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Poulin

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(54) **SYSTEM AND METHOD FOR DEVELOPING AN APPLICATION PLAYING ON A MOBILE DEVICE EMULATED ON A PERSONAL COMPUTER**

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(51) **Int. Cl.**
G06F 9/455 (2006.01)
G06F 17/50 (2006.01)

(52) **U.S. Cl.** **703/22**; 703/13; 703/24; 703/27; 709/206; 709/246; 715/526

(58) **Field of Classification Search** 703/14, 703/22, 24, 27, 2, 13, 17; 715/526; 455/423, 455/566; 709/246, 206; 707/201
See application file for complete search history.

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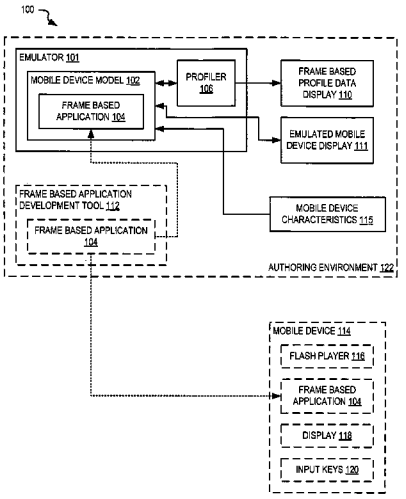
(74) *Attorney, Agent, or Firm*—Lathrop & Gage LLP

(57) **ABSTRACT**

A system, method and software product emulate and profile an application to play on a mobile device. Characteristics defining performance of the mobile device are defined. The mobile device is emulated using a model based upon the characteristics. The application is played and monitored within the model to determine resource utilization of the application for the mobile device.

32 Claims, 14 Drawing Sheets



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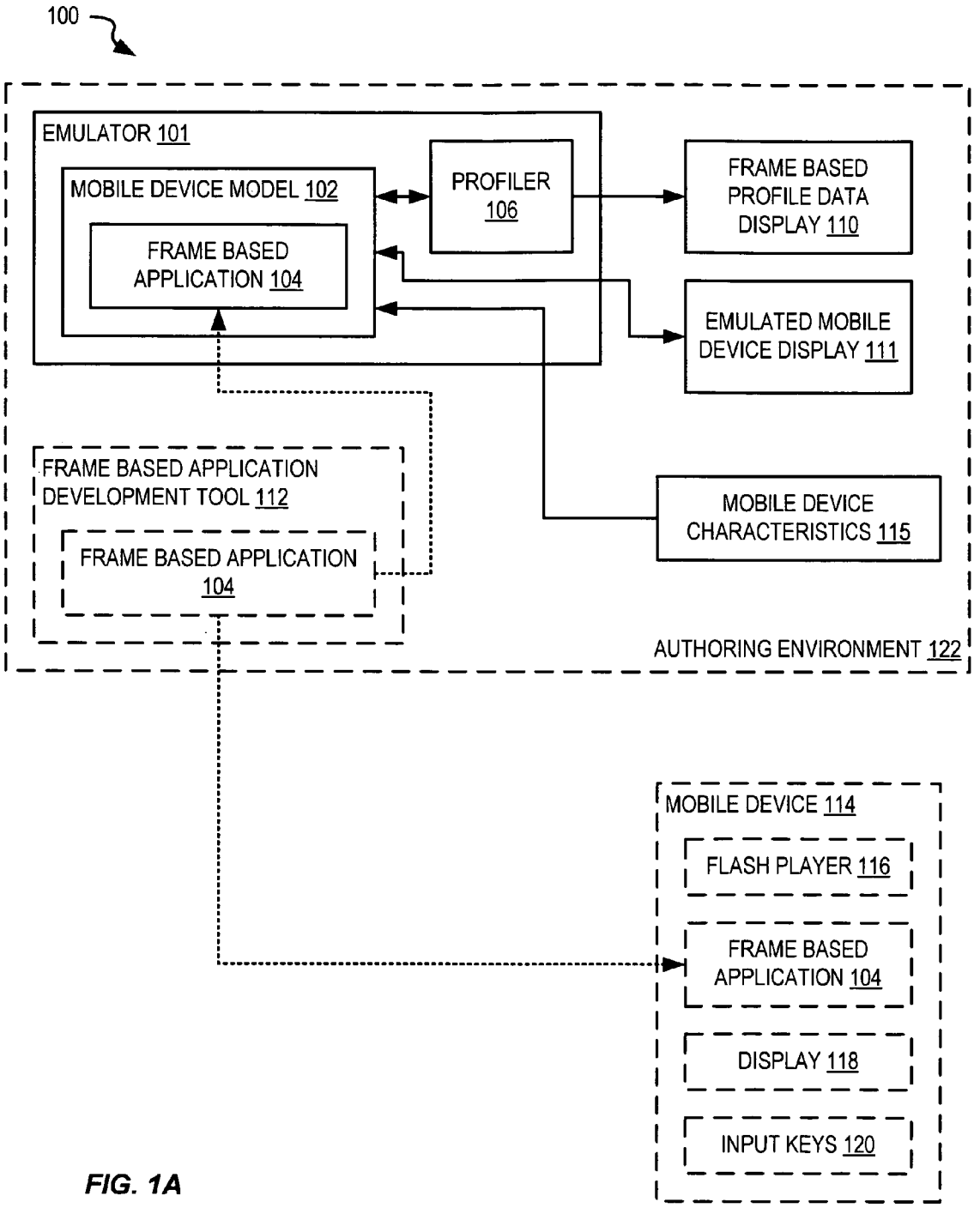
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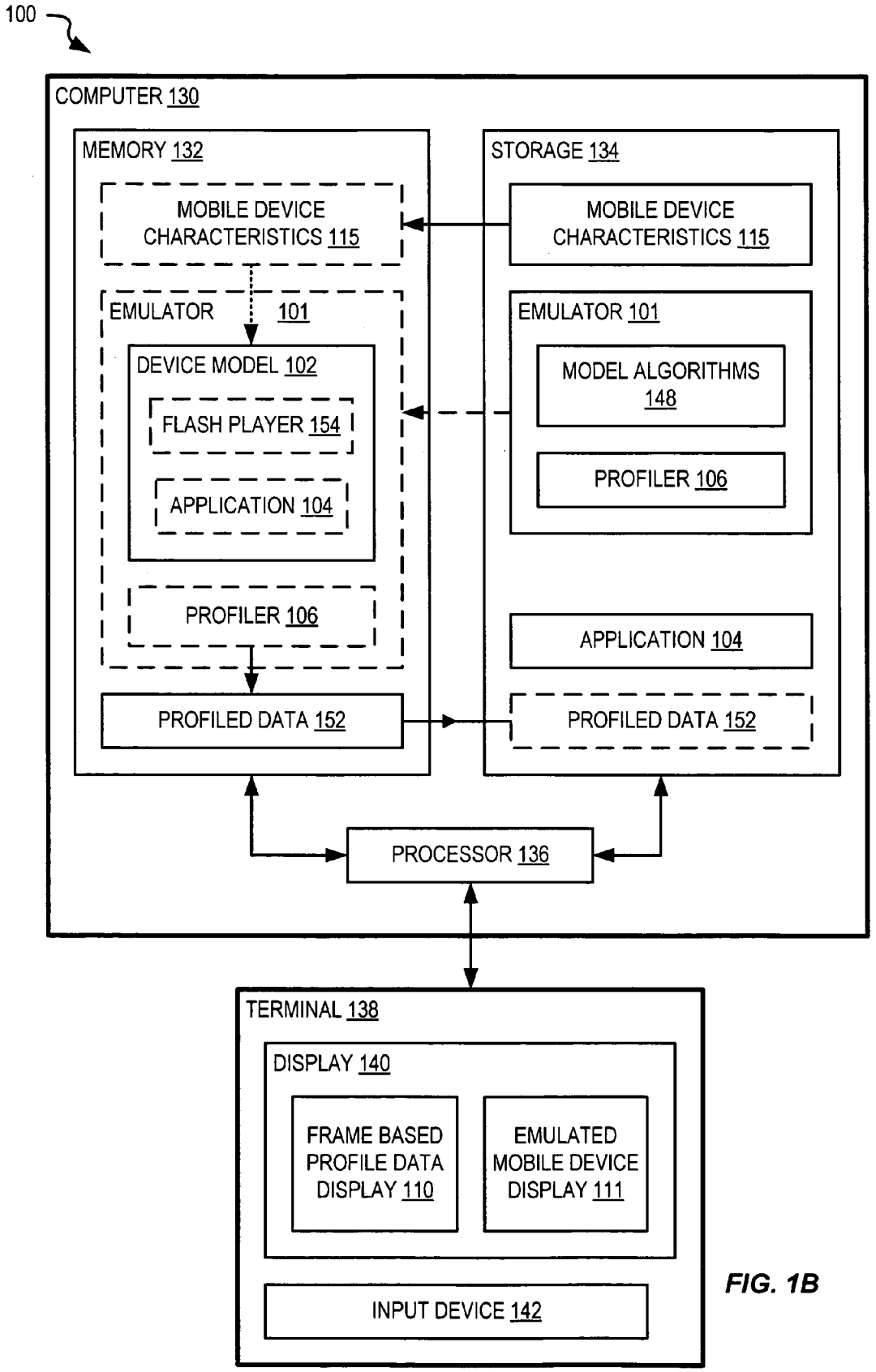
MOBILE DEVICE MODEL 102
FRAME BASED APPLICATION 104
PROFILER 106
FRAME BASED PROFILE DATA DISPLAY 110
EMULATED MOBILE DEVICE DISPLAY 111
FRAME BASED APPLICATION DEVELOPMENT TOOL 112
FRAME BASED APPLICATION 104
MOBILE DEVICE CHARACTERISTICS 115
AUTHORING ENVIRONMENT 122
MOBILE DEVICE 114
FLASH PLAYER 116
FRAME BASED APPLICATION 104
DISPLAY 118
INPUT KEYS 120

FIG. 1A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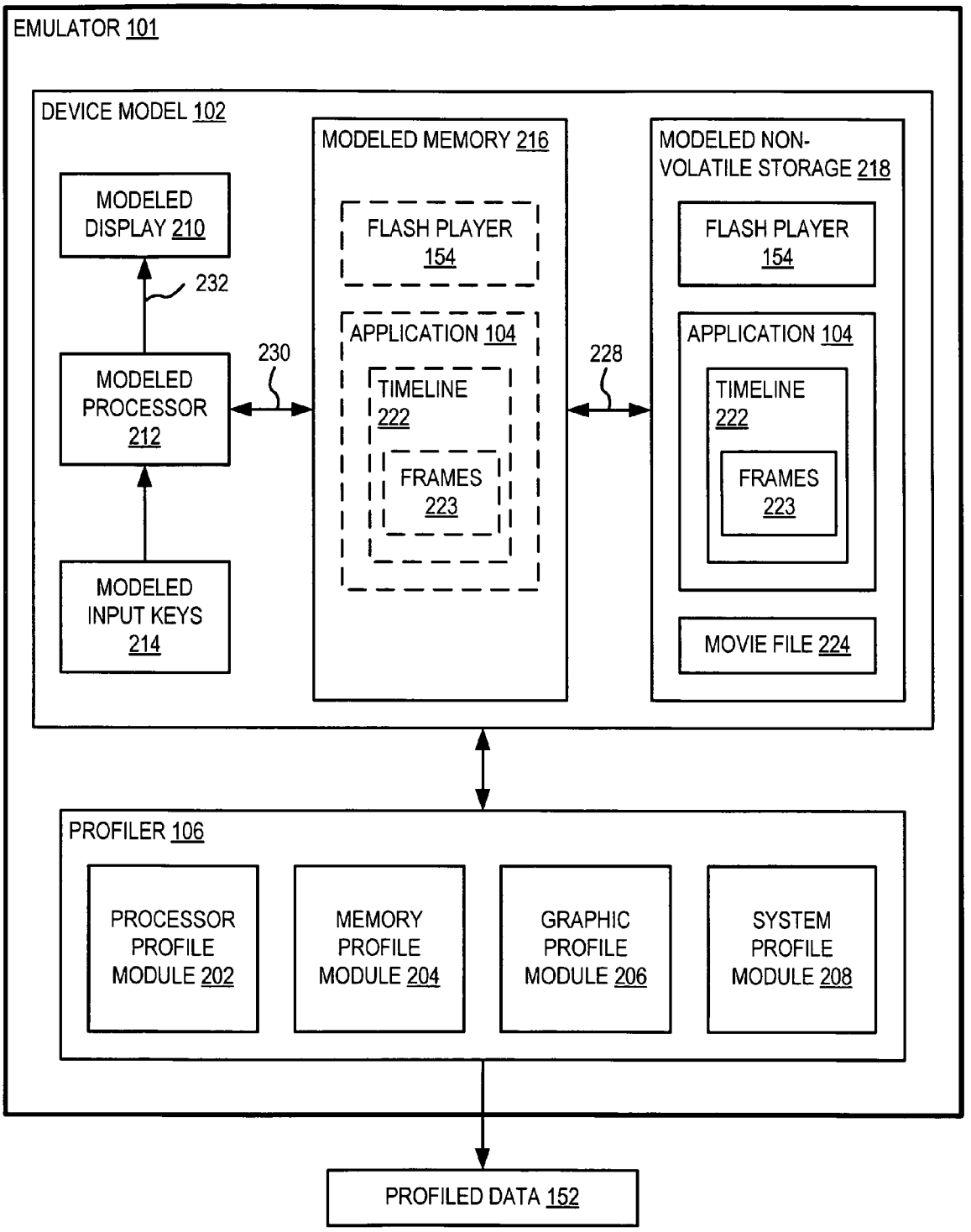
COMPUTER 130
MEMORY 132
MOBILE DEVICE CHARACTERISTICS 115
EMULATOR 101
DEVICE MODEL 102
FLASH PLAYER 154
APPLICATION 104
PROFILER 106
PROFILED DATA 152
STORAGE 134
MOBILE DEVICE CHARACTERISTICS 115
EMULATOR 101
MODEL ALGORITHMS 148
PROFILER 106
APPLICATION 104
PROFILED DATA 152
PROCESSOR 136
TERMINAL 138
DISPLAY 140
FRAME BASED PROFILE DATA DISPLAY 110
EMULATED MOBILE DEVICE DISPLAY 111
INPUT DEVICE 142

FIG. 1B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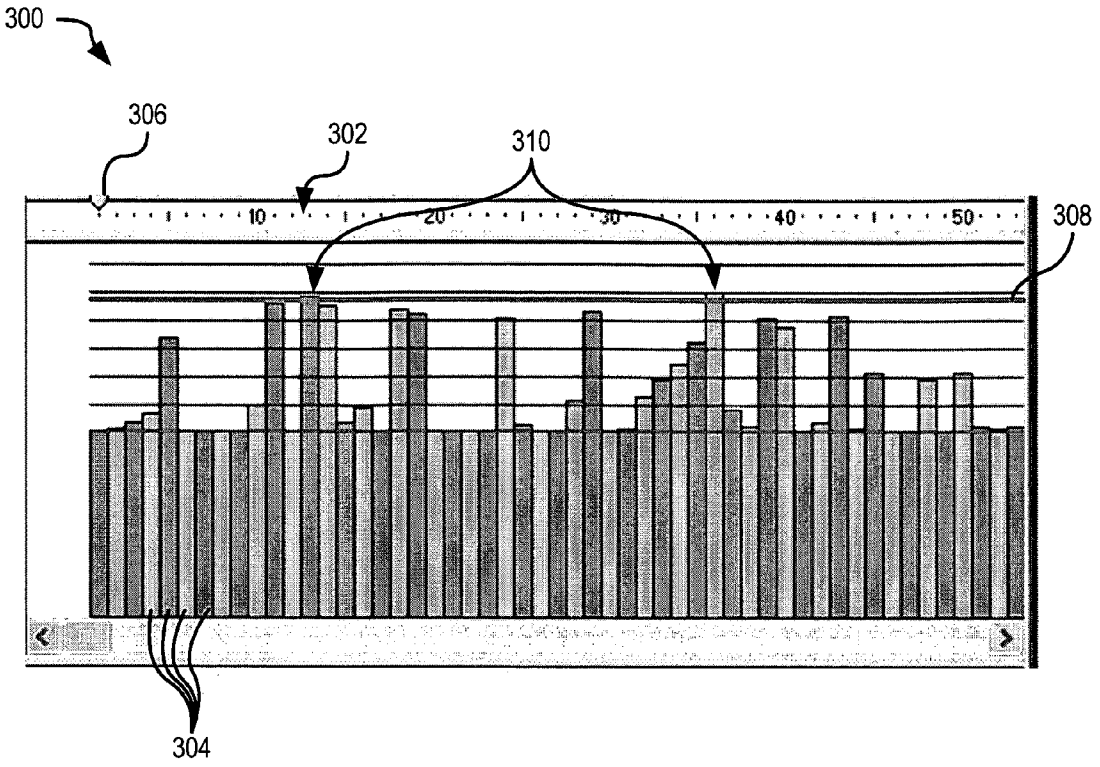
DEVICE MODEL 102
MODELED DISPLAY 210
232
MODELED PROCESSOR 212
MODELED INPUT KEYS 214
230
MODELED MEMORY 216
FLASH PLAYER 154
APPLICATION 104
TIMELINE 222
FRAMES 223
228
MODELED NON-VOLATILE STORAGE 218
FLASH PLAYER 154
APPLICATION 104
TIMELINE 222
FRAMES 223
MOVIE FILE 224
PROFILER 106
PROCESSOR PROFILE MODULE 202
MEMORY PROFILE MODULE 204
GRAPHIC PROFILE MODULE 206
SYSTEM PROFILE MODULE 208
PROFILED DATA 152

FIG. 2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306
302
310
10
20
30
40
50
308
304

FIG. 3

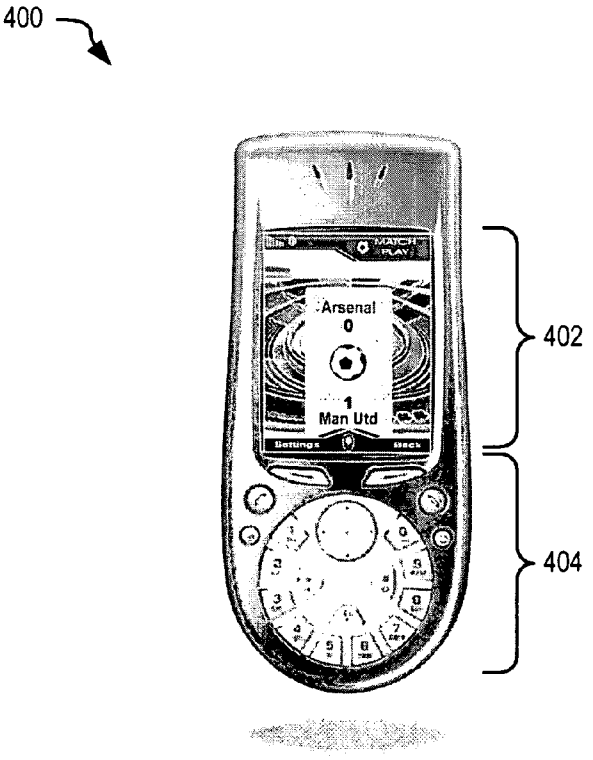
400
Arsenal
0
1
Man Utd
402
404

FIG. 4

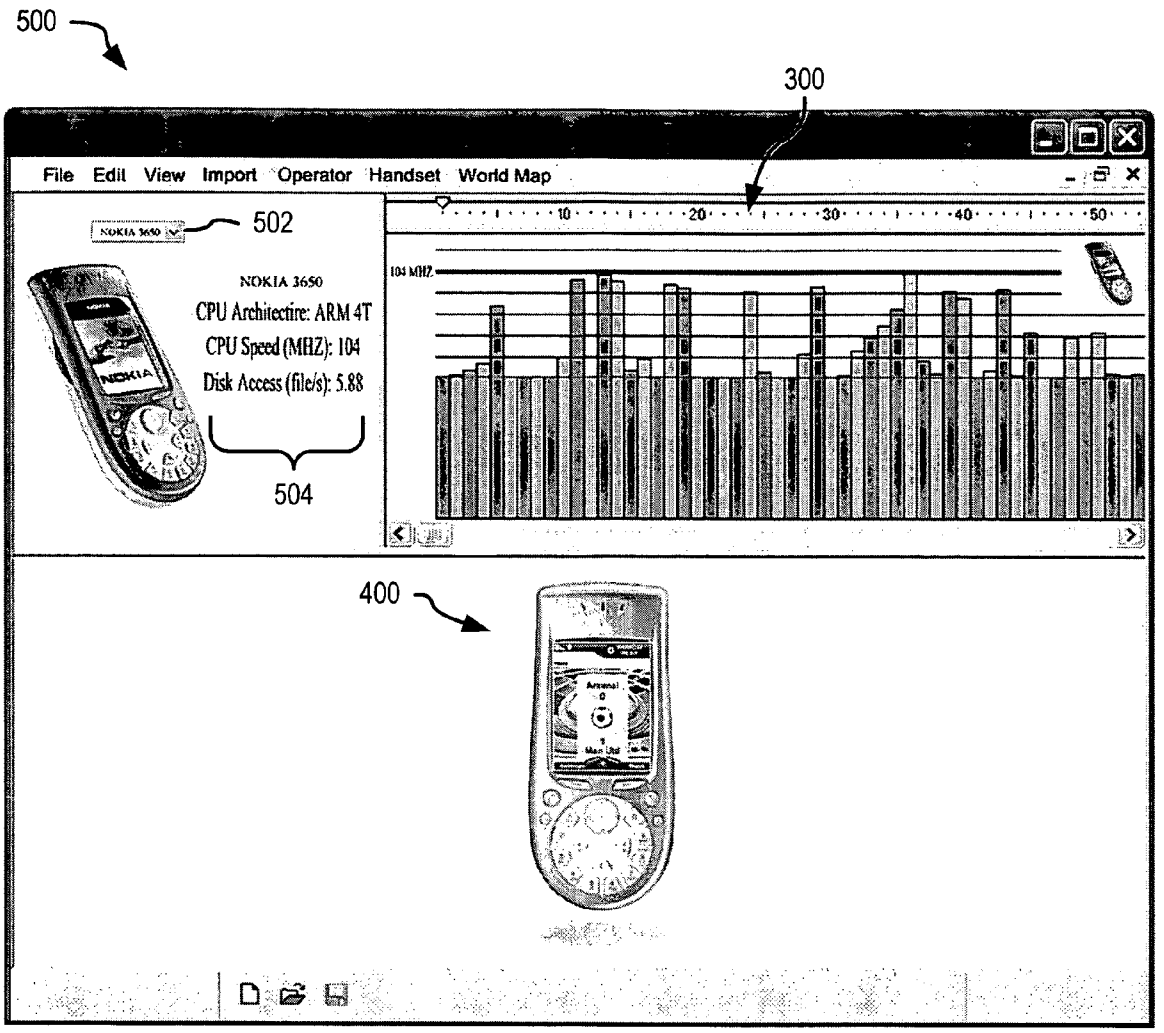
500
300
File Edit View Import Operator Handset World Map
NOKIA 3650
502
NOKIA 3650
CPU Architecture: ARM 4T
CPU Speed (MHZ): 104
Disk Access (file/s): 5.88
504
10
20
30
40
50
104 MHZ
400

FIG. 5

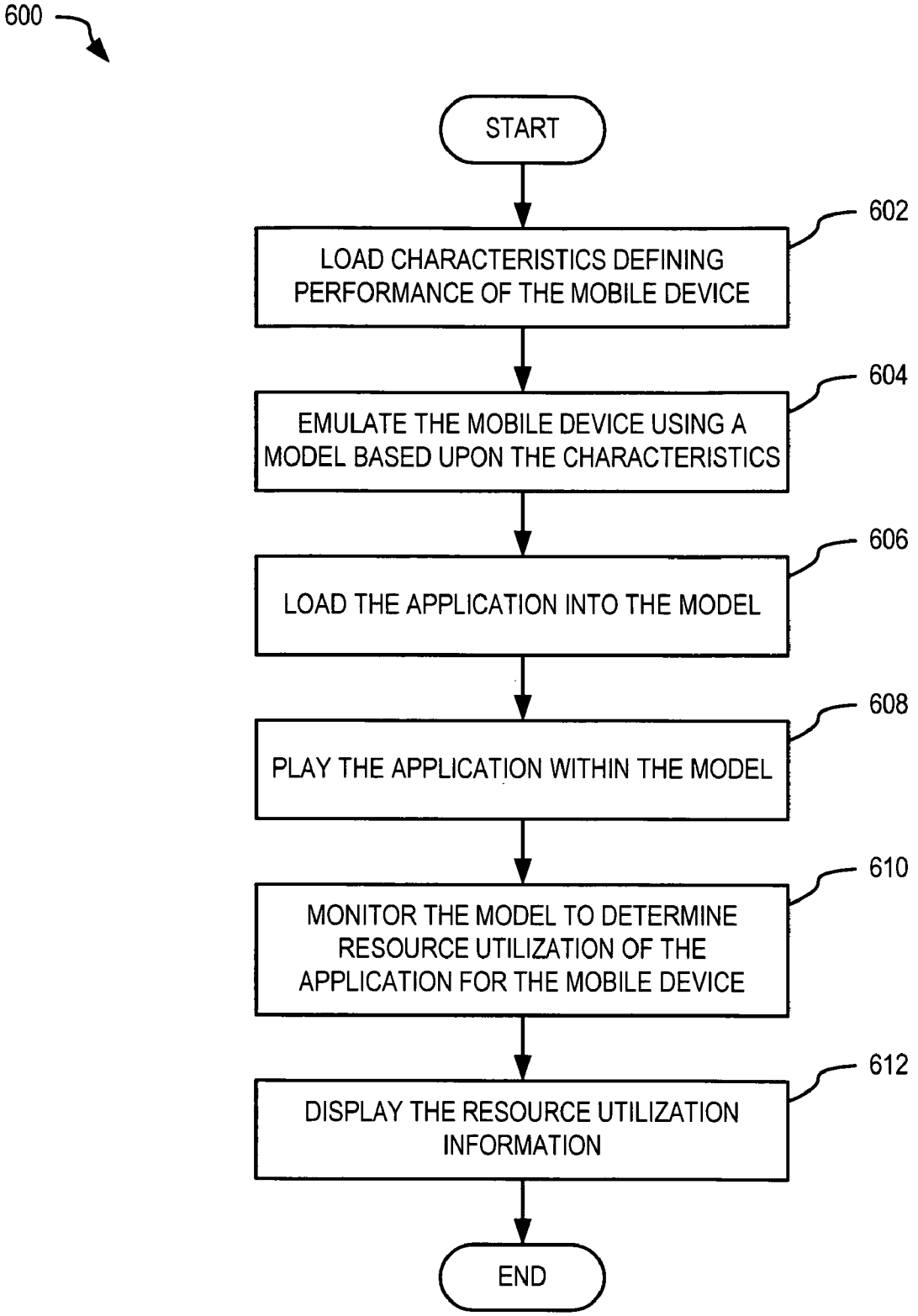
600
START
LOAD CHARACTERISTICS DEFINING PERFORMANCE OF THE MOBILE DEVICE
602
EMULATE THE MOBILE DEVICE USING A MODEL BASED UPON THE CHARACTERISTICS
604
LOAD THE APPLICATION INTO THE MODEL
606
PLAY THE APPLICATION WITHIN THE MODEL
608
MONITOR THE MODEL TO DETERMINE RESOURCE UTILIZATION OF THE APPLICATION FOR THE MOBILE DEVICE
610
DISPLAY THE RESOURCE UTILIZATION INFORMATION
612
END

FIG. 6

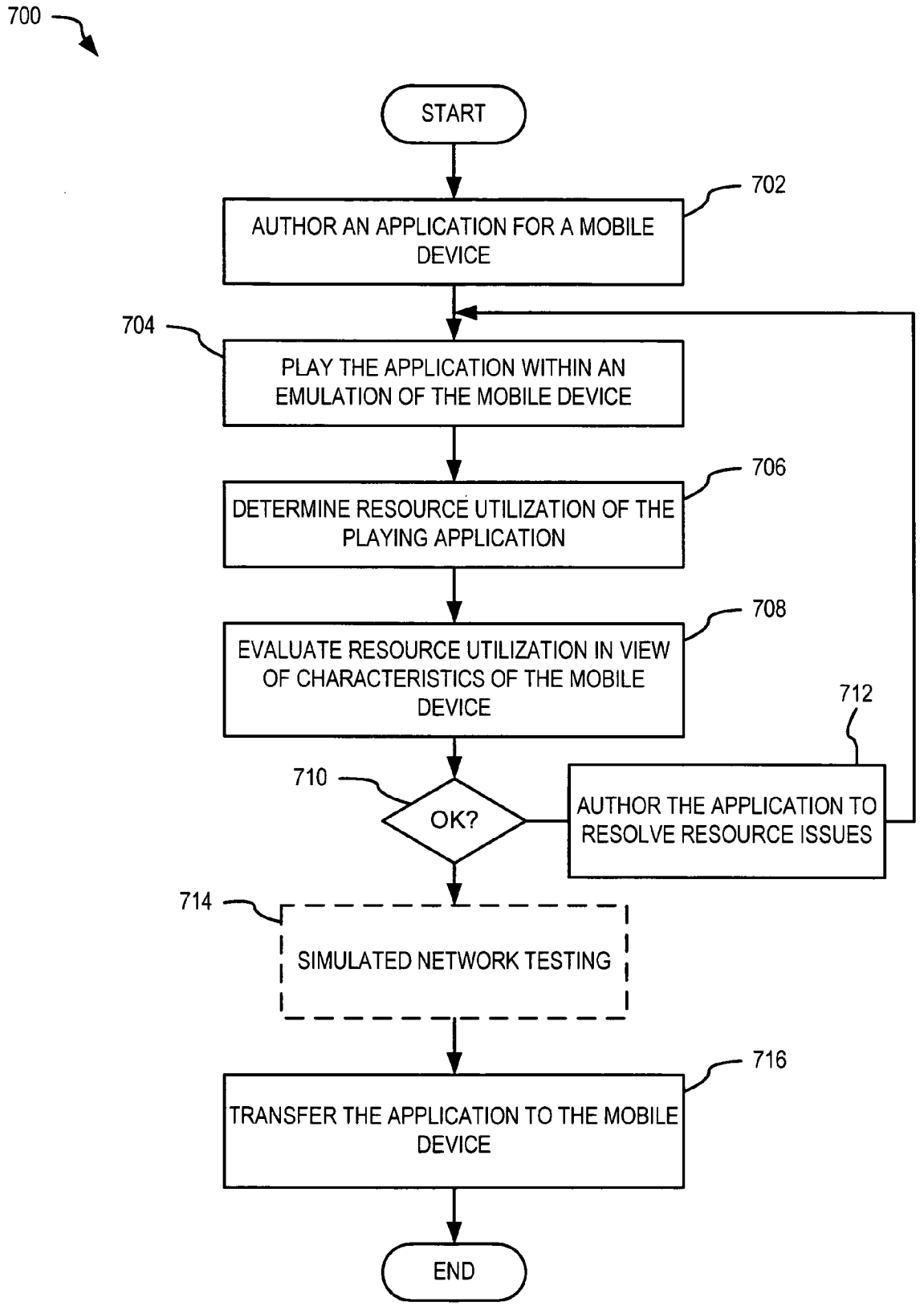
700
START
AUTHOR AN APPLICATION FOR A MOBILE DEVICE
702
704
PLAY THE APPLICATION WITHIN AN EMULATION OF THE MOBILE DEVICE
DETERMINE RESOURCE UTILIZATION OF THE PLAYING APPLICATION
706
EVALUATE RESOURCE UTILIZATION IN VIEW OF CHARACTERISTICS OF THE MOBILE DEVICE
708
712
710
OK?
AUTHOR THE APPLICATION TO RESOLVE RESOURCE ISSUES
714
SIMULATED NETWORK TESTING
716
TRANSFER THE APPLICATION TO THE MOBILE DEVICE
END

FIG. 7

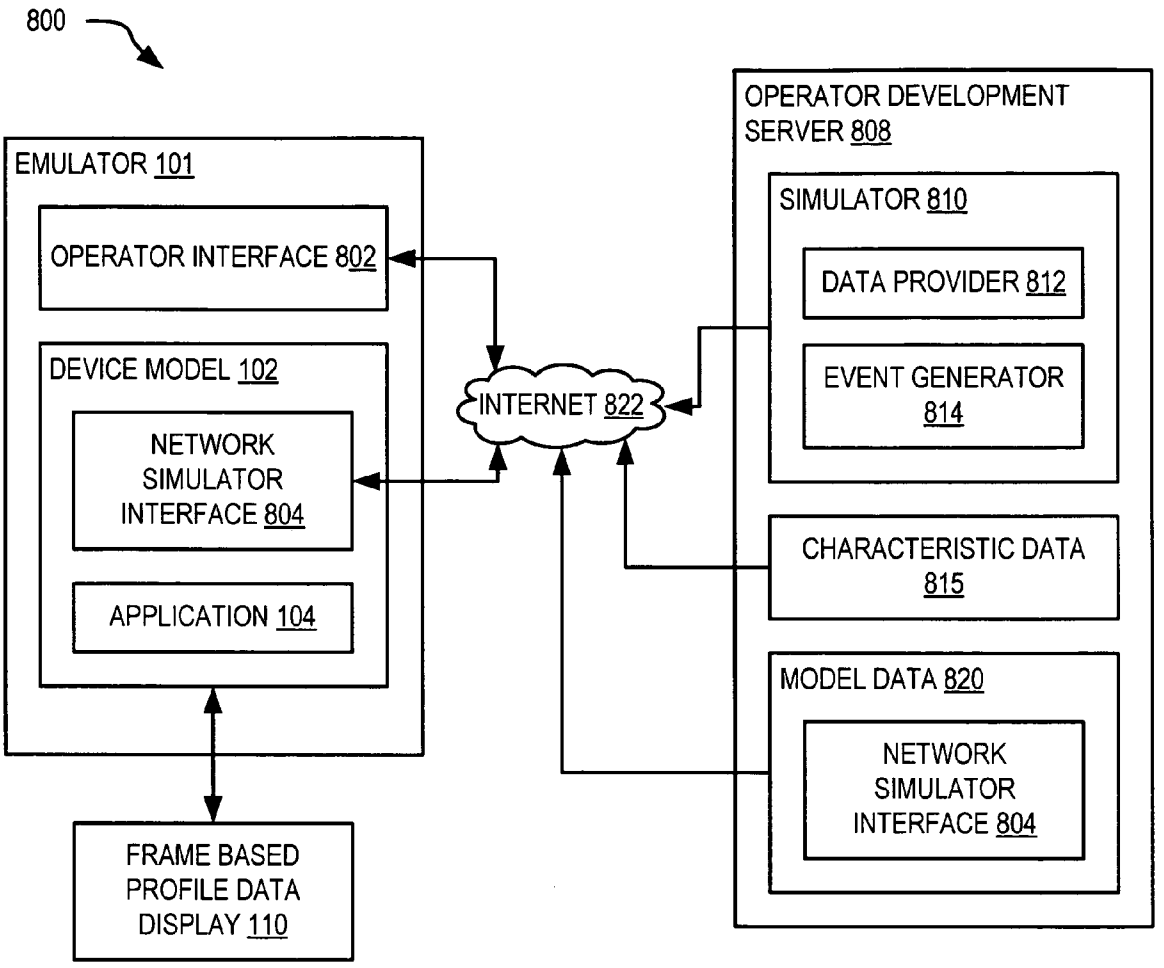
800
EMULATOR 101
OPERATOR INTERFACE 802
DEVICE MODEL 102
NETWORK SIMULATOR INTERFACE 804
APPLICATION 104
FRAME BASED PROFILE DATA DISPLAY 110
INTERNET 822
OPERATOR DEVELOPMENT SERVER 808
SIMULATOR 810
DATA PROVIDER 812
EVENT GENERATOR 814
CHARACTERISTIC DATA 815
MODEL DATA 820
NETWORK SIMULATOR INTERFACE 804

FIG. 8

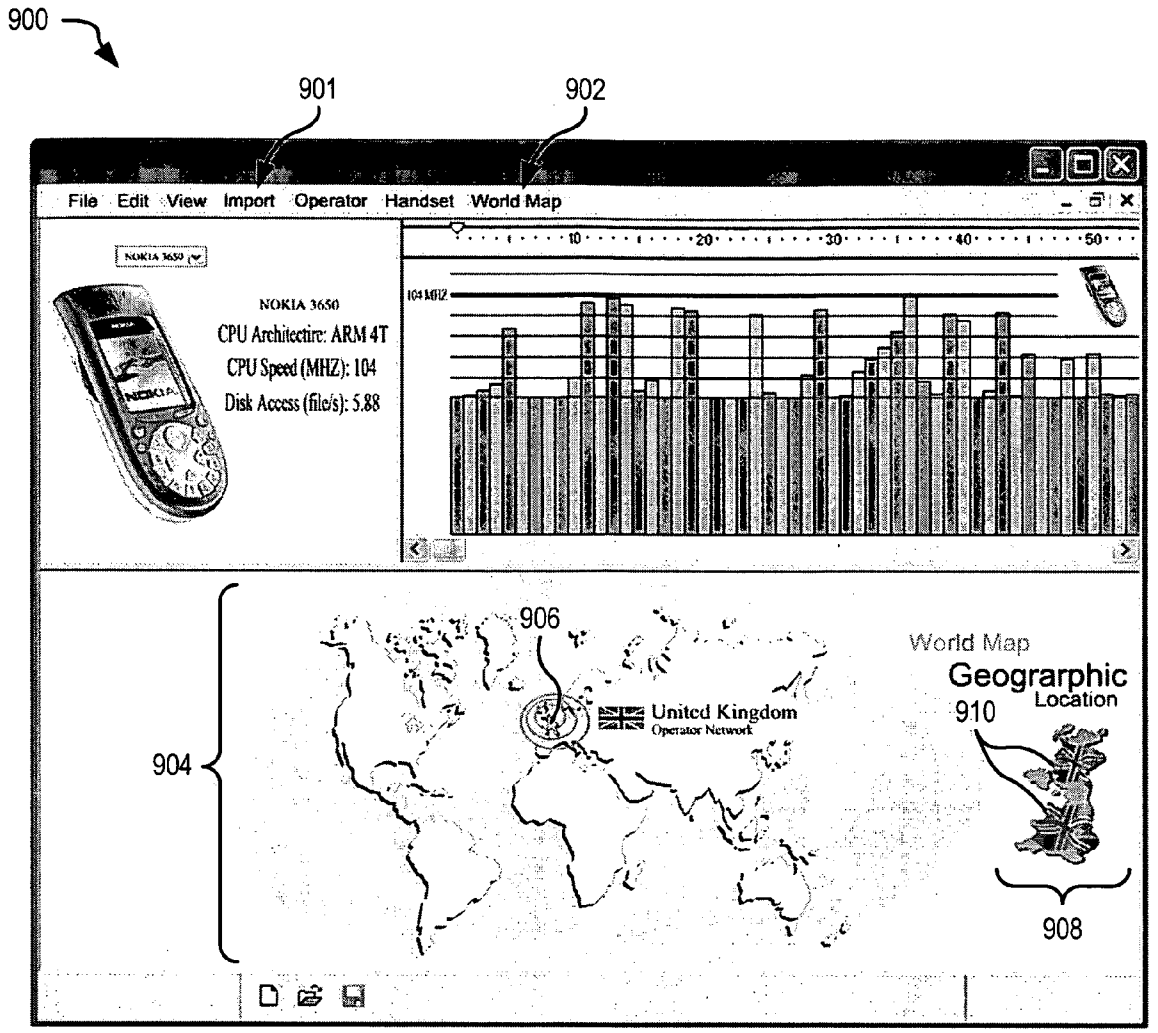
900
901
902
File Edit View Import Operator Handset World Map
NOKIA 3650
CPU Architecture: ARM 4T
CPU Speed (MHZ): 104
Disk Access (file/s): 5.88
10 20 30 40 50
104 MHZ
904
906
United Kingdom
Operator Network
World Map
Geograrphic
Location
910
908

FIG. 9

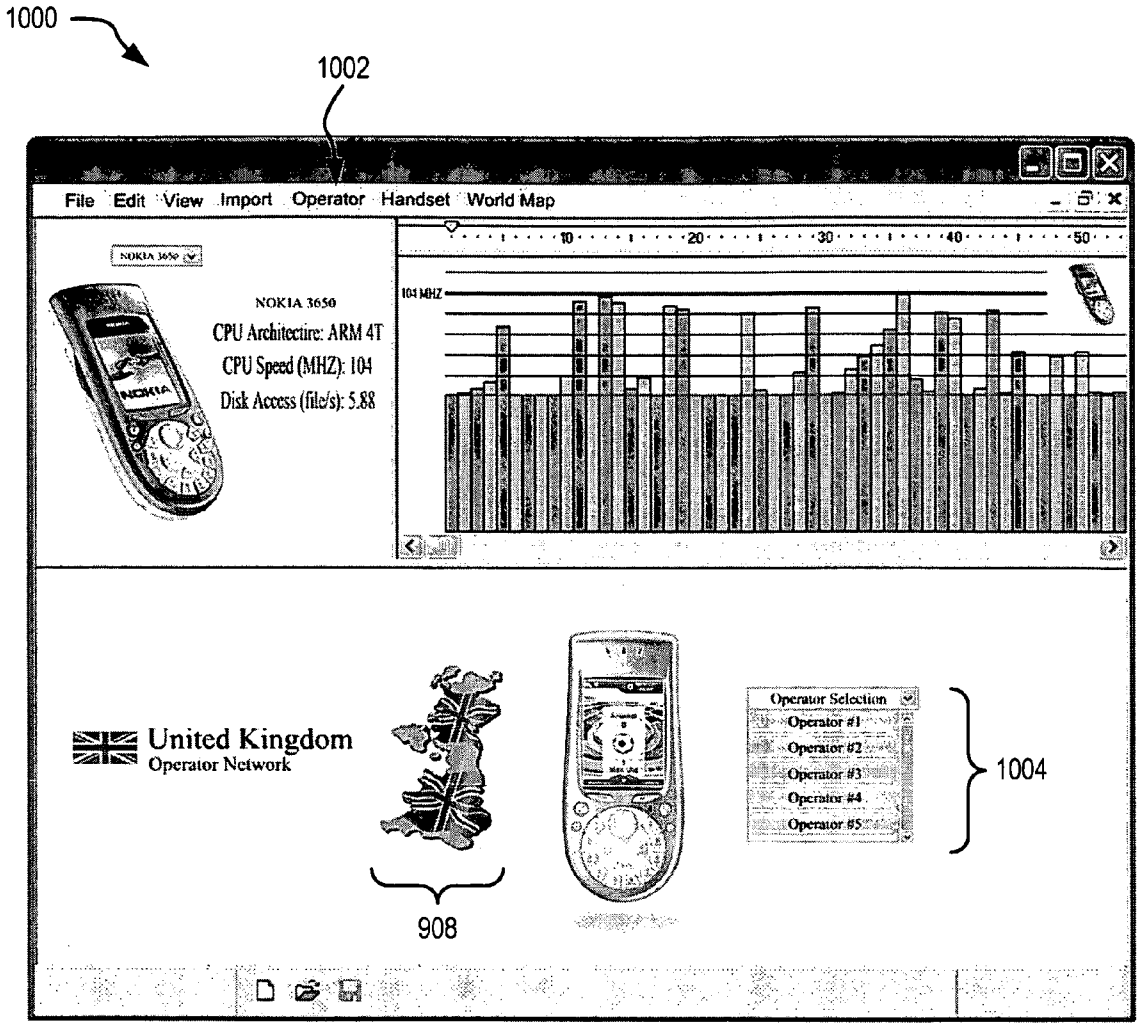
1000
1002
File Edit View Import Operator Handset World Map
NOKIA 3650
CPU Architecture: ARM 4T
CPU Speed (MHZ): 104
Disk Access (file/s): 5.88
104 MHZ
United Kingdom
Operator Network
908
Operator Selection
Operator #1
Operator #2
Operator #3
Operator #4
Operator #5
1004

FIG. 10

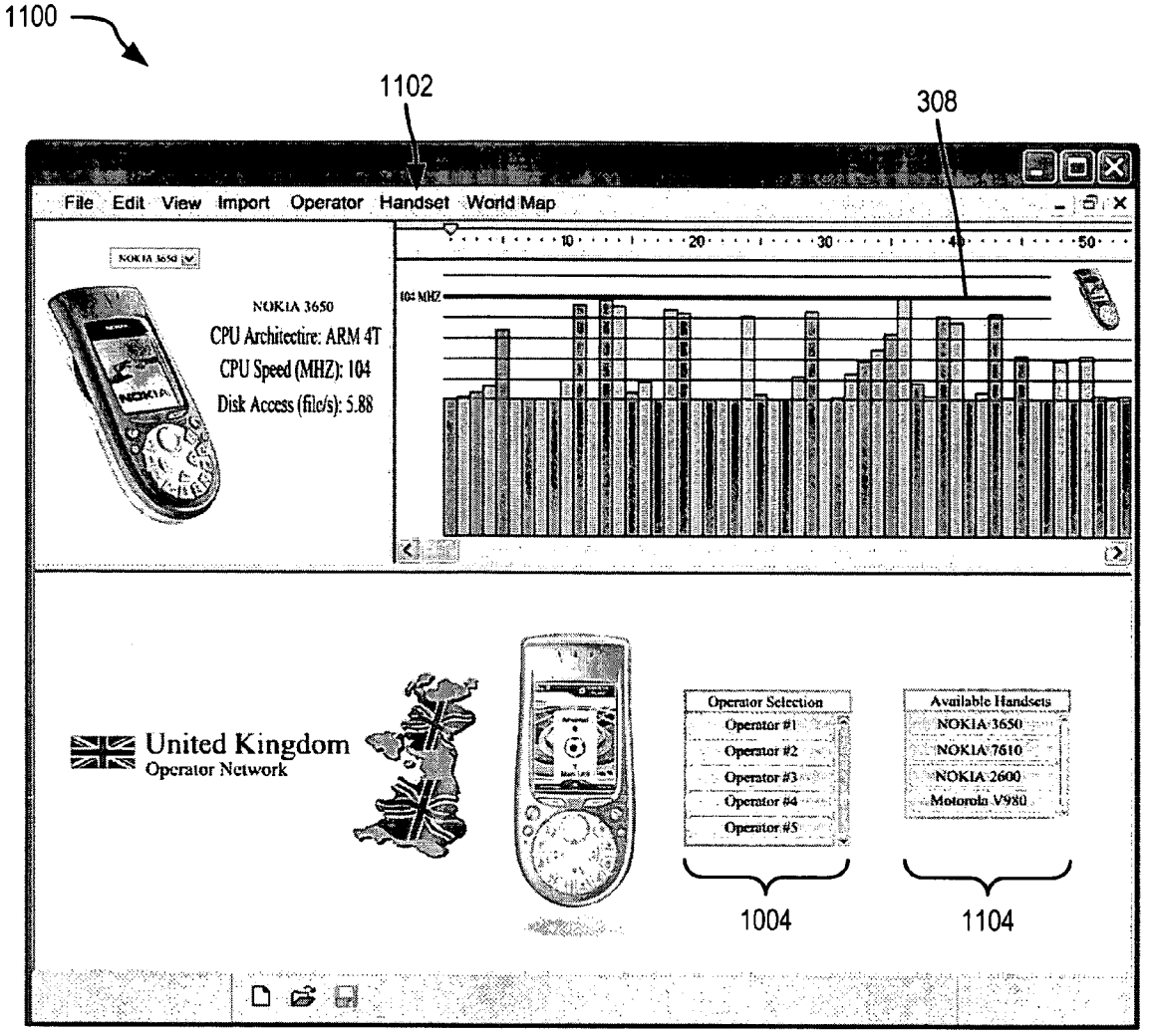
1100
1102
308
File Edit View Import Operator Handset World Map
NOKIA 3650
CPU Architecture: ARM 4T
CPU Speed (MHZ): 104
Disk Access (file/s): 5.88
United Kingdom
Operator Network
Operator Selection
Operator #1
Operator #2
Operator #3
Operator #4
Operator #5
Available Handsets
NOKIA 3650
NOKIA 7610
NOKIA 2600
Motorola V980
1004
1104

FIG. 11

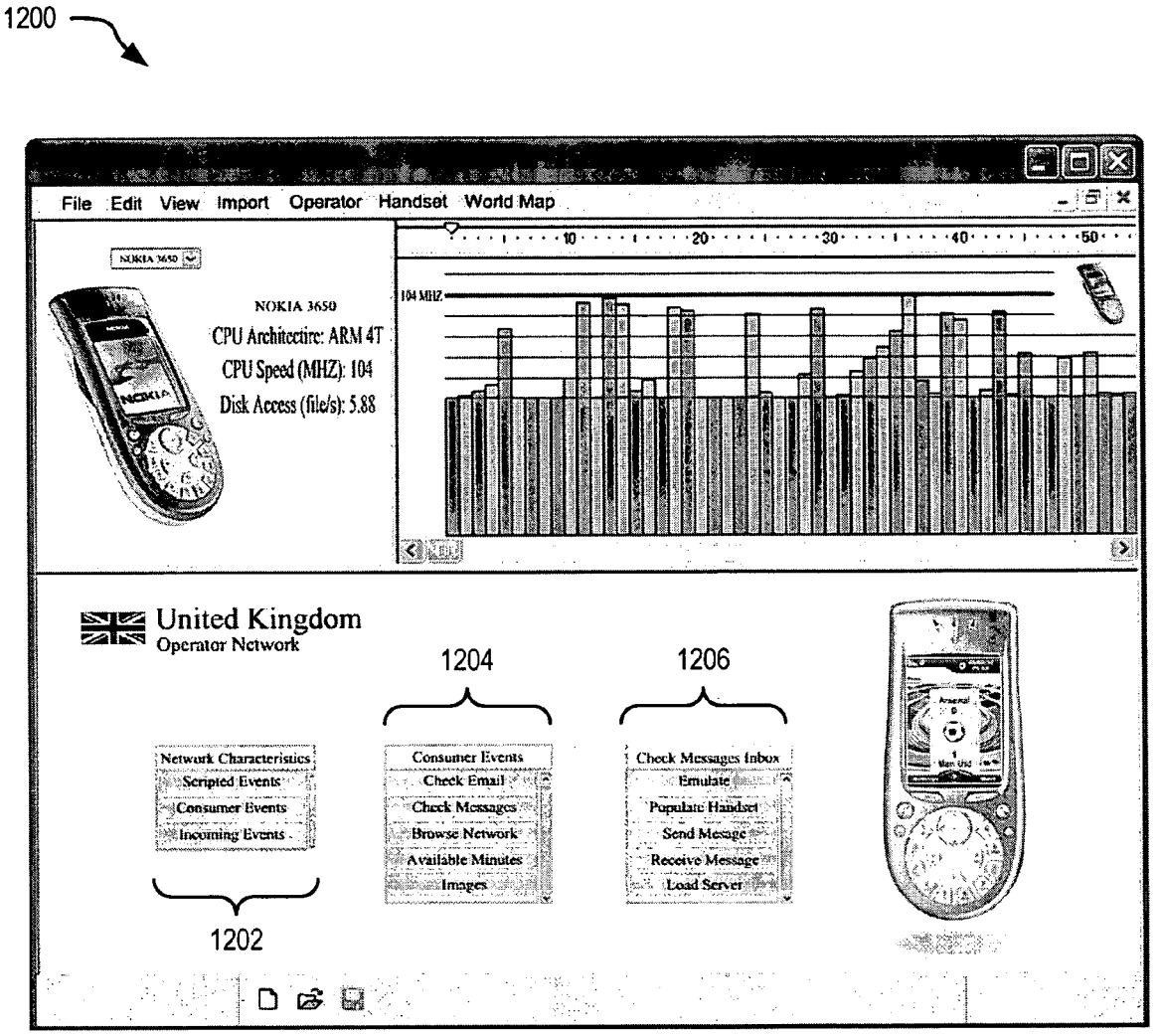
1200
File Edit View Import Operator Handset World Map
NOKIA 3650
CPU Architecture: ARM 4T
CPU Speed (MHZ): 104
Disk Access (file/s): 5.88
104 MHZ
United Kingdom
Operator Network
1204
1206
Network Characteristics
Scripted Events
Consumer Events
Incoming Events
1202
Consumer Events
Check Email
Check Messages
Browse Network
Available Minutes
Images
Check Messages Inbox
Emulate
Populate Handset
Send Message
Receive Message
Load Server

FIG. 12

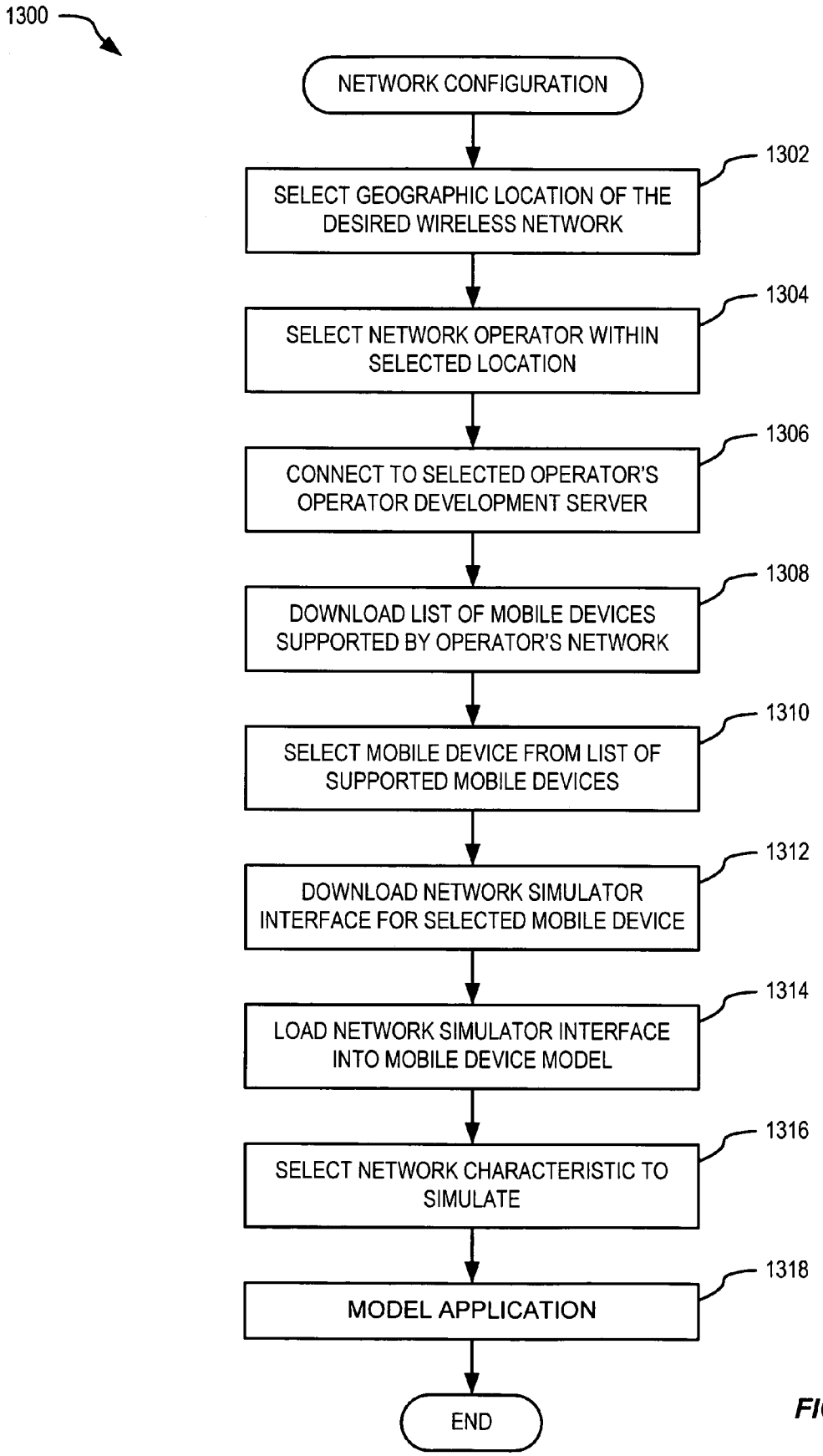
1300
NETWORK CONFIGURATION
SELECT GEOGRAPHIC LOCATION OF THE DESIRED WIRELESS NETWORK
1302
SELECT NETWORK OPERATOR WITHIN SELECTED LOCATION
1304
CONNECT TO SELECTED OPERATOR'S OPERATOR DEVELOPMENT SERVER
1306
DOWNLOAD LIST OF MOBILE DEVICES SUPPORTED BY OPERATOR'S NETWORK
1308
SELECT MOBILE DEVICE FROM LIST OF SUPPORTED MOBILE DEVICES
1310
DOWNLOAD NETWORK SIMULATOR INTERFACE FOR SELECTED MOBILE DEVICE
1312
LOAD NETWORK SIMULATOR INTERFACE INTO MOBILE DEVICE MODEL
1314
SELECT NETWORK CHARACTERISTIC TO SIMULATE
1316
MODEL APPLICATION
1318
END

FIG. 13

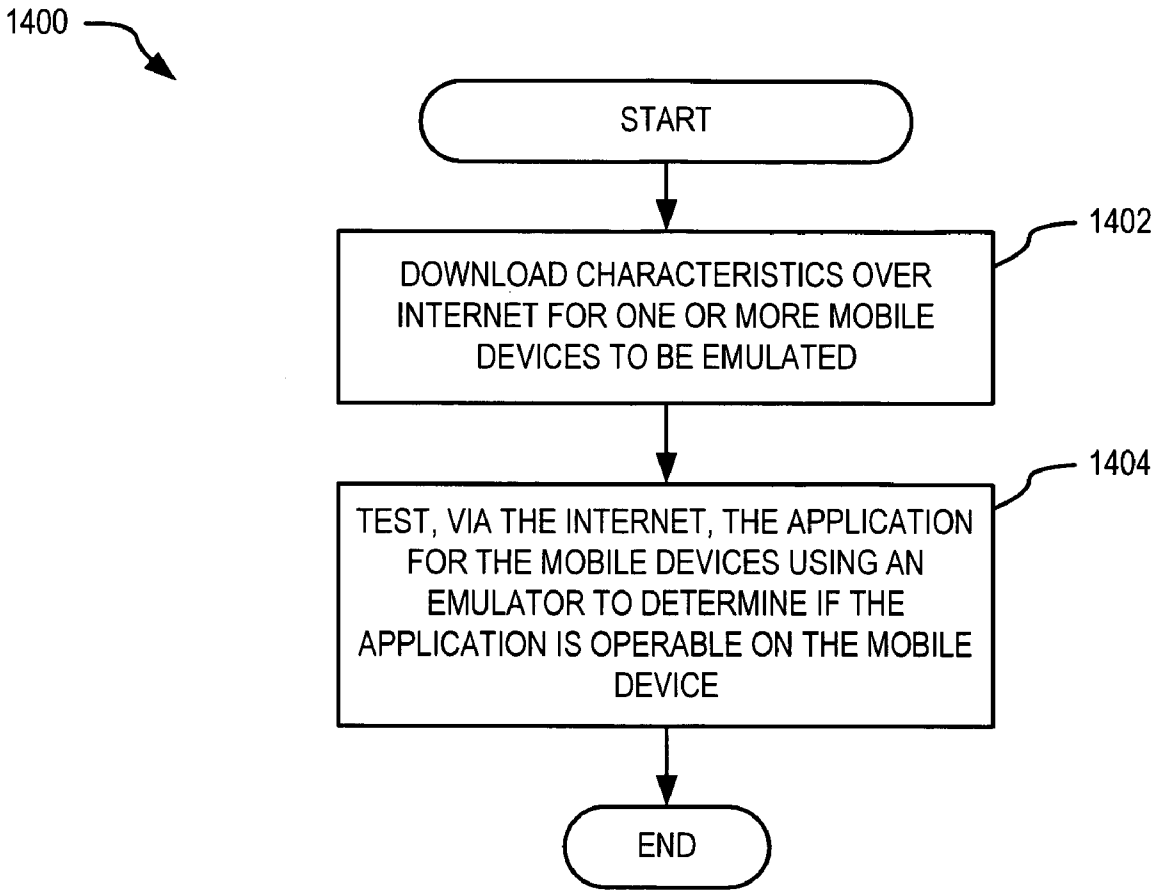
1400
START
DOWNLOAD CHARACTERISTICS OVER INTERNET FOR ONE OR MORE MOBILE DEVICES TO BE EMULATED
1402
TEST, VIA THE INTERNET, THE APPLICATION FOR THE MOBILE DEVICES USING AN EMULATOR TO DETERMINE IF THE APPLICATION IS OPERABLE ON THE MOBILE DEVICE
1404
END

FIG. 14

SYSTEM AND METHOD FOR DEVELOPING AN APPLICATION PLAYING ON A MOBILE DEVICE EMULATED ON A PERSONAL COMPUTER

RELATED APPLICATIONS

This application claims priority to provisional application No. 60/689,101 filed Jun. 10, 2005 and incorporated herein by reference.

BACKGROUND

It is estimated that the mobile market is evolving at five times the speed of the eCommerce market. It is estimated that nearly 700 million new mobile devices will be shipped in 2005, with a new handset model being launched every other day. This rapid mobile device development requires that applications designed to run on these mobile devices also sustain rapid development. Development systems targeted at one mobile device may become obsolete and possibly of little value to the developer at the time it is shipped as well as development life cycles.

Many new mobile devices include a display management engine called a Flash Player; one example of a Flash Player suitable for mobile devices is FlashLite, developed by Macromedia. The Flash Player provides a common application platform for playing applications on the mobile devices and allows developers to develop applications that may be played on multiple mobile devices that include the Flash Player. Applications for mobile devices are typically developed on a personal computer (PC) or workstation and target one or more types of mobile device that include a Flash Player. These applications require real-time testing of the application on all applicable mobile devices. Although a Flash Player application may operate correctly on one mobile device model, it may crash when playing on a different mobile device model. For example, a NOKIA 6600 has a 16% reduction in ARM CPU speed and available memory resources compared to a NOKIA 7610, thus an application that plays correctly on the NOKIA 7610 may not play correctly on the NOKIA 6600 due to this drop in inherent resources.

Development packages (e.g., FlashMX by Macromedia) are available to run on a PC and allow development of Flash Player applications for one or more mobile devices. However, although these development packages may simulate operation of the application playing on the targeted mobile device, they do not determine if the application will play correctly on the targeted mobile device based upon resource usage. Currently, the only way to determine if an application plays on a particular mobile device is to transfer the application to the device and play it. During development of an application for a mobile device, an application author may transfer and play the application hundreds of times (development life cycles) on the targeted mobile device before identifying and correcting all system resource problems within the application. Where an application is targeted to play on many types of mobile device, it must be transferred and tested on a mobile device representative of each targeted mobile device type. This transferring and testing process is time-consuming and therefore costly for the application author.

Further, having accessibility to all available mobile devices in targeted geographical markets worldwide as well as real-time interaction with network Operators to measure and emulate network characteristics within each market is presently not possible.

SUMMARY OF THE INVENTION

In one embodiment, a method emulates and profiles an application to play on a mobile device that includes a Flash Player. Characteristics defining performance of the mobile device are loaded. The mobile device is emulated using a model based upon the characteristics. The application is played and monitored within the model to determine resource utilization of the application for the mobile device.

In another embodiment, a method authors, emulates and profiles an application to play on a mobile device that includes a Flash Player. The application is authored using an application development tool and the mobile device is emulated using a model based upon the characteristics. The application is played within the model and the model is monitored to determine resource utilization of the application for the selected mobile device.

In another embodiment, a method authors an application to play on a mobile device that includes a Flash Player. The application is authored using an application development tool. Resource utilization of the application for the mobile device is estimated. The steps of authoring and estimating are repeated until the resource utilization is less than or equal to the resources available on the mobile device.

In another embodiment, a software product has instructions, stored on computer-readable media, wherein the instructions, when executed by a computer, perform steps emulating and profiling an application to play on a mobile device that includes a Flash Player, including: instruction for loading characteristics defining performance of the mobile device; instruction for emulating the mobile device using a model based upon the characteristics; instruction for playing the application within the model; and instruction for monitoring the application playing in the model to determine resource utilization of the application for the mobile device.

In another embodiment, an emulator profiles an application of a mobile device that includes a Flash Player, including: means for generating a model of the mobile device based upon mobile device characteristics, and means for playing the application within the model to determine resource utilization of the application when played by the mobile device.

In another embodiment, a method determines whether an application of a mobile device is operable. Characteristics are downloaded over Internet for one or more mobile devices to be emulated and the application for the mobile devices is tested, via the Internet, using an emulator to determine if the application is operable on the mobile device.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1**A shows one exemplary embodiment of a system for emulating, authoring and visually profiling an application playing on a mobile device that includes a Flash Player.

FIG. **1**B shows one exemplary embodiment of the system of FIG. **1**A within a computer.

FIG. **2** is a block diagram illustrating detail of an emulator of the system of FIGS. **1**A and **1**B.

FIG. **3** is a display showing one exemplary frame based profile graph.

FIG. **4** is a display showing the modeled mobile device of FIGS. **1**A and **1**B.

FIG. **5** shows one exemplary window that includes the display of FIG. **3**, the display of FIG. **4** and an exemplary user interface.

FIG. **6** is a flowchart illustrating a method for modeling and profiling an application to play on a mobile device that includes a Flash Player.

FIG. **7** is a flowchart illustrating one method for authoring, emulating and profiling an application to play on a mobile device that includes a Flash Player.

FIG. **8** is a block diagram illustrating the emulator of FIG. **1** interacting with an operator development server via the Internet for simulating playing of the application within a mobile device connected to a wireless network.

FIGS. **9**, **10**, **11** and **12** show exemplary user interface screens for interacting with the emulator of FIG. **1** to configure and test operation of the application within the model of the mobile device when connected to a wireless network.

FIG. **13** is a flowchart illustrating one exemplary method for configuring network simulation.

FIG. **14** is a flowchart illustrating one method for determining whether an application of a mobile device is operable.

DETAILED DESCRIPTION OF THE FIGURES

FIG. **1**A shows one exemplary embodiment of a system **100** for emulating and profiling a frame based application **104** playing on a mobile device **114** that includes a Flash Player **116**. System **100** is shown with an emulator **101**, a profiler **106** and a display **110**. Emulator **101** generates a mobile device model **102**, based upon mobile device characteristics **115** of mobile device **114**. Model **102** emulates mobile device **114** to play frame based application **104** and may, for example, generate an emulated mobile device display **111** that represents mobile device **114**. Emulated mobile device display **111** may be interactive to allow a user to interact (in a manner similar to interacting with device **114**) with application **104** while playing within model **102**.

Profiler **106** monitors playing of frame based application **104** within model **102** to estimate resource usage of application **104** and generates a frame based profile data display **110**. Frame based profile data display **110** may allow a user of system **100** to identify areas within application **104** that would exceed resources of mobile device **114**.

Application **104** may be developed using a frame based application development tool **112** (indicated in dashed outline). Frame based application development tool **112** may, for example, represent Flash MX or Studio 8 from MacroMedia (now Adobe Systems). Once the user of system **100** has verified that application **104** does not exceed resources of mobile device **114**, development tool **112** may be instructed to publish application **104** to device **114**, as shown.

In one example of operation, development tool **112** is used to develop frame based application **104**. Application **104** is transferred to emulator **101** for playing within mobile device model **102** to estimate resource usage of application **104** when played on mobile device **114**. Upon playing application **104** within model **102**, emulator **101** utilizes profiler **106** to determine resource utilization of application **104** based upon mobile device characteristics **115**.

In one embodiment, emulator **101** is integrated with flash development tool **112** to form an authoring environment **122** that facilitates development and testing of application **104** without the need to continually load application **104** into mobile device **114**.

In another embodiment, emulator **101** is an add-in module that may be configured to operate within flash development tool **112**.

Mobile device **114** is shown with Flash Player **116**, display **118** and input keys **120**. In one embodiment, Flash Player **116** is FlashLite™ from Macromedia™ (Adobe Inc). Mobile device **114** may, for example, represent one of: a cell phone, a personal digital assistant (PDA), an interactive home appliances and other such devices. In one example, display **118** represents a color liquid crystal display (LCD) device for displaying text and images to a user of mobile device **114** and input keys **120** represent buttons that allow the user to interact with mobile device **114**.

FIG. **1**B shows one exemplary embodiment of system **100** within a computer **130**. Computer **130** includes memory **132**, storage **134** and a processor **136**. Memory **132** is for example random access memory (RAM) and storage **134** is for example a disk drive or other non-volatile storage media.

Storage **134** is shown with emulator **101**, mobile device characteristics **115** and application **104**. Storage **134** may also include development tool **112**, if desired, for developing application **104**. Emulator **101** includes model algorithms **148** and profiler **106**. Model algorithms **148** represent one or more algorithms that operate to generate mobile device model **102** to emulate mobile device **114** while executing application **104**. Specifically, model algorithms **148** define operation of mobile device **114** based upon mobile device characteristics **115**.

TABLE 1

Mobile Device Characteristics

Parameter	Value
Name	NOKIA 3650
Processor	ARM 4T
Processor Speed	104 MHz
Storage Access Speed	5.88 files/second
RAM Size	256 MB
Storage Size	512 MB
Display Width	256
Display Height	394
Pixel Depth	24
Processor Availability	60%
RAM Availability	60%
Storage Availability	40%

Table 1 Mobile Device Characteristics shows exemplary characteristics that may be used to specify performance of model **102** to emulate mobile device **114**. For example, in Table 1, the characteristics have the following meaning: 'Processor' specifies the type of the processor in mobile device **114**; 'Processor Speed' specifies the clocked speed of the processor within device **114**; 'Storage Access Speed' specifies the rate at which data can be moved from storage to memory and/or screen within device **114**; 'RAM Size' specifies the size of the RAM in mobile device **114**; 'Storage Size' specifies the size of the non-volatile memory in mobile device **114**; 'Display Width' specifies the number horizontal pixels on display **118** of device **114**; 'Display Height' specifies the number of vertical pixels of display **118**; 'Pixel Depth' specifies the number of bits per pixel (e.g., the color depth) of display **118**; 'Processor Availability' specifies the percentage of processing resource available for use by applications (e.g., where mobile device **114** represents a cell phone, the phone has to maintain 'phone' operations while running any applications, thus there may only be a portion of the maximum processing resource available to applications); 'RAM Availability' specifies the percentage of RAM available to applications; and 'Storage Availability' specifies the percentage of non-volatile storage space available to applications.

Table 1 may be represented as a data structure (e.g., shown as mobile device characteristics **115** within storage **134**) and may be stored in a file (not shown) or a database (not shown) within storage **134**, or stored remotely. System **100** may include mobile device characteristics (e.g., mobile device characteristics **115**) for multiple devices (e.g., device **114**). For example, characteristics **115** may be included for each

mobile device type targeted by application **104**. A user of system **100** may then select one or more target mobile devices from a list based upon available characteristics **115**. As appreciated, additional or fewer characteristics may be included within characteristics **115** to specify performance of mobile device **114** without departing from the scope hereof.

As new mobile device types are created, additional mobile device characteristics **115** may be easily created to specify the performance of the new device types, allowing application development to start before a physical mobile device is available. For example, if a company introduces a new series of six mobile phone handsets, six additional mobile device characteristics **115** may be created based upon measured (e.g., by running benchmarks on the new handsets or prototype) or determined (e.g., by estimating performance based upon previous models) performance thereby allowing emulation and evaluation of applications targeting these new devices.

In one embodiment, mobile device characteristics **115** may be supplied with a device model specific to one mobile device. For example, a manufacturer may supply a combined device model and characteristics for each mobile device **114**. Emulator **101** may then utilize the combined device model as device model **102**.

In one example, computer **130** may include an interface (not shown) that provides communication with mobile device **114** via one or more of: USB, Ethernet, infra-red, Bluetooth, WiFi and other similar communication media. This interface may, for example, allow application **104** to be deployed on mobile device **114** for final testing of application **104**.

In one example of operation, processor **136** loads at least part of emulator **101** into memory **132** for execution. Emulator **101** then generates mobile device model **102**, based upon characteristics **115**, within memory **132**. Emulator **101** then loads and plays application **104** within model **102**. Emulator **101** may load all or part of profiler **106** into memory **132** to monitor resources and/or performance of application **104** within model **102**. Specifically, as application **104** is played (i.e., utilizing a Flash Player **154**) within model **102**, profiler **106** monitors and records, as profiled data **152**, resources utilized by application **104**. Profiled data **152** may be stored (as shown in dashed outline) within storage **134** and/or displayed as frame based profile data **110** on display **140** of terminal **138**. In particular, frame based profile data **110** may be used to identify areas within application **104** where upon playing of application **104** within mobile device **114**, performance of mobile device **114** would be stressed. Thus, areas where failure may occur within application **104** may be identified prior to running application **104** on mobile device **114**. For example, emulator **101** may display all or part of profile data **152** on display **140** to facilitate development of application **104**.

FIG. **2** is a block diagram illustrating emulator **101** of FIGS. **1**A and **1**B in further detail. In particular, profiler **106**, within emulator **101**, is shown with a processor profile module **202**, a memory profile module **204**, a graphic profile module **206** and a system profile module **208**. Processor profile module **202** may, for example, estimate processor utilization of application **104** within model **102**. Memory profile module **204** may, for example, estimate memory utilization by application **104** within model **102**. Graphic profile module **206** may, for example, estimate utilization of 3D fill rate and 3D polygon count of application **104** within model **102**. System profile module **208** may, for example, determine overall system utilization of application **104** within model **102**. More or fewer profile modules may be included within profiler **106** without departing from the scope hereof.

Device model **102**, within emulator **101**, has a modeled display **210**, a modeled processor **212**, modeled input keys **214**, modeled memory **216** and modeled non-volatile storage **218**. In this example, modeled display **210** represents display **118** of mobile device **114**, FIG. **1**, processor **212** represents a processor (not shown) of mobile device **114**, modeled input keys **214** represent input keys **120** of mobile device **114**, modeled memory **216** represents memory (e.g., RAM) of mobile device **114** and modeled non-volatile storage **218** represents non-volatile storage (e.g., flash memory, disk drive storage) of mobile device **114**. Fewer or more elements and/or components of mobile device **114** may be modeled within device model **102** without departing from the scope hereof.

Modeled non-volatile storage **218** is shown with Flash Player **154** that may be the same as, or similar to, Flash Player **116**, FIG. **1**. In one example, Flash Player **154** has similar operation to Flash Player **116**, but includes modifications that facilitate monitoring of application **104** within model **102** by profiler **106**.

Flash applications are based upon a timeline of frames that may include graphical information and action scripts, FS Commands, network protocols, selected frame rate, etc. Flash Player **116** within mobile device **114** thus operates upon a time line of frames within application **104** to provide graphical displays (e.g., animations, rich media content) upon display **118**. Accordingly, profiled data **152** may also be based upon the timeline and frames of application **104** and displayed (e.g., frame based profile data **110**) as resource utilization related to one or more of: timeline, frames and processing performance of action scripts.

In FIG. **2**, application **104** is shown with a timeline **222** that includes frames **223**. Each frame of frames **223** may include graphics and/or action scripts that generate the graphical image for display. For example, an action script may reference one or more graphic files (e.g., movie file **224**) to provide graphical images for display **111**. Where each frame of frames **223** includes multiple graphic elements and/or action scripts that involve image manipulation (e.g., retrieving data from non-volatile storage, Avatar manipulations, animations, etc.), each frame may require differing resources in order to display correctly. For example, where a frame includes Avatar (e.g., an animated character) manipulation, a certain amount of processor resource is required, whereas a frame that is based upon movie file **224** may simply require data transfer time. If mobile device **114** has insufficient processor resources (e.g., because the animation is too complex for the targeted mobile device), application **104** may crash (i.e., cease to function correctly). Thus, it is important to determine the 'stress' applied by application **104** to resources of mobile device **114**.

In one example of operation, Flash Player **154** plays application **104** within model **102**. In particular, player **154** processes frames **223** of application **104** based upon ordering of timeline **222**. One or more profiler modules **202**, **204**, **206** and **208** within profiler **106** monitor resource utilization of each frame, storing results as profiled data **152**. Profiled data **152** is then displayed as frame based profile data **110** on display **140** for review by the user. Profile data **152** may be displayed in real time as application **104** is played within model **102**. Alternatively, the user may scroll through profile data **152** as desired by interacting with data display **110**. Alternatively, profile data **152** may be output as a report (not shown). The user interacts with emulated mobile device display **111** to control application **104** as if application were running on device **114**.

FIG. **3** shows one exemplary display **300** showing a frame based display of profiled data **152**, FIG. **1**A, determined by

processor profile module **202**. In particular, display **300** is shown with a time line **302** that represents timeline **222** of application **104**. In this example, each bar **304** indicates processor resource utilization for certain frames **223** of application **104**. During play of application **104** within model **102**, a current position indicator **306** shows the frame (i.e., frame **1** in this example) currently displayed by emulated mobile device display **111** (see FIG. **4**). A capacity line **308** (capout) indicates the maximum processor resource available to application **128**. Where bars **304** rise above capacity line **308** at locations **310**, resource utilization for indicated frames of application **104** exceed the available processor resources of mobile device **114**; thus application **104** may 'capout' or crash when playing those frames. Display **300** clearly displays processor resource utilization by frame **223** of application **104**, thereby facilitating assimilation of stresses applied to mobile device **114** when playing application **104**.

Other profile modules **204**, **206** and **208**, may have similar displays that clearly indicate resource utilization during playing of application **104** within model **102**, thereby estimating resource utilization of application **104** when played within mobile device **114**.

FIG. **4** shows one exemplary display **400** generated from device model **132** within emulator **120**, FIG. **1**. In particular, display **400** shows an image (e.g., generated from a bitmap of mobile device **114**) of mobile device **114** with a display area **402** and input keys **404**. Display **400** allows the user to see and interact with an application running within device model **132**. For example, display area **402** may represent display **118** of mobile device **114** and input keys **404** may represent input keys **120** of mobile device **114**.

FIG. **5** shows one exemplary window **500** that includes display **300** of FIG. **3** and display **400** of FIG. **4** and an exemplary user interface. In particular, window **500** shows selection of a mobile device (i.e., NOKIA **3650** in this example) from a pull-down list **502** that results in display of characteristics **504** of the selected mobile device. Characteristics **504** may represent characteristics **115** of FIG. **1**A, for example. Window **500** facilitates interaction with model **102** through display **400** and monitoring of resource utilization of application **104** through window **300**. Further, pull-down list **502** allows easy selection of further mobile devices upon which application **104** is to be profiled.

FIG. **6** is a flowchart illustrating a method **600** for modeling and profiling an application playing on a mobile device that includes a Flash Player. Method **600** may, for example, be implemented within emulator **101**.

In step **602**, method **600** loads characteristics defining performance of the mobile device. In one example of step **602**, a user of window **500** selects a mobile device using pull-down list **502** and emulator **101** loads mobile device characteristics **115** into memory **132**.

In step **604**, method **600** emulates the mobile device using a model based upon the characteristics. In one example of step **604**, emulator **101** generates device model **102** based upon mobile device characteristics **115**.

In step **606**, method **600** loads the application into the model. In one example of step **606**, emulator **101** loads application **104** into device model **102**.

In step **608**, method **600** plays the application within the model. In one example of step **608**, emulator **101** plays application **104** within model **102**.

In step **610**, method **600** monitors the application playing in the model to determine resource utilization of the application for the mobile device. In one example of step **610**, emulator **101** utilized profiler **106** to monitor application **104** playing within model **102** to determine profiled data **152**.

In step **612**, method **600** displays the resource utilization information. In one example of step **612**, emulator **101** displays all or part of profiled data **152** as frame based profile data **110** on display **140**.

FIG. **7** is a flowchart illustrating one method **700** for authoring, emulating and profiling an application to play on a mobile device that includes a Flash Player. Method **700** may be implemented within emulator **101**, for example.

In step **702**, method **700** authors an application for a mobile device. In one example of step **702**, a user interacts with frame based application development tool **112** to author application **104**.

In step **704**, method **700** plays the application within an emulation of the mobile device. In one example of step **704**, emulator **101** generates model **102** based upon characteristics **115** of mobile device **114** and then loads and plays application **104** within model **102**.

In step **706**, method **700** determines resource utilization of the playing application. In one example of step **706**, emulator **101** utilizes one or more profile modules **202**, **204**, **206** and **208** of profiler **106** to determine resource utilization of application **104** within model **102** and stores the resource utilization information as profiled data **152**.

In step **708**, method **700** evaluates resource utilization in view of characteristics of the mobile device. In one example of step **708**, emulator **101** evaluates profiled data **152** to determine, based upon characteristics **115**, if resource utilization is within available resources of mobile device **114**.

Step **710** is a decision. If in step **710**, method **700** determines that the resource utilization of step **708** is within available resources of mobile device **114** (i.e., OK), method **700** continues with step **714**; otherwise method **700** continues with step **712**.

In step **712**, method **700** authors the application to resolve resource issues. In one example of step **712**, the user modifies application **104**, based upon determined resource utilization of step **708**, using development tool **112**. Method **700** continues with step **704**. Steps **704** though **712** thus repeat until the estimated resources requirement of the application is within available resources of the mobile device.

Step **714** is optional and is particularly suited for testing applications (e.g., application **104**) running on a mobile device (e.g., mobile device **114**) that is a mobile phone. In step **714**, emulator **101** interacts with one or more operator development servers (e.g., operator development server **808**, FIG. **8**) to configure device model **102** for simulated network operation to allow testing of application **104** within a simulated wireless network environment (e.g., a simulated mobile phone wireless network environment). Simulated network operation is described in further detail below and shown in FIGS. **8** though **13**.

In step **716**, method **700** transfers the application to the mobile device. In one example of step **716**, emulator **101** instructs development tool **112** to publish application **104** to mobile device **114**.

FIG. **8** is a block diagram illustrating interaction of emulator **101** with an operator development server **808** via Internet **822** for simulating playing of application **104** within a mobile device connected to a wireless network (e.g., a mobile phone wireless network). FIGS. **9**, **10**, **11** and **12** show exemplary windows that allow a user to interact with emulator **101** for configuring and testing operation of application **104** within model **102** when simulating connection to a wireless network. FIGS. **8**, **9**, **10**, **11** and **12** are best viewed together with the following description.

Emulator **101** is shown with an operator interface **802** that interacts with operator development server **808** via Internet

822. Internet 822 may, for example, represent the world wide web (WWW), an Intranet or any fixed or wireless server connection. Operator development server 808 is shown with a simulator 810, characteristic data 815 and model data 820. Model data 820 may, for example, represent live network profiles. To facilitate connection to operator development server 808, a user of emulator 101 purchases a subscription from a provider of operator development server 808 (or from a third party) that allows emulator 101 to connect to operator development server 808 via Internet 822. Upon connection to operator development server 808, emulator 101 may download characteristic data 815 from operator development server 808 for one or more mobile device types supported by operator development server 808 (i.e., supported by the operator's wireless network). Characteristic data 815 may, for example, represent mobile device characteristics 115 of FIG. 1. Further, emulator 101 may download additional model data 820 for use within device model 102 for increasing simulated functionality of model 102 (e.g., simulating additional handset functionality and/or network functionality). The user of emulator 101 may, for example, purchase data 820 for additional mobile device types as they become available, thereby allowing emulator 101 to include modeling capability for a new pre-release mobile device, scheduled release mobile device and current mobile devices. Alternatively, the use of data 815 and data 820 may be includes within a monthly subscription fee, thereby allowing the user to author applications for new mobile devices (e.g., new mobile phone models and live mobile profiles) provided by an operator (e.g., mobile phone wireless network operator).

In one example of operation, emulator 101 downloads a network simulator interface 804 from operator development server 808 into device model 102 as shown in FIG. 8. Network simulator interface 804 includes functionality that allows device model 102 to communicate with simulator 810 to simulate connectivity of mobile device 114 with a wireless network. Specifically, network simulator interface 804 within model 102 interacts with data provider 812 and event generator 814 to determine resource utilization resulting from network interaction by model 102. Thus, as application 104 plays within model 102, the effects of device 114 interacting with a wireless network are simulated such that frame based profile data display 110 shows resource utilization that includes the live or scripted effects of interaction with the wireless network. In one embodiment, capacity line 308 of display 300 within profile data display 110 is dynamically modified to show actual resource availability to application 104 resulting from resource utilization by simulated wireless network activity within device model 102. For example, if a message is received and/or retrieved by model 102 while playing application 104, certain resources are required to handle the received message, and therefore available resources for application 104 is reduced accordingly.

Simulator 810 is shown with a data provider 812 and an event generator 814. Data provider 812 may, for example, simulate data transfers within a wireless network. For example, the data transfer may be cased upon a certain bandwidth associated with the wireless network. Event generator 814 may, for example, generate certain events (e.g., incoming calls, incoming text messages, etc) that occur within a wireless network. Simulator 810, using data provider 812 and event generator 814, thus interacts with network simulator interface 804 to model operation of a wireless network (e.g., a mobile phone network).

Operator interface 802 may interact with multiple operator development servers 808 to facilitate testing of application 104 with many operators' networks. As appreciated, where application 104 is designed to function on multiple mobile devices operating on wireless networks worldwide, operator network simulation removes the burden of traveling to operator network locations from application developers, since application operation on a mobile device connected to a network may be simulated by emulator 101 and thus measured back against the authoring environment.

FIG. 9 shows one exemplary window 900 for selecting operator networks based upon geographic location. Window 900 shows a menu item 902 that, upon selection by the user, displays a world map 904 that allows the user to select a geographical region in which mobile device 114 is to operate. For example, window 900 shows a mouse pointer 906 selecting the United Kingdom, resulting in a sub-map display 908 of the selected location showing available wireless networks 910. Sub-map display 908 is, for example a 'mouse-over' event. Upon selection of the location, world map 904 is replaced by sub-map 908 of the selected location and a pull-down list 1004 of available operators within that location as shown in window 1000, FIG. 10. Alternatively, the use may select menu item 1002 to display pull-down list 1004.

Upon selection of an operator within list 1004, emulator 101 displays a pull-down list 1104 of mobile devices supported by the selected operator, as shown in window 1100 of FIG. 11. Alternatively, the use may select the menu item 1102 to display list 1104. Upon selection of a mobile device from list 1104, window 1200, FIG. 12, is displayed to allow the user to select desired network characteristics for simulation.

Window 1200 shows a pull-down list 1202 of network characteristics that may be simulated by simulator 810. For example, simulator 810 may allow control of scripted events (e.g., cell tower identification, service message, bandwidth, etc.), consumer events (e.g., checking email, checking messages, browsing network, available minutes, selecting images, etc.) and incoming events (e.g., phone calls, WAP Messages, receiving MMS, receiving SMS, etc.). Based upon selection from list 1202, a second list may be presented to allow further simulation requirements to be entered. In the example of window 1200, consumer events entry of list 1202 was selected, resulting in display of pull-down list 1204 from which check messages was selected resulting in the display of pull-down list 1206. In this example, the user may select 'send message' from list 1206 to evaluate the performance of application 104 while a message is received from the network.

In one embodiment, maps 904, 908 and lists 1004, 1104, 1202, 1204 and 1206 are based upon information received by operator interface 802 from one or more operator development servers 808. Thus, functionality of model 102 and selectable simulations of simulator 810 may be easily updated by the operator as new mobile devices are created without requiring updates to software of emulator 101.

Optionally, the user may select menu item 901, FIG. 9, to immediately locate, download and import modeling characteristics into emulator 101. These characteristics may be stored within storage 134 of computer 130, FIG. 1B.

FIG. 13 is a flowchart illustrating one exemplary method 1300 for configuring wireless network simulation.

In step 1302, method 1300 selects a geographic location of the wireless network. In one example of step 1302, emulator 101 displays window 900 and the user selects the United Kingdom as the wireless network location.

In step 1304, method 1300 selects a network operator from within the selected location. In one example of step 1304, emulator 101 displays window 1000 including pull-down list 1004 of network operators within the location selected in step 1302.

In step **1306**, method **1300** connects to the selected network operator's development server. In one example of step **1306**, emulator **101** utilizes operator interface **802** to connect to operator development server **808** based upon the operator selected in step **1304**.

In step **1308**, method **1300** downloads a list of mobile devices supported by the simulator of the operator selected in step **1304**. In one example of step **1308**, emulator **101** downloads characteristic data **815** from server **808** to determine mobile devices supported by simulator **810** and populates list **1104** of window **1100**. Of note, an operator may add functionality to simulator **810** based upon a new mobile device prior to supporting the device within the operator's wireless network, thereby encouraging development of applications for the new device before its launch, increasing operator and/or author revenues.

In step **1310**, method **1300** selects a mobile device from the list of supported mobile devices. In one example of step **1310**, the user selects a mobile device for emulation from list **1104** of window **1100**. In another example, where the user has already selected a mobile device from pull-down list **502**, emulator **101** automatically selects the same device, if available, from list **1104**.

In step **1312**, method **1300** downloads a network simulator interface for the selected mobile device. In one example of step **1312**, emulator **101** instructs operator interface **802** to download network simulator interface **804** from server **808**.

In step **1314**, method **1300** loads the network simulator interface into the mobile device model. In one example if step **1314**, emulator **101** loads network simulator interface **804** into model **102**.

In step **1316**, method **1300** selects network characteristics to simulate. In one example of step **1316**, the user utilizes lists **1202**, **1204** and **1206** of window **1200** to specify network characteristics for simulation by simulator **810**.

In step **1318**, method **1300** models the application running within a mobile device connected to a wireless network. In one example of step **1318**, model **102** interacts with simulator **110** via network simulator interface **804** and interne **822** while playing application **104** and displaying profile data display **110**.

In one embodiment, the user may purchase and download simulator **810** from operator development server **808** to facilitate local simulation of the wireless network (i.e., without utilizing Internet **822**). In this embodiment, simulator **810** may operate within emulator **101**, within authoring environment **122** or within computer **130** to provide interaction with model **102**.

Emulator **101** may utilize operator interface **802** to interact with one or more operator development servers **808** to download characteristics (e.g., characteristic data **815**) and modeling data (e.g., model data **820**) for generating mobile device model **102**. As new mobile devices are made available, each application author (i.e., user) is able to download these modeling characteristics and test applications for the new mobile device. As mobile devices become more sophisticated and include additional hardware and functionality, emulator **101**, though a subscription service with an operator, for example, may download this additional functionality for use in model **102**. These characteristics (e.g., characteristic data **815**) may include bitmaps, characteristics handset profiles, modeling algorithms, complete mobile device models, bandwidths etc. thereby automatically updating functionality of authoring environment **122**. Wireless network operators participate by updating their development servers (e.g., development servers **808**) to provide the latest emulation information and functionality for each supported mobile device (e.g., mobile phone handset) and by updating their network simulators (e.g., simulator **810**) to includes functionality and/or proposed functionality of their wireless networks.

Application authors (e.g., users of emulator **101**) are provided with a visual authoring environment in which the authored application may be emulated as operating within one or more modeled mobile devices (that are optionally connected to a simulated wireless network) without leaving the authoring environment.

The emulator (e.g., emulator **101**) may be provided as part of the authoring environment, or as an add-on to an existing development tool. In an embodiment, characteristics for each mobile device to be emulated are downloaded from a server for a determined price or subscription fee. Since new mobile devices are continually being produced, application authors continually require new modeling characteristics to be able to test their applications. For example, a subscribed charge of $10-15 dollars per handset saves each developer from purchasing a mobile device ($100-200 dollars) and alleviates the need to travel to a wireless network location when testing each mobile device. Thus, the wireless network operator may receive revenue from developers by providing the developers with online network simulation capability. The application authors, via the Internet, are then able to test applications for mobile devices running on wireless networks worldwide.

Characteristics for each mobile device to be emulated may be downloaded from a server for a determined price, licensing or subscription fee. It is estimated that nearly 700 million new mobile devices will be shipped in 2005, with a new handset model being launched every other day. This rapid mobile device development requires that applications designed to run on these mobile devices also sustain rapid development. Development systems targeted at one mobile device may become obsolete and possibly of little value to the developer at the time it is shipped. Since a new mobile device is being launched every other day, application authors continually require purchasing all addressable targeted devices prior to consumer release. For example, a charge of $10-15 dollars per modeled handset would save each developer purchasing each target mobile device ($100-200 dollars) as well as alleviating the need to travel to a wireless network location whilst testing each mobile device before public release, two substantial development and release costs.

During development of an application for a mobile device, an application author may transfer and play the application hundreds of times (development life cycles) on the targeted mobile device before identifying and correcting all system resource problems within the application. Live server and profile updates would substantially reduce and alleviate a high churn rate of development life cycles, enabling a more cost effective authoring model for the developer. As well, although the purchase of a 'static' PC authoring environment may become obsolete due to the ongoing release of new mobile handsets (the target release platform) emulator **101** and operator development server **808** maintains a live and continually updatable business model and authoring platform long after the initial authoring platform has released to the market.

FIG. **14** is a flowchart illustrating one method for determining whether an application of a mobile device is operable. In step **1402**, method **1400** downloads characteristics over Internet for one or more mobile devices to be emulated. In step **1404**, method **1400** tests the application for the mobile devices, via the Internet, using an emulator to determine if the application is operable on the mobile device.

Changes may be made in the above methods and systems without departing from the scope hereof. It should thus be

noted that the matter contained in the above description or shown in the accompanying drawings should be interpreted as illustrative and not in a limiting sense. The following claims are intended to cover all generic and specific features described herein, as well as all statements of the scope of the present method and system, which, as a matter of language, might be said to fall there between.

What is claimed is:

1. A method for testing an application on an application player on a mobile device emulated on a personal computer, the method comprising:

loading characteristics indicative of performance of the mobile device;

emulating the mobile device using a model, based on the characteristics, running on the personal computer;

playing the application in real time using the application player within the model; and

monitoring the application playing in the model to determine performance of the application on the mobile device.

2. The method of claim **1**, further comprising graphically displaying resource utilization of the application playing within the model.

3. The method of claim **1**, further comprising loading the application into the model.

4. The method of claim **1**, further comprising selecting the mobile device from a list of mobile devices stored in a library containing characteristics of the mobile devices in the list.

5. The method of claim **4**, further comprising:

loading the application into the model; and

selecting additional mobile devices from the list;

wherein the step of loading comprises loading the characteristics of each selected mobile device;

wherein the step of emulating comprises emulating each mobile device using a model based upon the characteristics of the mobile device;

wherein the step of playing comprises playing the application using the application player within each said model; and

wherein the step of monitoring comprises monitoring each model to determine performance of the application playing on the emulated mobile device.

6. The method of claim **1**, the step of emulating comprising:

determining, based on the characteristics,

the display size of the mobile device;

the amount of random access memory (RAM) in the mobile device; and

the processor speed of the mobile device; and

generating a model of the mobile device based upon the display size, the amount of RAM, and the processor speed.

7. The method of claim **1**, wherein the step of monitoring includes monitoring individual frames of the application.

8. The method of claim **1**, wherein the application player comprises a Flash Player.

9. The method of claim **1**, wherein the characteristics comprise memory size and processor speed.

10. A method for testing an application playing on an application player running on a mobile device emulated on a personal computer, the method comprising:

loading characteristics indicative of performance of the mobile device from a library containing said characteristics for a plurality of said mobile devices;

emulating the mobile device utilizing a model, based upon the characteristics, executing on the personal computer;

playing the application in real time using the application player within the model; and

monitoring the model to determine performance of the application playing on the emulated mobile device.

11. The method of claim **10**, further comprising displaying the application while being emulated on the personal computer.

12. The method of claim **11**, wherein the application being played on the emulated mobile device is displayed on a per-frame basis.

13. The method of claim **10**, wherein the application being played on the emulated mobile device is displayed on a per-frame basis.

14. The method of claim **10**, further comprising publishing the application to the mobile device once the performance is determined to be within available resources of the mobile device.

15. A software product comprising instructions, stored on computer-readable media, wherein the instructions, when executed by a computer, perform the steps of the method of claim **10**.

16. The method of claim **10**, wherein the application player comprises a Flash Player.

17. A method for developing an application to play on an application player on a mobile device emulated on a personal computer, the method comprising:

interacting with a user to author the application within an application development tool;

estimating resource utilization by the application when played by the application player; and

repeating the steps of interacting and estimating until the estimated resource utilization is less than or equal to the resources available for playing the application on the mobile device;

wherein the step of estimating comprises emulating the mobile device utilizing a model based upon characteristics of the mobile device and monitoring the application playing by the application player within the model to determine resource utilization by the application.

18. The method of claim **10**, wherein the characteristics comprise memory size and processor speed of the mobile device.

19. The method of claim **17**, further comprising selecting the mobile device from a list of mobile devices stored in a library containing performance-related characteristics of the mobile devices in the list.

20. A software product comprising instructions, stored on computer-readable media, wherein the instructions, when executed by a computer, perform steps of testing an application playing on an application player running on a mobile device emulated on a personal computer, the instructions comprising:

instructions for emulating the mobile device using a model based upon characteristics indicative of performance of the mobile device;

instructions for playing the application using the application player within the model; and

instructions for monitoring the application playing in the model to determine performance of the application running on the mobile device.

21. The software product of claim **20**, wherein the characteristics comprise memory size, and processor speed for the mobile device.

22. The software product of claim **20**, wherein the application being played on the emulated mobile device is displayed on a per-frame basis.

23. The software product of claim **20**, wherein the characteristics comprise memory size and processor speed for the mobile device.

24. An emulator for testing an application playing on an application player on a mobile device emulated on a personal computer, comprising:

means for generating a model of the mobile device based upon characteristics indicative of performance of the mobile device; and

means for playing the application in real time using the application player within the model to determine performance of the application when played on the mobile device.

25. The emulator of claim 24, further comprising means for authoring the application.

26. The emulator of claim 24, further comprising means for monitoring playing of the application within the model to determine resource utilization of the application running on the emulator.

27. The emulator of claim 26, the means for monitoring comprising means for displaying the resource utilization.

28. The method of claim 24, wherein the characteristics include memory size and processor speed of the mobile device.

29. The method of claim 24, wherein the application being played on the emulated mobile device is displayed on a per-frame basis.

30. A method for determining whether an application for a mobile device having an application player is operable on the mobile device, comprising:

downloading, over the Internet, characteristics indicative of performance of the mobile device to be emulated; and

emulating, via a personal computer, the mobile device, based on the characteristics to determine if the application is operable by the application player on the mobile device;

wherein the step of emulating comprises playing the application in real time using the application player within the model.

31. The method of claim 30, the step of downloading being responsive to an online payment to a third party.

32. The method of claim 31, wherein the online payment comprises one of a subscription fee and a usage fee.

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