When a user makes a discovery or download request message, the client runtime type of the devices **102** is validated and the proper bundle is constructed for delivery by the web server **106** to the device **102** over the network **104**. For those Web Service consumers, the client application programs **302** could contain selected presentation components **403***a,b,c* linked with the data **400** and message **404** components through the workflow components **406**, thereby providing a customized component application **302**.

[0036] The workflow components **406** of the component application program **302** define processing that occurs when an action is to be performed, such as an action specified by a presentation component **402** as described above, or an action to be performed when messages arrive. Presentation workflow and message processing are defined by the workflow components **406**. The workflow components **406** are written as a series of instructions in either metadata or a programming language or a scripting language, such as European Computer Manufacturers Association (ECMA) Script, and can be compiled into native code and executed by the application container **300**, as described above. An example of the workflow components **406** may be to assign values to data, manipulate screens, or send the message. The workflow component **406** supports a correlation between the messages and defines application flow as a set of rules for operations on the other components **400**, **402**, **404**.

[0037] Some other examples of script languages include Perl, Rexx, VBScript, JavaScript, and Tcl/Tk. The scripting languages, in general, are instructional languages that are used to manipulate, customize, and automate the facilities of an existing system, such as the devices **102**. In such systems, useful functionality is already available through the user interface **202** (see FIG. **2**), and the scripting language is a mechanism for exposing that functionality to program control. In this way, the device **102** is said to provide the host runtime environment of objects and facilities which completes the capabilities of the scripting language.

[0038] Referring again to FIG. **3**, the components **400**, **402**, **404**, **406** of the application program **302**, once provisioned on the communication device **102**, are given access to the predefined set of framework services **304** by the application containers **300** of the component framework **206**. The framework services **304** include a communication service **306**, a presentation service **308**, a persistence service **310**, an access service **312**, a provisioning service **314** and a utility service **316**. The communication service **306** manages communication between the component application programs **302** and external resources. The presentation service **308** manages the representation of the component application programs **302** as they are output on the output device of the user interface **202** (see FIG. **2**). The persistence service **310** allows the component application programs **302** to store data in the memory module **210** (see FIG. **2**) of the device infrastructure **204**. The access service **312** provides the component application programs **302** access to other software applications which are present on the communication device **102**. The provisioning service **314** manages the provisioning of software applications on the communication device **102**. Application provisioning can include requesting and receiving new and updated component application programs **302**, configuring component application programs **302** for access to services which are accessible via the network **104**, modifying the configuration of component application programs **302** and services, and removing component application programs **302** and services. The utility service **316** is used to accomplish a variety of common tasks, such as performing data manipulation in the conversion of strings to different formats.

[0039] It is recognized that the framework services **304** of the communication device **102** can provide functionality to the component application programs **302**, which can include the services described above. As a result, the component application programs **302** can have access to the functionality of the communication device **102** without having to implement it. Unlike ordinary applications where all service requests or service API calls are programmed by developers in the native code, the component definitions **400**, **402**, **404** and workflow **406** describe service requests using the structured definition language such as XML and the set of instructions such as ECMAScript. The XML provides a non-procedural definition of the application's user interface **202**, persistent storage and communications with the Web Service, while the ECMAScript provides the procedural component linkage. The Client runtime environment interprets these definitions **400**, **402**, **404** into the native calls to supported services.

[0040] The application container **300** can be referred to as a smart host container for the client application program **302**, and can be responsible for analyzing message metadata and for updating the representation of the meta-data in the memory module **210**.

[0041] In the present embodiment, the device runtime provides an intelligent software framework, or container, for providing a set of basic services to manage and execute typical application behaviour, including data storage, messaging, screen navigation and display, as described above.

[0042] By introducing the concept of intelligent container with applications defined by metadata, the burden that constitutes the wireless environment complexity is shifted from the application to the intelligent container. Accordingly, the primary complexity left to an application developer to solve is to clearly define a contract between the application and the container in order to insure the desired functionality.

[0043] The intelligent container runs metadata-defined applications and maintains its own internal representation of these applications. As such, from the intelligent container's perspective the application is perceived in two formats: Application Definition and Application Internal Representation. These two formats are described below, including details of the device runtime responsibilities for providing efficient metadata based execution models.

[0044] The Application Definition is the format used to publish applications externally using a well-defined, standard format that is highly structured and provides clear instructions to the intelligent container as to how the application needs to be executed: The Application Definition includes a set of definitions of the components that collectively comprise an application. These definitions are declarative and are expressed in a well-defined, structured language such as XML, for example. Moreover, in order to define custom, complex application logic it is sometimes required to use scripting language (or code) sequences either embedded in the metadata definition or separately attached thereto.

[0045] As previously described, the Application Definition comprises a data definition, a screen definition, a message definition and workflow definition. Examples of these definitions are provided further in the description with reference to FIGS. **6-16**, for illustrative purposes only.

[0046] The Application Internal Representation is the format of the application inside the intelligent container at runtime. It comprises executable metadata that is built ad-hoc using the Application Definition. Executable metadata comprises the internal representation of all the application components, including their inter-relationships, running inside the intelligent container. Executable metadata is dependent on the intelligent container implementation.

[0047] As part of the contract between the application and its intelligent container, the device runtime is responsible for building efficient models from the application component's metadata that comprise the Application Internal Representation. Accordingly, the device runtime constructs a data model, a screen model, and a communication model for each application from the application's metadata.

[0048] Referring to FIG. **5**, a sample device runtime environment for an application is illustrated by numeral **500**. The device runtime environment **500** includes a data manager **502**, a screen manager **504**, a communication service **506**, a user interface (UI) service **508**, and a script interpreter **510**. The device runtime environment **500** is also in communication with an application store **512** and an external application **514**. The application store **512** is a device repository for storing application definitions and application data. The external application **514** is an application operating external to the device via a wired or wireless connection.

[0049] The data manager **502** manages a data model **503** of the application as well as application data on behalf of the application.

[0050] The data model **503** includes in-memory templates for each data component definition, intelligence about data component relationships and hierarchy as well as persistence, and references to external APIs that need to be notified of data changes. For example, data may be related such that when one variable changes, others need to be updated automatically. Further, different data may require different levels of persistence.

[0051] The data manager **502** uses the data model **503** for application data manipulation, including creation, updates, deletion, as well as data persistence and external data access.

[0052] The screen manager **504** is a service for managing a screen model **505**. The screen model **505** includes in-memory templates for each screen component definition and an intelligence model for handling UI events as well as navigating and rendering screens built exclusively from declarative actions defined in the screen component. The screen model **505** further includes references to incoming messages that trigger an automatic screen refresh and references to script sequences used in UI Event handling and conditional controls. The screen model **505** manages a screen representation **509**, which is displayed to the user.

[0053] The screen manager **504** handles modeling of conditional controls and layouts, and continuously updates the screen model **505** based on events received from the UI service **508**. The screen manager **504** uses the screen model **505** to render the appearance of the application screen, establish screen navigation paths and process UI events.

[0054] The UI service **508** provides the visualization of the screen representation in the native UI framework of the device. The UI service **508** also communicates user events to the screen manager **504**.

[0055] The communication service **506** manages a communication model **507** of the application and handles all application communication and message processing. Due to the nature of wireless applications, the communication model **507** used in present embodiment is asynchronous. The communication model **507** includes in-memory templates for each message definition including message hierarchy. The communication model **507** further includes intelligence regarding message mapping to data components or data fields, message security and reliability, and references to script sequences that handle incoming messages. Accordingly, the communication model **507** describes a set of messages that the application initiates or is capable of receiving and processing.

[0056] The communication service **506** uses the communication model **507** to enable an application's communication needs with other wireless or wired applications, whether they are located on the device or externally.

[0057] The script interpreter **510** executes script portions of the application, for example ECMAScript and the like. The script interpreter **510** and has the ability to manipulate the screen model **505** through interaction with the screen manager **504**, the data model **503** through interaction with the data manager **502**, and the communication model **507** through interaction with the communication manager **506**.

[0058] The operation of the device runtime is described generally as follows. The device runtime is presented with the Application Definition when the application is uploaded onto the device. The device runtime could either construct the Application Internal Representation at that time or delay this operation until receiving a request to execute the application. Accordingly, the device runtime can host an application in "raw" format, that is Application Definition, or in "executable" format, that is Application Internal Representation.

[0059] Accordingly, it can be seen that the device runtime executes template based generic code built from the metadata definition of the components rather than executable code of a pre-compiled wireless application.

[0060] Further, the device runtime can execute in a mixed execution mode. In the mixed execution mode, the device runtime provides the ability to switch between an execution mode and an interpreted mode.

[0061] In the execution mode the device runtime provides an execution environment to run both the Application Internal Representation and specific script instructions in the native code. As described above, the Application Internal Representation, in the form of executable metadata, is built ad-hoc from the Application Definition. Further, associated script instructions are redirected from the script interpreter using global symbols libraries. That is, proxy execution is performed of predefined global symbols in the script to the native environment.

[0062] Further, the device runtime can switch to the interpreted mode in order to execute more complex functionality. That is, the runtime switches to interpreted mode to run scripts when executing application metadata is not enough to achieve desired complexity. FIGS. **6-23**, described below, provide several examples of component definitions and logic flow described either exclusively though metadata or by script.

[0063] Referring to FIG. **6**, a sample XML portion of a data definition of the Application Definition is illustrated generally by numeral **600**. The data definition describes the data components that the application uses, including their persistence mechanism. Data components may contain primitive fields or may refer to other data components, which are also defined therein. In the example illustrated in FIG. **6**, the data component shown is named “Race” and requires persistence. The data component includes several fields of varying types and complexity. For example, the field name “description” is a string, whereas the field name “horses” acts as a reference to another component named “Horse”.

[0064] Referring to FIG. **7**, a sample XML portion of a screen definition of the Application Definition is illustrated generally by numeral **700**. The screen definitions describe all application screens, their associated layouts, menu items, controls and screen rendering metadata. In this particular example, the name of the screen component is “scrLogin” and the title is “Login”. The screen component has a data component “Player” as a parameter and does not represent a dialog box. The screen component includes two labels and two edit boxes.

[0065] The first label is named “ebPlayerNamelbl” and has a text value “Player Name:”. The first label is associated with the first edit box, which is named “ebPlayerName” and has a value associated with the “name” attribute of the parameter “Player”. This edit box allows the user to input a player name.

[0066] Similarly, the second label is named “ebPlayerCodeNamelbl” and has a text value “Player Code:” The second label is associated with the second edit box, which is named “ebPlayerCode” and has a value associated with the “code” attribute of the parameter “Player”. This edit box allows the user to input a code, or password, associated with the player name. Both of the edit boxes have a readOnly value set to false, which allows the user to input data.

[0067] The screen component further includes three menu items. The first menu item is named “regPlayer” and has a corresponding label “Register New Player”. This menu item allows the user to navigate to a screen component named “scrRegisterNewPlayer” for registering a new player.

[0068] The second menu item is named “loginPlayer” and has a corresponding label “Login”. This menu item allows the user to login to the application by accessing a pblock “2”. In the present embodiments, a pblock is a reusable piece of “workflow” code that is described either declaratively by metadata, or by script. Pblock “2” describes the workflow associated with a user login.

[0069] The second menu item is named “logout” and has a corresponding label “Logout”. This menu item allows the user to logout of the application by accessing a pblock “3”. In the present example, pblock “3” describes the workflow associated with a user logout.

[0070] As can be seen, terms such as layout, menu, label, edit, name, value, readOnly, action and condition are understood by the runtime environment and detailed programming need not be provided by the programmer in order to achieve the desired functionality.

[0071] Referring to FIG. **8**, a sample XML portion of a message definition of the Application Definition is illustrated generally by numeral **800**. Messages are either inbound or outbound and comprise a list of primitive or complex fields. The present example illustrates the definition of an incoming message named “in ViewingReq”. Each message field describes the type of data expected as part of the message and maps the data to local application components, where applicable. For example, the message will have a field name “requestor”. The data associated with that field name is mapped to the field “name” in the component “Agent”.

[0072] Further, the application logic of the Application Definition may be expressed declaratively through metadata exclusively. Application Logic includes data manipulation, screen rendering for dynamic screens, UI event processing and declarative message processing.

[0073] FIGS. **9***a-c* illustrate some examples of declarative data manipulation, including mapping data to intelligent UI controls, passing data as parameters to screens or script sequences and mapping messages to data.

[0074] Referring to FIG. **9***a*, an example of mapping data to intelligent UI controls is shown generally by numeral **900**. UI controls are bound through declarative statements to the data components that they are displaying or are associated with. When a UI control’s value changes the underlying data may change or vice versa. In this example, the user is presented with radio button that is named “chClients”. This particular radio button is mapped to a component named Client. Therefore, when the user changes the input, the data mapped to the input changes.

[0075] Referring to FIG. **9***b*, an example of passing data as parameters to screens or script sequences is shown generally by numeral **930**. As previous described with reference to FIG. **7**, the data component “Player” is passed to the screen as a parameter. Generally, passing data as parameters to screens, to script sequences or to data components that are automatically mapped to messages are all contenders for declarative action.

[0076] Referring to FIG. **9***c*, an example of mapping messages to data is shown generally by numeral **960**. In the present example, when an incoming message has the name “in PropertyInfo”, it is mapped to a data component named “PropertyInfo”. When a message definition maps directly to data, the device runtime has a predefined instruction that upon receipt of such a message it updates or creates data automatically, without requiring additional processing.

[0077] Referring to FIG. **10** an example of declarative screen rendering for a dynamic screen is shown generally by numeral **1000**. Conditional controls, those are controls whose value and appearance can change dynamically, are specified declaratively. In the present example, “Canada” and “USA” are possible choices for a user. Depending on the user’s selection, the screen is dynamically rendered to display either Canada’s provinces or the United States of America’s states as a subsequent choice for the user. Using conditional controls defined by metadata, the appearance and behavior of the screen is deferred to runtime criteria managed by the device runtime.

[0078] Referring to FIG. **11** an example of declarative UI event processing is shown generally by numeral **1100**. In the present example screen navigation as a result of a user event is specified declaratively. As a result of menu item "Client Details" being selected, the screen manager of the device runtime is instructed to render the next screen, "scrClientInfo". Similarly, if menu item "Client Workbook" is selected, the screen manager of the device runtime is instructed to render the next screen, "scrClientWrbk" and if menu item "New Client" is selected, the screen manager of the device runtime is instructed to render the next screen, "scrNewClient".

[0079] FIGS. **12***a* and **12***b* illustrate examples of declarative message processing. In these examples, inbound message processing that results in data updating and screen refreshing are shown.

[0080] Referring to FIG. **12***a*, an example of a declarative data update is illustrated generally by numeral **1200**. Fields in an incoming message are mapped directly to corresponding data. When the device receives such a message, the device runtime automatically updates the data without requiring additional instruction. In the present example, if a message titled "in MyListing" is received, a message field titled "forClient" is automatically mapped to attribute "name" of data component "Client".

[0081] Referring to FIG. **12***b*, a declarative screen refresh is illustrated generally by numeral **1250**. In the present example, the screen is refreshed upon receipt of a message. Therefore, data changes affected by the messages can be indicated to the user. In the present embodiment, the screen is refreshed upon receipt of messages "in PropertyInfo" and "in PropertyStatusChange".

[0082] The declarative sample screens described above are a few examples where metadata can play an important role in describing application logic. Other examples will be apparent to a person of ordinary skill in the art. Accordingly, the device runtime may be able to transform an entire application to executable metadata for execution.

[0083] When application logic is more complex than the metadata can handle, the application definition uses script sequences either embedded in the component metadata or defined separately from the component metadata for reuse. The following are several examples of implementing application logic by script.

[0084] Referring to FIG. **13**, an example of script for data manipulation is illustrated generally by numeral **1300**. The script in the present example amends data in accordance with passed parameter "propertyinfo". The attributes "propID", "status", and "price" of component "outPropertyStatusChange" are updated with the corresponding attributes of the passed parameter "propertyinfo".

[0085] Referring to FIG. **14**, an example of script for screen rendering is illustrated generally by numeral **1400**. The script in the present example renders different elements on the screen in accordance with passed parameters "race", "horse", and "bet". If the "bet" parameter is not null then appropriate properties on the screen are rendered using the corresponding properties of the "bet" parameter. If the "bet" parameter is null, then appropriate properties on the screen are rendered using corresponding attributes of the "race" and "horse" parameters.

[0086] Referring to FIG. **15**, an example of screen navigation effected by script is illustrated generally by numeral **1500**. In the present example, the screen rendering includes a button named "btnDone". If the user clicks on this button the script named "ahStatusChange" illustrated in FIG. **13** is implemented. In addition to data rendering, as previously described, the script in FIG. **13** renders screen component "scrPropDetails" using the data of parameter "propertyInfo".

[0087] Additionally, FIGS. **15** and **13** illustrate an example of message sending effected by script. Prior to rendering the screen component "scrPropDetails" as described above, a message related to component "outPropertyStatusChange" is sent.

[0088] Referring to FIG. **16**, an example of message processing by script is illustrated generally by numeral **1600**. In the present example, data in an incoming message is manipulated by the script and stored in an associated data component. If no data is present in the received message, the script causes a message box to be displayed to the user.

[0089] The script sample screens described above are a few examples where script can play an important role in describing application logic. Other examples will be apparent to a person of ordinary skill in the art.

[0090] The following describes several device runtime flows illustrating mixed mode operation in accordance with the present embodiment. Referring to FIG. **17** a method for performing an initial screen loading is shown generally by numeral **1700**. In step **1702** application screens are extracted from the application store **512** as either pre-digested application metadata or XML. In step **1704** a screen internal representation, or screen model **505**, is produced. In step **1706** the screen model **505** produces a current screen representation **509**, including all field values and settings that reflect the current state of screen conditions and passes it to the UI service **508** for visualization.

[0091] Referring to FIG. **18** a method for performing a UI initiated data change that is declaratively defined is illustrated generally by numeral **1800**. In step **1802**, a UI change, triggered by a user changing an edit control, is communicated to the screen model **505**. In step **1804**, an underlying data component mapped to the edit control has its value changed in the data model **503**. Concurrently, in step **1805**, the data change is updated in the screen representation **509**. In step **1806**, the data change is persisted in the application store **512**.

[0092] Referring to FIG. **19** a method for performing a UI initiated data change that is defined by script is illustrated generally by numeral **1900**. In the present example, in addition to modifying the data, the UI initiated change generates an outgoing message.

[0093] In step **1902** a UI change triggered by a user changing an edit control is communicated to the screen model **505**. The screen model **505** validates the nature of the event over the internal screen metadata representation and detects any driving or dependent controls affected as a result of the UI event by virtue of any conditional control relationships specified entirely through application XML. In step **1904**, the screen model detects that the UI change requires script processing and invokes the script interpreter **510**. In step **1906**, the script interpreter **510** modifies the data model **503** in accordance with the interpreted script. In step **1908**, the data change is persisted the application store **512**.

[0094] Since the script executed as a result of the UI change generates an outgoing message, in step **1910**, the script interpreter **510** generates an outbound message and communicates that message to the communication model **507**. The communication model **509** transmits the message to an external application **514** as required.

[0095] In step **1912**, the script interpreter **510** modifies the screen model **505** as specified in the script. In turn, at step **1914**, the screen model produces an updated screen representation **509**, which is passed to the UI Service **508** in step **1916** for visualization.

[0096] Referring to FIG. **20**, a method for performing screen navigation that is declaratively defined is illustrated generally by numeral **2000**. In step **2002**, user interaction results in a change in the UI. Accordingly, a UI event is communicated to the screen model **505**. In step **2004**, the screen model **505** detects by means of executable metadata that this is a screen navigation event and generates the screen representation of the new screen to be displayed. In step **2006**, the screen representation is passed to the UI service **508** for visualization.

[0097] Referring to FIG. **21**, a method for performing screen navigation that is defined by script is illustrated generally by numeral **2100**. In step **2102**, user interaction results in a change in the UI. Accordingly, a UI event is communicated to the screen model **505**. In step **2104**, the screen model determines that UI event relates to a script call and passes control to the script interpreter **510**. In step **2106**, the script interpreter **510** executes the script, which instructs the screen model **505** to produce a new screen representation. In step **2108**, the screen model **505** produces the new screen representation **509** as required by script interpreter **510**. In step **2110**, the screen representation **509** is passed to the UI Service **510** for visualization.

[0098] Referring to FIG. **22**, a method for modifying data and updating the UI in accordance with a received message that is declaratively defined is illustrated generally by numeral **2200**. In step **2202**, the communication service **506** receives an inbound message from an external application **514**. In step **2204**, the communication service **506** determines that the message is mapped to data so it passes control to the data manager **502**. The data manager **502** updates the data model **503** and persists the new data in the application store **512**.

[0099] In step **2206**, the communication service **506** triggers an update, or screen refresh, for the screen model **505**. In step **2208**, the screen model **505** produces a new screen representation **509**. In step **2210**, the screen representation **509** is passed to the UI service **508** for visualization.

[0100] Referring to FIG. **23**, a method for modifying data and updating the UI in accordance with a received message that is defined by script is illustrated generally by numeral **2300**. In step **2302**, the communication service **506** receives an inbound message from an external application **514**. In step **2304**, the communication service **506** determines that the message is to be handled by script so it passes control to the script interpreter **510**, which executes the script to process message.

[0101] In step **2306**, the script interpreter updates the data model **503** as required by the interpreted script and persists the new data in the application store **512**. In step **2308**, the script interpreter modifies the screen model **505** as specified by the script. In step **2310**, the screen model **505** produces a new screen representation **509**. In step **2312**, the screen representation **509** is passed to the UI service **508** for visualization.

[0102] Accordingly, it can be seen that providing the device runtime with a larger responsibility for executing the application not only permits applications to be written in component format, as described herein, but also facilitates mixed mode execution. Therefore, when an application requires complex functionality that cannot be achieved solely by running executable metadata, the application can use script components, thus switching to interpreted mode. The script interpreter then communicates the resulting executable metadata to the corresponding component model for execution.

[0103] Although preferred embodiments of the disclosure have been described herein, it will be understood by those skilled in the art that variations may be made thereto without departing from the spirit of the disclosure or the scope of the appended claims.

What is claimed is:

1. A wireless communication device comprising:

a memory for storing instructions; and

a processor for executing the instructions stored in memory, when executed by the processor the instructions configuring the wireless device to provide:

a runtime environment for executing an application definition defined declaratively in a plurality of component definitions, the runtime environment coordinating communication between a plurality of runtime environment components comprising:

an application container for hosting an internal model of the application defined declaratively, the internal model comprising:

a data model of one or more data types defined in the application defined declaratively;

a screen model of one or more screen definitions defined in the application defined declaratively; and

a message model of one or more messages defined in the application defined declaratively;

a screen manager to render an application screen based on the screen model;

a communication service to transmit and receive messages to and from an external computer based on the communication model; and

a data manager for manipulating the data model to store application data.

2. The wireless communication device as claimed in claim **1**, wherein the internal model of the application is created when the application definition is loaded onto the wireless communication device.

3. The wireless communication device as claimed in claim **1**, wherein creation of the internal model of the application is delayed until a request to execute the application is received.

4. The wireless communication device as claimed in claim **1**, wherein the application further comprises one or more portions expressed in a script language and wherein the runtime environment further comprises a script interpreter for interpreting the script portions of the application.

5. The wireless communication device as claimed in claim **1**, wherein the data manager further manipulates the data model to create, update and delete data.

6. The wireless communication device as claimed in claim **1**, wherein the runtime environment further comprises a user interface (UI) service for providing visualization of the screen representation in a native UI framework of the portable communication device and wherein the screen manager further handles modeling of conditional controls and layouts expressed in the application definition, and continuously updates the screen model based on events received from the UI service.

7. The wireless communication device as claimed in claim **1**, wherein the application definition is expressed in extensible mark-up language (XML).

8. A method of executing an application on a wireless communication device, the wireless communication device comprising a memory for storing instructions and a processor for executing the instructions stored in memory, the instructions implementing the method comprising:

receiving at a runtime environment an application definition defined declaratively in a plurality of component definitions;

creating an internal model of the application hosted in an application container including:

creating a data model of one or more data types defined in the application defined declaratively;

creating a screen model of one or more screen definitions defined in the application defined declaratively; and

creating a message model of one or more messages defined in the application defined declaratively;

manipulating the data model using a data manager of the runtime environment to store application data;

transmitting and receiving messages using a communication service to and from an external computer based on the communication model; and

rendering an application screen using a screen manager based on the screen model.

9. The method as claimed in claim **8**, wherein the internal model of the application is created when the application definition is loaded onto the wireless communication device.

10. The method as claimed in claim **8**, wherein creating the internal model of the application is delayed until a request to execute the application is received.

11. The method as claimed in claim **8**, further comprising interpreting using a script interpreter of the runtime environment one or more portions of the application expressed in a script language.

12. The method as claimed in claim **8**, further comprising creating, updating and deleting data using the data manager to manipulate the data model.

13. The method as claimed in claim **8**, further comprising:

providing visualization of the screen representation in a native user interface (UI) framework of the portable communication device using a UI service;

modeling conditional controls and layouts expressed in the application definition using the screen manager; and

updating the screen model based on events received from the UI service using the screen manager.

14. The method as claimed in claim **8**, wherein the application definition is expressed in extensible mark-up language (XML).

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