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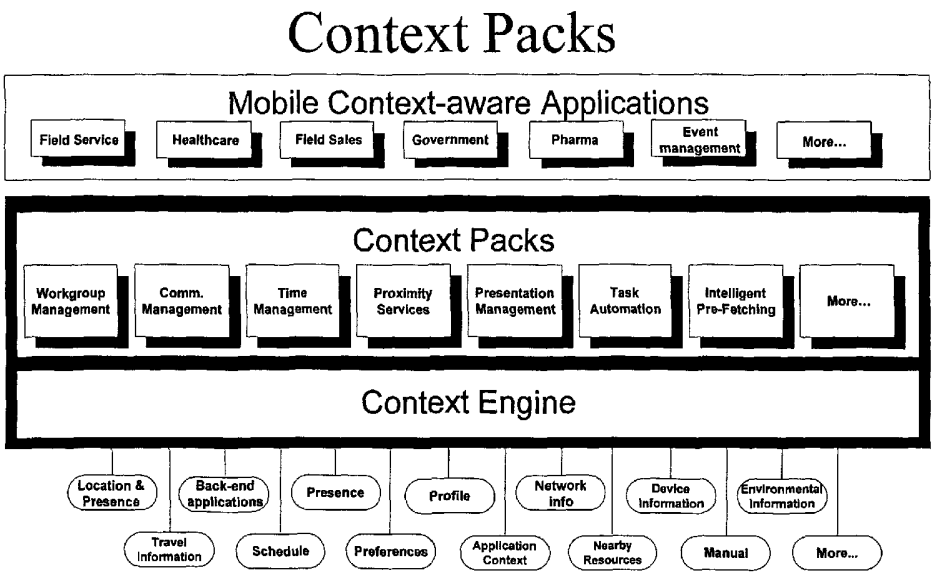
(54) Title: METHOD AND SYSTEM FOR PROVIDING CONTEXT AWARENESS



(57) Abstract: A method and system for providing context information, systems, and actions for a range of information technology platforms and interfaces. Context includes the aggregate knowledge about a user's siuation and intent. Included in the system are tiers of features for enabling context awareness, including a collection tier, analysis tier, and action/effect tier. Information relating to entities, which are the elements that are included in the system, such as users and communication devices, along with states and relationships, is identified and accessed by a context engine, which obtains the information from sensors and interpreters for the information. In one application tier, the context engine is used with any set of entities, and relationships. Another application tier, referred to as "context packs", includes preset sets of entities, states, and relationships identified for predetermined applications.

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TITLE OF THE INVENTION

METHOD AND SYSTEM FOR PROVIDING CONTEXT AWARENESS

This application claims priority from U.S. Provisional Applications Serial No. 60/296,650 filed June 7, 2001, Serial No. 60/300,457 filed June 26, 2001, and Serial No. 60/300,458 filed June 26, 2001. The entirety of each of these provisional patent applications is incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to methods and systems for providing context aware information, and in particular to methods and systems for determining use, intent, and situation specific information about users and any other entity, such as devices on networks usable, among other purposes, to optimize the effectiveness of applications and interfaces based on the context information obtained.

Background of the Technology

The introduction of mobile data networks has enabled the use of applications even when not in the office, such as when at home or in any other stable environment (e.g., the typical office, chair, telephone, and screen environment, which is readily predictable). However, the mobile user is not able to control an ever-changing environment; movement, device and network resources, and the setting (e.g., car, customer site, meeting room), among other factors, affect the user, while the application maintains its preordained behavior at the time of initial development, typically without incorporating or addressing these effects.

As a result of the ever-changing environment of many situations, the user can face an ordeal when interacting with mobile applications via the mobile device (e.g., size of device, limited input methods). This ordeal manifests itself in the usability of so-called mobile applications; the amount of interaction the user is

required to go through produces an acute problem, resulting, in many cases, in the abandonment of the mobile applications by the user.

Today, many applications are available for personal and business use. As computing platforms and Internet use increasingly become commonplace, the productivity of application users is on the rise. However, as discussed above, little has changed in how applications are developed and presented to the user. A developer, usually according to a specification, writes the application, tests are performed, and the application is made available for the user.

Once the application has left the desk of the developer and has been tested, it does not modify its behavior as presented to the user. While the user encounters different situations and schedule changes throughout the day, the application is oblivious to these adjustments, and continues to present information in an unchanging manner. This non-flexible application behavior, while minimizing the efforts required of the application developer, has increased the degree of effort required of the user, in terms of usability.

In this light, it is useful to consider the "context" of an application. Context can be defined as the aggregate knowledge about the Users' situation and intent. There is an unmet need for software applications to optimize the effectiveness of the application in view of context. Examples for such knowledge include the following: 1) Where is the user? 2) What is the user activity? 3) Who is nearby? 4) What is nearby? 5) What devices is the user using? 6) With whom is the user talking? 7) Where is the user going to be? and 8) What the user is going to do?

Some limited manifestations of context exist in the prior art. Although they are simple and rather constant, changes to an application are possible in view of the person that is using the application. One example is personalization engines available in some e-commerce sites. In search of better understanding of the target user for these applications, such personalization engines typically seek limited information about the user. These can be accumulated across several interactions the user has made with the engine.

To determine the situation and intent of the user, there remains an unmet need for methods and systems that collect information about the user, such as the

user's location, the user's role, the user's responsibilities, the user's calendar, the presence of the user, the user's device, the situation of, for example, the user's peers, and the user's preferences.

As is apparent, there is thus a further, more general need for a user-centric approach to application development: an approach is needed that incorporates the aggregate knowledge of the users' situation and intent, for which a software application could then optimize the effectiveness of the application. Such an approach would, among other advantages, enable the system to maximize the results to fit with each user's preferences and needs. The usage of context could vary. Context could be used to present the user with relevant information based on the current context situation; it could also be used, for example, to choose the preferred method for communicating with the user.

The major problems preventing developers in the prior art from making context aware applications readily available include the following:

1) Sensors needed for such methods and systems typically involve one or more complex systems, distributed over a variety of physical and logical domains. Sensors generally are not constant in their existence; they may be unavailable or become intermittently available. Sensors present and access data in proprietary ways. For example, after developing access to a sensor for a location finding service, the developer typically cannot re-use it for another system with a different location finding service.

2) Modifying applications according to sensory information would be complex, if possible at all. Developers would be required to build complex analysis into the application in order to use the sensory information. This analysis has no re-use, as it is performed per application. For example, longitude and latitude parameters do not allow the developer to determine if the user is at the office or at a customer site; only after analysis can this information be determined.

3) Modifying the application to match the user's requirements would entail an intricate task. While the analysis could be expected to discover much about the user's activity, actual application behavior would not be expected to be simple to

deduce. For example, some users may need sales information after a meeting with a customer, while others require technical data.

In the prior art, there have been several methods and systems that have considered the issue of context, but only in a cursory manner.

For example, U.S. Patent No. 5,642,303 to Small, et al. discloses a beacon based system for use particularly with specific personal digital assistants (PDAs), such as the Apple® Newton®. Beacons and a sensor attached to the PDA determine the user location, and, when information, such as event locations, is linked to particular information, this information may be provided to the user in a useful manner.

U.S. Patent No. 6,177,905 B1 to Welch provides a location-triggered reminder method and system for PDA users. With the invention of Welch, the user is able to associate reminders with particular locations, and, with location sensitive input, such as global positioning system (GPS) location information linked to the input, a reminder or other information is generatable for the user upon reaching each particular location.

U.S. Patent No. 5,664,133 to Malamud et al. provides a computer resource context information provider. The system facilitates control of resources, such as printers and servers, by providing context sensitive pop up menus for each resource. The menus vary by the resource specific environment.

U.S. Patent No. 5,910,799 to Carpenter, et al., discloses a location motion sensitive user interface. The device of Carpenter, et al., includes an interface environment that provides and/or prevents access to applications based on the location of the user (e.g., prevents user access in unsecured locations). As the user moves, the interface changes.

Pending U.S. Patent Application S.N. 09/825,159 to Abbott, et al., includes disclosure of methods and devices for modeling and using themes and theme-related information, representing various types of contextual aspects or situations, including a wearable computer and inputting and sensing devices used to determine the user state, the user's computing device, the surrounding physical environment, and/or the current cyber-environment.

However, none of the prior art discloses or suggests a broadly applicable interface that is dynamically context sensitive based on a wide variety of user needs and multiple context inputs. There remains an unmet need to provide applications aware of the contextual setting of the user (Context Aware Applications), and methods and systems for implementing and using such applications.

Related Art

U.S. Patent No. 5,470,233 to Fruchterman, et al.

U.S. Patent No. 5,570,100 to Grube, et al.

U.S. Patent No. 5,642,303 to Small, et al.

U.S. Patent No. 5,664,133 to Malamud, et al.

U.S. Patent No. 5,699,244 to Clark, Jr., et al.

U.S. Patent No. 5,732,074 to Spaur, et al.

U.S. Patent No. 5,790,974 to Tognazzini

U.S. Patent No. 5,910,799 to Carpenter, et al.

U.S. Patent No. 5,938,721 to Dussell, et al.

U.S. Patent No. 6,040,781 to Murray

U.S. Patent No. 6,052,563 to Macko

U.S. Patent No. 6,078,314 to Ahn

U.S. Patent No. 6,085,148 to Jamison, et al.

U.S. Patent No. 6,133,853 to Obradovich, et al.

U.S. Patent No. 6,148,261 to Obradovich, et al.

U.S. Patent No. 6,163,274 to Lindgren

U.S. Patent No. 6,177,905 to Welch

SUMMARY OF THE INVENTION

The present invention includes a method and system for providing context information, systems, and actions for a wide range of information technology platforms and interfaces. In embodiments of the present invention, "context" includes the aggregate knowledge about a user's situation and intent, which a

software application or other method and/or system can apply, among other factors, to optimize the effectiveness of the application. Sources of information for determining Context include static sources, such as user roles, user responsibilities, and user preferences, as well as dynamic sources, such as the user's location, user's direction of travel, device being used, calendar, the user's presence or absence at a location, the user's flight or other travel information, the application being used, the network involved, and other impacts on the user, such as determinable impacts on the user's location and direction of travel, such as traffic and weather.

Context is one essential factor in improving computing in general, and mobile computing in particular. Understanding the Context of the user -- business and personal -- facilitates the creation and deployment of intelligent mobile applications that are more effective, efficient, and easier to use. The Context information is usable to optimize both the information content and its presentation to the user in a manner that reduces the complexity of the human-machine interaction, while increasing information processing capabilities.

One advantage of the present invention is that it provides application developers with a development and runtime environment that enables applications to take into account changes in the settings the user is experiencing. This results in more streamlined applications, with minimal required user interaction, increasing the usability and the user-adoption of applications in general, and mobile applications in particular. These applications are herein referred to as "context-aware applications."

An embodiment of the present invention includes tiers of features for enabling Context awareness. In an embodiment of the present invention, the tiers include a collection tier, an analysis tier, and an action/effect tier.

The Context Collection Tier provides the developer with simple access to Context Parameters (Context raw data) by way of sensors. In an embodiment of the present invention, this tier masks the complexity of collecting Context Parameters and using sensors, incorporating data availability and how the data are accessed. Furthermore, new Context Sensors can be created and re-used, as long as they conform to the defined interface. In one embodiment, two core tasks are

included for the Collection Tier: 1) interfacing and collecting information from various sources and services (e.g., the User's device); and 2) providing some extent of intelligence, by mediating between various context sources. In an embodiment of the present invention, this tier provides a uniform method for accessing Context Parameters within the Architecture, as well as outside of the Architecture.

The Context Analysis Tier provides the developer with Context States—meaningful information about the environment the user is experiencing. One objective of this tier is to "mirror" the settings and environment of the user, including applications applicable to or accessible by the user, in an analytical way and make information thereby produced or determined available for applications. An example Analysis Tier task is combining several context values to generate a more powerful understanding of the current situation. For instance, knowing the current location and current time, together with the user's calendar, the application is able to determine the user's current social situation, such as having a meeting, sitting in a class, or waiting in the airport. In an embodiment of the present invention, this tier provides a uniform method for accessing Context States within the Architecture, as well as outside of the Architecture.

The Context Actions/Effects Tier merges context states, user preferences, and application content to derive the objective and/or inferentially or otherwise determine the intent of the user, resulting in actions that modify the application. Actions are then applied, for example, to the presentation, navigation, or the application logic of an existing application, or even the launch of an external application. In an embodiment of the present invention, this tier provides a uniform method for accessing Context Actions/Effects within the Architecture, as well as outside of the Architecture.

In operation, in order to provide context information and services, as well as to perform many other functions, some input data is required and the overall context-related environment needs to be modeled. For example, for a user, the user's name, address, and other personal information is useful. In addition, the relationships between a user and other aspects of their environment, such as what meetings they are scheduled to attend or who is currently with them, is also

valuable in determining a particular user's situation and intent. In one embodiment of the present invention, the input data and the various relationships are provided to a "context engine" for processing. Since information relating to a user and the user's environment may reside in various sources (e.g., databases, airline reservation system, scheduling system), each component of hardware and/or software required to obtain the necessary information is located and placed in direct contact with the context engine or via other hardware or software components linked to the context engine. Each person, place, or thing that is determined to be useful in deriving contextual information is modeled within the current invention to form a network of components, each of which is referred to herein as an "entity." Entities include, for example, the user, each of the user's devices, any network with which the user is interfacing, along with many other items maintained within the context engine, such as other hardware components, and other discrete elements, such as each meeting or other event. This information is provided to the Context Engine via, for example, an interface to the network of locations for the information.

In embodiments of the present invention, the provision of information to the context engine is generally referred to as being provided by "sensors." Sensors include, for example, sensed data, such as location information received from a cellular telephone, as well as collected data, such as data obtained from an accessed database by an interface for the context engine.

Another aspect of the invention that allows interconnection and use of sensor data and other input is referred to as an "interpreter." An "interpreter" transforms, for example, sensed data into useful information for context. For example, an interpreter may use raw data from a cellular telephone to determine an address location for the cellular telephone, or for the user, if, for example, another interpreter interprets the user as having or likely having the cellular telephone in the user's possession.

Context Modeling

The context engine also maintains information relating to the entities and the relationships among entities, which may be constantly or periodically updated. In an embodiment of the present invention, relationships are referred to as "first class objects" (e.g., these objects are able to have associated features referred to as "states" and "properties"). "States" are provided for and relate to each entity or to a relationship among two or more entities.

For example, each of the following illustrates states of objects:

1) "Tim is busy" -- Tim is the entity and busy is a state of Tim;

2) "Tim is scheduled for Flight 1043" -- Tim is an entity, Flight 1043 is an entity, and a relationship is created between Tim and the Flight; and

3) "Tim is late for Flight 1043" -- Tim is the entity, but the state of "late" is on the relationship between Tim and the Flight, not on the Tim entity.

The following provide a similar example:

1) "Tim has a 1:00 p.m. meeting";

2) "Tim has a 2:00 p.m. meeting";

3) Three entities (Tim, 1:00 p.m. meeting, 2:00 p.m. meeting);

4) Two relationships (Tim to 1:00 p.m. meeting, Tim to 2:00 p.m. meeting); and

5) "Tim is late for the 1:00 p.m. meeting" -- the relationship between Tim and the 1:00 p.m. meeting has the state of "late," not the Tim entity or the 1:00 p.m. meeting entity, because Tim is not late for the 2:00 p.m. meeting, and the 1:00 p.m. meeting is on time.

As exemplified above, three types of "relationships" exist in the context engine in an embodiment of the present invention. These relationships include the following: 1) the relationship of each entity to a state (e.g., Tim is busy); 2) the relationship that may exist between the two entities (e.g., Tim is scheduled for Flight 1043); and 3) the relationship of a state to the relationship between two entities (e.g., Tim is late for Flight 1043).

For the context engine to maintain and provide information or other services or actions relating to each of these components, a large amount of information relating to entities, states, and relationships must be identified and be

accessible for the context engine. In an embodiment of the present invention, some state information is obtained via interfacing software connected to each component in the system, and the state and relationship parameters are used by this interfacing software or other software that determines state and relationship information.

In the broadest application, the context engine of the present invention allows use of any set of entities, states, and relationships that may be input. The context engine is thus a raw engine (something like a "blank slate") for any such input entity, state, and relationship.

Context Packs

Another application of an embodiment of the present invention provides preset groups or sets of entities, states, and relationships (something like a "template") that are particularly useful for predetermined applications, such as a group of workers in corporate applications. These specific implementations of the present invention are referred to as "context packs." For example, a context pack may include as entities for input information, along with appropriate states and relationships, the following: users; cellular telephones for the users; office computers for the users; and meetings scheduled on a network for the users. Thus, particular entities, states, and relationships are predefined in context packs. Another feature of each context pack includes particularly defined sensors and interpreters for that pack.

Additional advantages and novel features of the invention are set forth in the attachments to this summary, and in part will become more apparent to those skilled in the art upon examination of the following or upon learning by practice of the invention.

BRIEF DESCRIPTION OF THE FIGURES

In the drawings:

FIG. 1 provides a representative block diagram of the Context Pack build on top of the Context Engine, in accordance with an embodiment of the present invention;

FIG. 2 illustrates factors and considerations involved in determining a user's need and intent, in accordance with an embodiment of the present invention;

FIG. 3 shows examples of the usage of context information, in accordance with embodiments of the present invention;

FIG. 4 illustrates some of the differences between customization, personalization, and context, as used in accordance with the present invention;

FIG. 5 shows examples of using 'Static Context' to determine relevant content and services/actions, in accordance with an embodiment of the present invention;

FIG. 6 presents an example of using 'dynamic context' factors and considerations involved therein to determine context and services/actions, in accordance with an embodiment of the present invention;

FIG. 7 is an example representative diagram of how wired and wireless portals can leverage the Context information to determine relevancy, in accordance with an embodiment of the present invention;

FIG. 8 provides a representative block diagram of the general operation of one embodiment of the present invention that produces context information that is usable to determine relevant information;

FIG. 9 presents a representative diagram of the Context Architecture, including three tiers of abstractions to simplify the developers' work in delivering Context Aware Applications, in accordance with an embodiment of the present invention;

FIGs. 10 and 11 present variations of context awareness maps for determining context aware information and producing context aware applications, in accordance with embodiments of the present invention;

FIG. 12 illustrates a representative diagram of how, by applying the various context states, the available information can be filtered into relevant information, in accordance with an embodiment of the present invention;

FIG. 13 presents an example UseCase Diagram of architecturally significant use cases, in accordance with an embodiment of the present invention;

FIG. 14 shows as Class diagram of a domain model, in accordance with an embodiment of the present invention;

FIG. 15 is a Collaboration diagram of an example context state domain model, in accordance with an embodiment of the present invention;

FIG. 16 contains a Class diagram of state hierarchy, in accordance with an embodiment of the present invention;

FIG. 17 is a Collaboration diagram of relationships of services functions, in accordance with an embodiment of the present invention;

FIG. 18 presents a Class diagram of entity service functions, in accordance with an embodiment of the present invention;

FIG. 19 contains a Class diagram of notification service functions, in accordance with an embodiment of the present invention;

FIG. 20 is a Class diagram of event hierarchy structure, in accordance with an embodiment of the present invention;

FIG. 21 presents a Class diagram of a JiniBean model for use in accordance with an embodiment of the present invention;

FIG. 22 contains a Statechart diagram of a JiniBean state model for use in accordance with an embodiment of the present invention;

FIG. 23 is a Class diagram of a SensorBean model for use in accordance with an embodiment of the present invention;

FIG. 24 provides a components diagram of context engine components, in accordance with an embodiment of the present invention;

FIG. 25 provides an Activity diagram for generating an example event for user being late for an appointment, in accordance with an embodiment of the present invention;

FIG. 26 is a flow diagram of the flow of information to and from the Context Pack, in accordance with an embodiment of the present invention;

FIG. 27 shows a representative diagram of how the functionality of various Context Packs can be layered for reuse (e.g., the Workgroup Context Pack utilizes functionality from the Basic Pack) to handle the information about the user, the

user's appointments, the user's location, and the appointments location, in accordance with an embodiment of the present invention;

FIG. 28 is a representative diagram of the high level external interfaces to the Context Pack system;

FIG. 29 contains a table of actors involved in the process for the diagram of FIG. 28;

FIG. 30 presents a representative diagram of the overall architectural structure of an embodiment of the present invention;

FIG. 31 shows a representative diagram of the technology for each component in the Context Pack for an embodiment of the present invention;

FIG. 32 is a representative block diagram of an example query service subsystem and its dependencies, in accordance with an embodiment of the present invention;

FIG. 33 provides a table of summary information relating to the query service subsystem, in accordance with an embodiment of the present invention;

FIG. 34 is a representative block diagram of the event service feature of the Context Pack, in accordance with an embodiment of the present invention;

FIG. 35 provides summary information for the ActivitySubscriber feature, in accordance with an embodiment of the present invention;

FIG. 36 contains a representative flow diagram of a method summary for Appointment Subscriber, in accordance with an embodiment of the present invention;

FIG. 37 provides a method summary table for the AvailabilitySubscriber feature, in accordance with an embodiment of the present invention;

FIG. 38 contains a table of field summary information for the TimeProximitySubscriber feature, in accordance with an embodiment of the present invention;

FIG. 39 contains a table of method summary information for the TimeProximitySubscriber feature, in accordance with an embodiment of the present invention;

FIG. 40 contains a representative block diagram of an interpreter subsystem, in accordance with an embodiment of the present invention;

FIG. 41 is a representative block diagram of an infrastructure subsystem, in accordance with an embodiment of the present invention;

FIG. 42 provides a representative block diagram of a sensor subsystem, in accordance with an embodiment of the present invention;

FIG. 43 presents a table of Topics and Queues for the messaging system for an embodiment of the present invention;

FIG. 44 presents a diagram of an example Context model used in a Context Pack, in accordance with an embodiment of the present invention;

FIG. 45 is a representative block diagram of a state model for use in accordance with an embodiment of the present invention;

FIG. 46 contains a flow diagram of an example distance proximity event, in accordance with an embodiment of the present invention;

FIG. 47 presents a flow diagram of an example time proximity event, in accordance with an embodiment of the present invention;

FIG. 48 is a representative ER diagram showing the database schema for an example Context Pack, in accordance with an embodiment of the present invention;

FIG. 49 shows a table of information for use in conjunction with the database schema of FIG. 48;

FIG. 50 is an example user proximity event activity, in accordance with an embodiment of the present invention;

FIG. 51 shows an example group proximity query, in accordance with an embodiment of the present invention;

FIG. 52 contains an example user location updating activity, in accordance with an embodiment of the present invention;

FIG. 53 is an example flow diagram for handling of sensor specified location in the Context Pack, in accordance with an embodiment of the present invention;

FIG. 54 shows an example flow diagram for location handling in the event service, in accordance with an embodiment of the present invention;

FIG. 55 contains an example flow diagram for location handling in the query service, in accordance with an embodiment of the present invention;

FIG. 56 is a representative block diagram of a runtime view, including processes, threads, and remote objects, in accordance with an embodiment of the present invention;

FIG. 57 presents a representative flow diagram of a deployment view, including JVM nodes with distributed objects model, a distributed objects model, and mapping of development jars to deployment jars, in accordance with an embodiment of the present invention; and

FIGs. 58 and 59 present context based information examples for a hand held device, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

The present invention includes a method and system for providing context information, systems, and actions for a wide range of information technology platforms and interfaces.

One advantage of the present invention is that it provides application developers with a development and runtime environment that enables applications to take into account changes in the settings the user is experiencing or the context of other individuals or machines that are relevant to them. With regard to machines, for example, the present invention is able to provide context information to other software programs, such as a portal display, and to provide context information to other machines, such as by providing an alarm system that automatically turns itself off when nobody is detected in a building after a certain hour. Another example is room thermostats that automatically adjust, depending on the number of people in the room or who is in the room (e.g., a baby). Thus, the present invention is also usable to optimize situations for users or machines.

These features of the present invention also result in more streamlined applications, with minimal required user interaction, increasing the usability and

the user-adoption of applications in general, and mobile applications in particular. These applications are herein referred to as "context-aware applications."

The present invention may be best understood by considering an illustrative example application, and by then considering various components of the present invention utilized to meet the features of the illustrated example.

In the illustrative example application, contextually appropriate information is to be provided to a user who has, for example, a hand-held device, such as a personal digital assistant (PDA), a cellular telephone, and a desktop PC located at the user's home, each of which is associated with the user. Among other functions, the present invention provides methods and systems for continually or intermittently transmitting information to and about the user in a manner consistent with the context of the information provided and the medium by which it is provided. For example, the present invention may remind the user via the user's hand-held device of the approach of a meeting, the reminder being formatted appropriately for the hand-held device, while a similar reminder provided to the user at the home computer is formatted quite differently. The present invention may also automatically provide the user with directions to the meeting based on the user's location, which is determined, for example, by locating the user via the location of the user's cellular telephone, and by using the location of the meeting, which is determined, for example, via input from a database containing the meeting location. The present invention may also determine the likelihood of the user been late to the meeting, and then inform each of the other meeting participants of the user's status in relation to the meeting (e.g., transmit to other users via their PDA's the fact that the user will be 5 minutes late).

In order to provide this example context-aware information and services, as well as to perform many other functions, information relating to the user, such as the user's name, address, and other personal information, as well as other user specific information, such as information in the user's contacts database, is provided to a "context engine" feature of the present invention. In addition, each component of hardware and/or software relating to the user is located and placed in contact with the context engine or other hardware or software components linked

to the context engine. Each element making up the network of components for the invention is referred to as an "entity." Entities include, for example, the user, each of the user's devices, any network with which the user is interfacing, and other items maintained within the context engine, such as other hardware components, and other discrete elements, such as each meeting or other event. This information is provided to a context engine feature of the present invention, such as by providing an interface via a network to locations for the information (e.g., databases on the user's PC or a connected server).

In embodiments of the present invention, the provision of information to the context engine is generally referred to as occurring via "sensors." Sensors include, for example, sensed data, such as location information received from a cellular telephone, as well as collected data, such as data obtained from an accessed database by an interface for the context engine. Appendix A illustrates some sensor examples for use in accordance with embodiments of the present invention.

Another aspect of the invention that allows interconnection and use of sensor data and other input is referred to as an "interpreter." An "interpreter" transforms, for example, sensed data into useful information for context. For example, an interpreter may use raw data from a cellular telephone to determine an address location for the cellular telephone, or for the user, if, for example, another interpreter interprets the user as having or likely having the cellular telephone in the user's possession.

Context Modeling

The context engine also maintains information relating to the entities and the relationships among entities, which may be constantly or periodically updated. In an embodiment of the present invention, relationships are referred to as "first class objects" (e.g., these objects are able to have associated features referred to as "states" and "properties"). "States" are provided for and relate to each entity or to a relationship among two or more entities.

For example, each of the following illustrates states of objects (see also FIG. 15 and accompanying text below):

1) "Tim is busy" -- Tim is the entity and busy is a state of Tim;

2) "Tim is scheduled for Flight 1043" -- Tim is an entity, Flight 1043 is an entity, and a relationship is created between Tim and the Flight; and

3) "Tim is late for Flight 1043" -- Tim is the entity, but the state of "late" is on the relationship between Tim and the Flight, not on the Tim entity.

The following provide a similar example:

1) "Tim has a 1:00 p.m. meeting";

2) "Tim has a 2:00 p.m. meeting";

3) Three entities (Tim, 1:00 p.m. meeting, 2:00 p.m. meeting);

4) Two relationships (Tim to 1:00 p.m. meeting, Tim to 2:00 p.m. meeting); and

5) "Tim is late for the 1:00 p.m. meeting" -- the relationship between Tim and the 1:00 p.m. meeting has the state of "late," not the Tim entity or the 1:00 p.m. meeting entity, because Tim is not late for the 2:00 p.m. meeting, and the 1:00 p.m. meeting is on time.

As exemplified above, three types of "relationships" exist in the context engine in an embodiment of the present invention. These relationships include the following: 1) the relationship of each entity to a state (e.g., Tim is busy); 2) the relationship that may exist between the two entities (e.g., Tim is scheduled for Flight 1043); and 3) the relationship of a state to the relationship between two entities (e.g., Tim is late for Flight 1043).

For the context engine to maintain and provide information or other services or actions relating to each of these components, a large amount of information relating to entities, states, and relationships must be identified and be accessible for the context engine. In an embodiment of the present invention, some state information is obtained via interfacing software connected to each component in the system, and the state and relationship parameters are used by this interfacing software or other software that determines state and relationship information.

Context Packs

In the broadest application, the context engine of the present invention allows use of any set of entities, states, and relationships that may be input. The context engine is thus a raw engine (something like a "blank slate") for any such input entity, state, and relationship.

Another application of an embodiment of the present invention, uses preset groups or sets of entities, states, and relationships (something like a "template") that are particularly useful for predetermined applications, such as a group of workers in corporate applications. These specific implementations of the present invention are referred to as "context packs," for which an example implementation is described further with respect to FIG. 1. FIG. 1 provides a representative block diagram of the Context Pack build on top of the Context Engine, in accordance with an embodiment of the present invention. As shown in FIG. 1, the Context Packs are usable by various applications to establish context aware applications.

These example Context Packs and their associated description are as follows:

1) Intelligent Synch/Prefetch - at device cradle sync, on demand, and upon detecting return to coverage, selectively sync/pre-fetch information that is relevant based upon the user's schedule, location and activity;

2) Workgroup - provides access to information about peer availability/presence, location, skills, and on-hand inventory;

3) Travel - provides alerts and menu options based upon time, schedule, location, and commercial content services (e.g., flight, traffic, weather);

4) Application - provides context options based on the specific usage of an application by sensing the application (including field specific context) and providing access to relevant menu options (across other applications and services) and triggering new filtering parameters for Alerts;

5) Presentation - optimizes content delivery based on user activity (e.g., driving), location (e.g., customer site), device, and network characteristics;

6) Communications - manages the preferred communication options based on presence, work status and preferences of user;

7) Location/Proximity Services - Identifies physical locations, services, or devices based on user's location, commercial content services (e.g., maps, directions, locator guides), and schedule; and

8) Workflow - provides menu options based on specific alert generation requirements and application (workflow) context.

These example Context Packs may include as entities for input information, along with appropriate states and relationships, the following: users; cellular telephones for the users; office computers for the users; and meetings scheduled on a network for the users. Thus, particular entities, states, and relationships are predefined in context packs for use by the users. Another feature of each context pack includes particularly defined sensors and interpreters for that pack.

Various features of the present invention will now be discussed in greater detail.

A. What is Context?

Context is one essential factor in improving computer applications in general, and mobile applications in particular. Understanding both the context of the user and any other object, such as mobile devices, facilitates the creation and deployment of intelligent mobile applications that are more effective, efficient, and easier to use. The present invention enables applications to use context to optimize both the information content and its presentation to the user in a manner that reduces the complexity of the human-machine interaction, while increasing information processing capabilities.

Before defining context, as used herein, it is important to define in more particularity the concept of "context-aware" applications, as used herein. When one looks at the dictionary definition of context, one generally finds a broad definition, such as the following: 1) the part of a text or statement that surrounds a particular word or passage and determines its meaning; or 2) the circumstances in which an event occurs; a setting.

Some academic definitions are as broad as the dictionary definition: "Context is any information that can be used to characterize the situation of an

entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and application themselves." See, e.g., Dey, A.K., et al., Toward a Better Understanding of Context and Context-Awareness, (1999), which is hereby incorporated by reference.

FIG. 2 presents examples of factors relating to context, in accordance with an embodiment of the present invention. These factors include both static factors and dynamic factors. Context, as used herein, can be generally described as the aggregate knowledge about the user's situation and intent, which a software application or other aspect of the method and system of the present invention applies to optimize the effectiveness of the application.

FIG. 3 shows an overview of factors involved in using context for methods and systems, in accordance with embodiments of the present invention. As indicated, context can be applied, among other factors, to determine relevant information, relevant actions/services, and relevant methods of delivery.

In addition, simpler manifestations of context exist: Customization and Personalization. In the case of Customization, the user is able to specify presentation preferences according to specific interests. In the case of Personalization, the application changes its behavior based on the user attributes, usage habits, and personal preferences.

While Personalization and Customization are common in many web applications in the prior art, a more detailed discussion of their place within Context, in accordance with the present invention, is appropriate to a full understanding of the present invention. Customization occurs when the user provides explicit information to the application, prior to application launch. This general application of Customization falls within a well-explored domain, in which Customization is recognized as an important ingredient in web applications. Personalization is a more complex entity that includes both explicit and implicit information regarding the user, usually on an on-going basis (e.g., accumulating historical user data). Personalization is targeted at learning more about an anonymous user (e.g., in e-commerce) in search of relevant information. In most

cases, the first interaction with the user occurs with complete ignorance of the personalization engine. As more user interactions take place, the personalization engine modifies the information sent to the user. This information can be stored for future interactions.

FIG. 4 illustrates some of the differences between customization, personalization, and context, as used in accordance with the present invention. The X Axis represents time, and the application-launch marks the time the user starts the application. The Y Axis represents the modifications the application makes in view of new context information (e.g., customization, personalization, and mobile context). Note that, in the case of context, the application is actually in constant change, adapting itself after the application was launched. In regard to customization and personalization, the application is relatively constant once launched. Another way to look at this is to consider an application that has been tailored to a particular user—this tailoring (customization and personalization) can be performed off-line before the application is launched. Imagine, as an example, the John Doe Sales Force Automation: customization and personalization would include an application that is tailored to John Doe, including his personal preferences and details. However, because it does not include context, this example application is not be able to consider changes in John Doe's environment, as these changes are not constant.

Personalization and customization are part of the context aware application concept; however, the context concept is wider and contains, in addition to the explicit and implicit information determined by the system as Customization and Personalization, information about the user's environment, such as the location of the user, the location of co-workers, the device type used, and the network bandwidth available.

As indicated above, FIG. 2 illustrates factors and considerations involved in determining a user's context, in accordance with an embodiment of the present invention. FIG. 5 shows examples of using 'Static Context' to determine relevant content and services/actions, in accordance with an embodiment of the present

invention. The user's dynamic context can be applied to determine relevancy, as described in FIG. 6.

Applications that use dynamic Context sources in addition static Context and user's preferences, increase significantly the ability to infer the user's need and intent, thereby allowing increase in the accuracy of relevancy. (See also FIG. 12 and accompanying text, below).

FIG. 7 is an example representative diagram of how portals can leverage Context information to better determine relevancy. As shown in FIG. 7, from available content and services/actions, an enterprise portal (as described further below), using application of context, can provide, for example, more relevant information, and the same is true for a wireless portal, such as a hand-held device (e.g., PDA or wireless telephone). Where the importance of presenting only the most relevant information is critical, the provision of more relevant information can be achieved by applying the user's context, as described in accordance with the present invention.

FIG. 8 provides a representative block diagram of the general operation of one embodiment of the present invention that produces relevant information that can be used by other applications to present, for example, relevant information and services.

Complexities Involved in Developing Context-Aware Applications

Developing Context Aware Applications is not an easy task. While the benefit is clear, the technology that supports context awareness and the complexity of the environment causes Context Aware Application development to be complex and cumbersome. In addition, no current architecture supports the reuse of complex applications from one environment to another. This has caused Context Aware Applications to be tailored to specific needs and environments.

Specifically, Context Awareness relies on the ability of Context Sensors to collect user and environment data (i.e., Context Parameters). The highly complex process of Context Awareness has no well-defined interface to access the Context

Parameters or the Sensors, and as a result exposes the developer to the high complexity of gathering this information.

The complexity does not end there; sensors tend to produce a large amount of data, frequently requiring further analysis to reveal the user's environment and actions. Again, this complexity is not masked from the developer, who must analyze the data and turn it into useful information.

Context Aware Applications are able to modify their behavior according to the information derived by sensors and the analysis. This is also not a simple task—knowing what the user is doing and understanding the experienced environment does not always easily translate into an effect that modifies the behavior of the application.

To summarize, three major problems prevent developers from making Context Aware Applications readily available:

1) Sensors are a complex system, distributed over physical and logical domains. Sensors are not constant in their existence; they may be unavailable or become intermittently available. Sensors present and access data in a proprietary way. For example, after developing access to a sensor for a location finding service, the developer cannot re-use it for another system with a different location finding service.

2) Modifying applications according to sensory information is complex, if possible at all. Developers must build complex analysis into the application in order to use the Sensory information. This analysis has no re-use as it is performed per application. For example, longitude and latitude parameters do not allow the developer to know if the user is at the office or at a customer site; only after analysis can this be achieved.

3) Modifying the application to match the user's requirements is an intricate task. While the analysis discovers much about the user's activity, actual application behavior is not simple to deduce. For example, some users may need sales information after a meeting with a customer while others require technical data.

The present invention addresses the above complexities by presenting a process and architecture for the development of a context aware system.

B. Process for Producing Context Aware Application

In accordance with these parameters, a general overview of a process for producing a context aware application will now be described, in accordance with embodiments of the present invention. In order to present a user's context (or entity's context), information must be gathered about the user's environment and activities. This information is distributed and cuts across many constituents (e.g., location, weather, traffic, network bandwidth). Analysis is made of the collected information in order to deduce a credible representation of the user's context (e.g., activity and environment). Actions are then applied to the application. These actions are designed to be in line with the user's intent – to create the total effect of easier and more accurate use of the application.

One feature of the present invention provides developers with a development and runtime environment that enables the application to recognize changes in the user's context. This feature results in more streamlined applications, with minimal required user interaction, which increases the usability and the user-adoption of applications.

Context Architecture. As discussed in greater detail below with regard to Context Engine Architecture below, the Context Architecture of the present invention provides developers with a complete set of services, enabling the development and deployment of context aware applications. The Architecture masks the complexity required to deliver context aware applications by providing context abstraction layers to the application developers. In embodiments of the present invention, as shown in FIG. 9, the Context Architecture includes three tiers of abstractions to simplify the developers' work in delivering Context Aware Applications. This enables more rapid context aware application development and delivery of re-usable context aware application components.

While the underlying architecture of the present invention provides a very flexible structure to support many of the requirements of Context Aware

Applications, most developers should be relieved from comprehending and developing according to that underlying architecture. The Context development paradigm of the present invention adopts the notion of supporting the division of labor between various types of developers.

As shown in FIG. 9, the three tiers utilized in accordance with embodiments of the present invention include the following.

The Context Collection Tier, in an embodiment of the present invention, provides the developer with simple access to Context Parameters by way of sensors. In an embodiment of the present invention, this tier masks the complexity of collecting Context Parameters and using sensors, incorporating data availability and how the data are accessed. Furthermore, new Context Sensors can be created and re-used, as long as they conform to the defined interface. In one embodiment, two core tasks are included for the Collection Tier: 1) interfacing and collecting information from various sources and services (e.g., for use by the User's device); and 2) providing some extent of intelligence, by mediating between various context sources. In an embodiment of the present invention, this tier provides a uniform method for accessing Context Parameters within the Architecture, as well as outside of the Architecture.

The Context Analysis Tier, in an embodiment of the present invention, provides the developer with Context States—meaningful information about the environment the user is experiencing. One objective of this tier is to "mirror" the settings and environment of the user in an analytical way and make it available for applications. An example Analysis Tier task is combining several context values to generate a more powerful understanding of the current situation. For instance, knowing the current location and current time, together with the user's calendar, the application is able to determine the user's current social situation, such as having a meeting, sitting in a class, or waiting in the airport. In an embodiment of the present invention, this tier provides a uniform method for accessing Context States within the Architecture, as well as outside of the Architecture.

The Context Actions/Effects Tier, in an embodiment of the present invention, merges context states, user preferences, and application content to derive

the objective of the user, resulting in actions that modify the application. Actions are then applied, for example, to the presentation, navigation, or the application logic of an existing application or even the launch of an external application. In an embodiment of the present invention, this tier provides a uniform method for accessing Context Actions/Effects within the Architecture, as well as outside of the Architecture.

Various other aspects of the features of context interpretation and analysis, which are designed to address these complex issues, in accordance with an embodiment of the present invention, will now be discussed in greater detail.

Mediation - In embodiments of the present invention, Context is sensed from different sensors, which may conflict with each other. For example, location can be sensed from several different sensors, such as the following: a geographical positioning system (GPS), Schedule (location of user's meeting), telephone carrier, and others (e.g., manual, the user using a desktop may allow deduction of the user's location – home, office). Logical features of the present invention, referred to in one embodiment as "Interpreters," are used with embodiments of the present invention to determine what is the highest probability for the 'User Location State' by, for example, analyzing the various location-related context sources.

Abstraction – In embodiments of the present invention, high-level states are determined from low-level parameters, usually by probing different sensory information and/or other information and determining high-level states by applying certain logic. For example, a high-level Context State can be 'User's Activity,' which is deduced by analyzing low-level parameters, such as Schedule, Location, and Presence.

Prediction – This feature, in accordance with embodiments of the present invention, predicts the User's 'Future Context.' The system of the present invention attempts to determine what the User's (or other Entity's) Context will be in the future, such as "Late for a meeting." By predicating future situations, the system is able to alert the user or act otherwise upon the predicted situation. For instance, the system is able to alert the user that the user should leave for a meeting by a certain time to avoid being late. In another example application, the System

predicates the future location of the user and alerts the user of traffic delays, provides directions, etc. One of the sources used for prediction is stored and/or analyzed information relating to the user's past context, referred to in embodiments of the present invention as the "Context History," as discussed further with regard to Past, Present and Future Context Information below.

The following discussion provides examples of how embodiments of the present invention address use of Past, Present and Future Context Information. One interesting way to look at Context-Information is to divide it into these three context-information types (Past, Present and Future Context Information), as follows:

Present Context Information – Information that describes the User's (or other Entity's) Present Context State.

Past Context Information (also referred to herein as "Context History") – Information that describes the Entity's Past Context State. To obtain more accurate results, the Interpreters of the present invention use 'Past-Context-Information' (History). For example, upon receiving conflicting information from two location sensors having the same accuracy, if the User is usually at a certain location at that time and day, the Interpreters determine that there is a better probability that the usual location is the right location. In addition, Past Context Information is substantially usable in the predictive use of the Context Engine.

Future Context Information – Information that describes what the system predicts will be the User's (or Entity's) Future State.

These features of the present invention are also usable with another aspect of the present invention, referred to in one embodiment as the user's "Privacy Policy" (Control). With this feature, users may elect to determine the type of Context Information the System is allowed to collect about them using the Past, Present, and Future definitions. For example, Users may set the Privacy Policy such that only Present Information may be collected by the System (and after 5 minutes this information is erased from the system, if not updated); or the system may be allowed to predict the user's future State (which typically is much more

invasive). Similarly, for Past Context-Information, users are able to select an option to 'turn-off' collection of context history information.

An embodiment of the present invention includes the paradigm of separation of Data Acquisition, Business Logic, and Presentation from the world of enterprise applications, and inclusion of these features in a Context Aware Application, as follows: 1) Data Acquisition is analogous to the Collection tier; 2) Business Logic corresponds to the Analysis Tier and the interpreters that derive Context States; and 3) Presentation is on par with Context Action/Effect. In an embodiment of the present invention, the development paradigm and architecture is the recommended approach for logically partitioning and constructing scalable applications required of business–critical deployments. One application model includes a clear separation of Context Driven Actions/Effects, Context Analysis, and Context Information Collection, which, among other advantages, promotes code reusability and provides significant cost savings and faster deployment over more traditional approaches.

FIGs. 10 and 11 present variations of context awareness maps for determining context aware information and producing context aware applications, in accordance with embodiments of the present invention. Various features of the present invention, as shown in FIGs. 10 and 11, include the following.

Context Actions/Effects - Context Actions/Effects, in an embodiment of the present invention, are the manifestation of the user environment and activity adaptation in the application. These Context Actions/Effects are executable at the presentation, logic, or navigation level.

As aforementioned, the usage of context varies in accordance with various features of the present invention. Following are several examples for how Context can be used in various paradigms, in accordance with embodiments of the present invention.

Context Aware Map Component. In this case the well-known map presentation includes more than one option for delivery of information to the user, and these features may be considered to provide additional dimensions for presentation made possible by the architecture of the present invention. The map is

representable, for example, as a graphical image, a set of directions to the next destination, or as a set of directions that are being read aloud. The following scenario illustrates how this map component functions, in accordance with embodiments of the present invention.

When the user is viewing, the next destination on the map is represented in the most intuitive way – graphical representation. When, for example, the user enters a vehicle and motion is detected, the graphical representation is replaced with directions with a large font size. As velocity increases, the map is represented as a set of the directions, but those are read aloud before any turn is needed.

Context Aware Navigation. Another manifestation of Context Awareness, in embodiments of the present invention, is the continual modification of the Navigational Model of the application. For example, an employee may be using a workflow engine with an approval cycle. As the employee is in the car with the boss, for example, the application does not require the employee to contact the boss for approval, as the boss's presence is sensed to be in the same car with the employee.

Yet another manifestation of context awareness includes modification of the application navigation. For example, if the user is presented with an option list that is part of the application, each option leads the user to a specific part of the application. Those options may be made irrelevant by the context state of the user (e.g., when the user is off work); some of the options may not be needed, as other options may be made possible instead.

Using Context to Determine Relevancy. Context Information can be very beneficial in systems that aim to provide users with Relevant Information, Relevant Actions, or Services and Relevant Method of Delivery. By applying the User's situation and Intent, the system of the present invention is able to infer what the user is interested in, or in some cases what the user is predicted to be interested in, and provide the user with relevant information. FIG. 12 illustrates how, by applying the various context states, the available information can be filtered into relevant information.

Context and Portals. Another factor involved in application of the present invention is the concept of enterprise portals. Portals are an example of a domain in which Context is usable to provide the User with Relevant Information and Services, in accordance with an embodiment of the present invention. Context can be highly used in Portals. For example, in existing applications, Portals can provide Relevant Information and Services based on static information, such as Identity or Role, or based on personalization. Portals facilitate people to process integration by exposing only those parts of multiple applications that users need in a consolidated interface. Among other advantages, portals make business applications more accessible to a wider audience of users by simplifying the number and type of application interfaces and the amount of training and maintenance needed to use them. Factors such as personalization, aggregation, and integration are important to portal concepts, and use of portals is generally appropriate when the capability to individually customize or personalize the user interface is important.

Additional advantages that result from use of portals include the following: 1) increased employee efficiency and productivity, since information is personalized and easier to find; employees can use fewer applications or sources to find information and complete tasks; 2) improved decision-making due to better access to more relevant information; 3) improved relationships with employees, partners, and customers via personalization and aggregation of information and services; 4) improved corporate communications to employees and among employees; and 5) increased revenue due to partners having better access to up-to-date product information and services.

In accordance with embodiments of the present invention, Context can be highly used in Portals. In existing applications, Portals can provide Relevant Information and Services based on static information, such as Identity or Role, or based on personalization. By applying the User's context, in accordance with embodiments of the present invention, Portals are able to provide the user with even more relevant information and services. In particular, in an embodiment of the present invention, Portals used with Context provide the User with information

and services that are relevant to the current situation of the user. Also note that such usage of context with portals represents situation context influencing another software application (e.g., the portal software) to affect the user experience in any environment in which the portal is accessed (e.g., mobile, desktop, or otherwise).

Context and Alert Engines. Another domain Context is usable with embodiments of the present invention is with a feature referred to as Alert Engines. Context can be applied to provide the user with relevant alerts, according to context states, or in other words, according to the situation and intent of the user, including, for example, information obtained regarding relevant method of Delivery, such as send Alert to the desktop PC if the user is currently active at the desktop, or send Alert to PDA or Telephone if the user is currently remote and available (e.g., based on the User situation and intent).

Context and Voice Engines. Another domain in which Context Information is usable with embodiments of the present invention is with a feature referred to as Voice Engines. Applying Context can improve the User Interaction with voice systems, for example, by reducing the amount of explicit information required from the user. For example, instead of using specific commands, such as "Show Directions from 7010 Gentle Shade Rd., Columbia, MD to 9101 Guilford Rd., Columbia, MD," where the likelihood for error is high, the user could reuse patterns, such as: "Show Directions to next Meeting," in which the System interprets such information as the user's intention by applying the User's Context States, the user current location, or the user's next meeting details. By using these short patterns, the likelihood for errors is significantly reduced, and the user is able to use short sentences/commands.

Context and Data Entry. In embodiments of the present invention, Context can be used to mask the complexity of entering data into devices, such as PDAs, telephones, and PCs. The System is able to pre-populate input fields or prompt the user for input based on such information as the User's Context (e.g., the user's situation and intent). For example, consider a service portion of the present invention that provides directions, and that prompts for the origin address and the destination address. To provide such information using a cellular telephone is

almost an impossible task. By using the User's context states, the System can pre-populate the screen with the origin information (e.g., the User's current location state), and what is likely to be the destination (e.g., the user's next event), and simply prompt the user to confirm this information. By applying the User's context states, the system is able to reduce significantly the interaction between the system and the user, while providing the user with the same results.

Context and Synchronization. Current mobile devices are low in memory, and furthermore, syncing over a wireless network can be almost an impossible mission, due, for example, to latency issues. To address this problem, embodiments of the present invention can be used by sync platforms to reduce the amount of information to be synced, thus reducing the sync time and volume. Using the context information sync platform can reduce the amount of information, enhance deduction of what is the relevant information, and increase the likelihood of determining of what is of interest to the user. To be able to determine what is relevant, or what is the user is interested in, the system applies the User's Context, including static and dynamic context, as well as Preferences – the user's pre-defined preferences; the user's preferences can, in addition, define how to apply the Static and Dynamic Context.

Context and Menus. Menus are included in common user interfaces used with almost any computer based device. A typical Menu includes a list of actions that a user can perform. Most of the Menus today are static (e.g., static list of actions), or based on the application state. In an embodiment of the present invention, Context can be used to provide users with more relevant actions in Menus. In this embodiment, actions are associated with the User's situation and intent (e.g., the User's context). For example, a user can be provided with different actions for the same menu based on current location.

Context and Machine-to-Machine. While many of the examples discussed above involve influencing the interaction of a system with a user, in accordance with embodiments of the present invention, context is also usable to influence the interaction among devices (e.g., machine to machine interaction or between applications and machines). For example, knowing the situation that an office

building is empty of people after a certain time can trigger the light system to shut down and the security system to be activated. Knowing that the number of people in a particular room of specified capacity can trigger a thermostat to adjust the temperature downward or trigger a capacity warning event if the room capacity is exceeded. Thus, context is usable to improve the effectiveness of devices in a similar fashion to improving the effectiveness of an actual user.

In an embodiment of the present invention, the Context Framework provides a flexible architecture, allowing for various implementations for use in building context aware applications. This framework supports the collection, analysis, and action tiers.

The Architecture and development paradigm discussed above may be implemented in many ways with many technologies, in accordance with the present invention. Regardless of the specific technologies selected, some assumption can be made with regard the characteristics of the implementation, such as the following: 1) Distributed Computing Environment (e.g., J2EE, Jini, .NET -- the use of industry standard XML interfaces for communication with third party application and context sources); 2) a flexible Query language to satisfy context awareness logic; and 3) a synchronous and asynchronous operation.

Building Framework Context-Components and employing the framework services, in accordance with embodiments of the present invention, will now be described in greater detail. The tier for these framework related features facilitates the collection of Context Parameters. Collection of Context Parameters may be a very complex task: the information is gathered from distributed machines, and, among other things, Context Parameters are diverse and the availability of these parameters is volatile. This tier masks the complexity of Context Parameters, their availability, and how they are being accessed. For example, in embodiments of the present invention, the developer is able to create new Context Sensors and re-use existing ones, as long as they conform to the framework-defined interface. The Analysis Tier provides an abstraction layer to the Developer by analyzing Context Parameters and presenting the result in a uniform way.

Low-level Context sensory information is difficult to address. To mask the complexity of low-level Context Parameters from the application developer, in an embodiment of the present invention, the Context Framework provides the Analysis tier, which enables the Developer to define multiple layers of abstractions above low-level Context Parameters. A Context State represents the result of the analysis on various Context Parameters and/or Context States. For example, the application developer is not likely to find the user's longitude/latitude useful; however, the fact that the user is at a customer site is very useful. Furthermore, the application may need to know if the user is driving, is late, etc.

The Analysis Tier of an embodiment of the present invention also enables the developer to re-use scenarios for various applications. When creating a new Context State, the developer may use Context Parameters, as well as other Context States.

In embodiments of the present invention, Context States provide various levels of abstraction. Some Context States provide higher abstraction than other Context States. For example, the location context state may be defined as follows: Location in the form of longitude/latitude and "at office" / "at home" / "at customer." Longitude/Latitude may be regarded as a lower abstraction than "at office" / "at home" / "at customer." In an embodiment of the present invention, the Developer indicates the level of abstraction of each Context State.

In an embodiment of the present invention, the Action Tier combines context states to derive the objective of the user, resulting in actions that modify the application. Actions are applied to the presentation, navigation, or the application logic of an existing application, or even to launch another application.

The Context Framework collects the Context information (e.g., Context States and Context Parameters) relative to an Entity. An Entity is a person, place, or any other object considered relevant to the interaction between a user and an application. In an embodiment of the present invention, the developer is able to obtain a list of existing Entities in the Context Framework.

In an embodiment of the present invention, the Developer is able to obtain a list of all available Context States in the Framework.

In an embodiment of the present invention, the Developer is able to obtain a list of all available Context States of a certain Entity, such as, for example, all Context States collected on the entity 'Sharon Agam.' In an embodiment of the present invention, the Developer is able to explicitly obtain the Context State of an Entity.

In an embodiment of the present invention, the Subscribe feature enables the application to be notified when change occurs; this may be used in lieu of the feature of embodiments of the present invention referred to as "Get Context State." In an embodiment of the present invention, this feature further masks the complexity of dealing with the often occurring changes of Context States. An embodiment of the present invention includes a feature referred to as "Get the Attributes," which obtains the attributes of an Entity's Context State, enabling the developer to obtain the attributes of a context state of an Entity.

In an embodiment of the present invention, the Developer is able to access Context Parameters; usually this is used to create new Context States.

Description of Context Engine Architecture

The Context Engine Architecture, in accordance with embodiments of the present invention, will now be discussed in greater detail.

FIG. 13 presents an example UseCase Diagram of architecturally significant use cases, in accordance with an embodiment of the present invention, which includes the following features, referred to herein as "actors" and "usecases."

Actor Context Consumer. This actor includes any component that requires either asynchronous notification of Context State change events or synchronous access to Context State Producers. In an embodiment of the present invention, the components of this actor are located either inside or outside of the system boundaries of the Mobile Context Engine (e.g., at a Wireless Application Client or an Interpreter, respectively).

Actor Context Producer. This actor is any component that generates or modifies a Context State. Typically, in embodiments of the present invention, this

actor asynchronously generates Context State change events due to changes to the application's environment, although this actor can also have synchronous request operations to enable point in time access to the Context States produced. In embodiments of the present invention, some of these producers interface with external services, which asynchronously or synchronously provide the raw data, or parameters, that are transformed into a Context State.

UseCase Add Context States to Catalog. In embodiments of the present invention, the Context Framework provides a catalog service that contains a list of all Context States (e.g., schedule, location, and motion). Upon initialization of the system of the present invention, Context Producers registers the Context States that they can generate with the catalog service. The service ensures that the list of states is unique.

UseCase Publish Context State Change. In embodiments of the present invention, upon generation of or update to a Context State, Context Producers deposits Context State into a repository for persistence. A notification service is informed of the change event and is passed the associated Context State, resulting in the broadcast of the change event to all requesting Consumers.

UseCase Register for Context State Change. In embodiments of the present invention, the Context Framework enables Context Consumers to request and receive notification upon the creation/update of specific Context States. The Consumers are able to access well-known services that provide the notification service. The Context Framework provides standard interfaces to register for and to process such Context related events.

UseCase Request Context State. In embodiments of the present invention, Context Consumers are able to synchronously request an update to a specific Context State from a Context Producer.

UseCase Retrieve Context States from Catalog. In embodiments of the present invention, Context Consumers are able to retrieve a list of valid states within the Context Engine. The states have an abstraction level associated with them, and the Consumer can request the states of a specific abstraction level, range of abstraction levels, or set of abstraction levels.

UseCase Update Context State. In embodiments of the present invention, the interface of Context Producers enables Consumers to request the update of a specific Context State.

FIGs. 14-24 contain logical block diagrams of various components of the present invention, reflecting, for example, software, such as Java programming, used to perform functions for these components.

FIG. 14 shows as Class diagram of a domain model, in accordance with an embodiment of the present invention. As shown in FIG. 14, the context domain model includes three main classes: Entity, State, and Relationship. This structure provides the flexibility necessary to represent a complex environment and its state, which is collectively referred to as 'Context State.'

FIG. 15 is a Collaboration diagram of an example context state domain model, in accordance with an embodiment of the present invention. As shown in FIG. 15, when modeling a context state, in accordance with an embodiment of the present invention, three types of relationships are represented to accurately depict a context state, as follows: 1) Entity has a state (e.g., Tim is Busy); 2) the relationship between two entities has a state (e.g., Tim is late for Flight 1043); and 3) an entity's state effects another entity that has a relationship to that entity (e.g., Tim's mobile telephone is at home). These three types of relationships can be combined in infinite ways to accurately represent the context state of an environment.

FIG. 16 contains a Class diagram of state hierarchy, in accordance with an embodiment of the present invention.

FIG. 17 is a Collaboration diagram of relationships of services functions, in accordance with an embodiment of the present invention. As shown in FIG. 17, the relationships between the components of the Context Engine at runtime are presented. Objects in shaded boxes represent components that are outside the scope of the Context Engine framework. The framework provides the specifications to allow plugin of these components into the engine.

FIG. 18 presents a Class diagram of entity service functions, in accordance with an embodiment of the present invention.

FIG. 19 contains a Class diagram of notification service functions, in accordance with an embodiment of the present invention.

FIG. 20 is a Class diagram of event hierarchy structure, in accordance with an embodiment of the present invention.

FIG. 21 presents a Class diagram of a JiniBean model for use in accordance with an embodiment of the present invention.

FIG. 22 contains a Statechart diagram of a JiniBean state model for use in accordance with an embodiment of the present invention.

FIG. 23 is a Class diagram of a SensorBean model for use in accordance with an embodiment of the present invention.

FIG. 24 provides a components diagram of context engine components, in accordance with an embodiment of the present invention.

Appendix B contains additional details of various program functions, in accordance with embodiments of the present invention.

Description of Example Context Pack Architecture

A more detailed description of an example Context Pack Architecture (also referred to herein as "Context Pack") will now be provided, in accordance with an embodiment of the present invention.

The Context Pack provides a framework to develop a context-aware application. In an embodiment of the present invention, the Context Pack provides access to a user's context that is affected by location, schedule, and state, and also allows management of the effect of the context of other users on the user's context. In an embodiment of the present invention, the Context Server provides the underlying Context framework, and the user's context is accessed through queries and events. The data needed to determine context is provided by external data sources through sensors. The Context Pack provides a framework to plug in various data sources into the sensors. The interpreters interpret the data and changes to a context are reported through subscribed events.

In an example application of the Context Pack, a user is subscribed to a late for appointment event. FIG. 25 provides an Activity diagram for generating an

example event for the user being late for an appointment, in accordance with an embodiment of the present invention. In FIG. 25, the following activities occur: 1) the user subscribes to the *Late for Appointment* event with the Context Pack; 2) the Context Pack registers with the Context Server to be notified of changes to the state of the relationship between the user and all appointments; 3) whenever the user location changes, Context Pack is notified, and the system updates the user location on the Context Server; 4) when an appointment is added, the Context Pack updates the information with the Context Server; 5) the Context Pack starts monitoring the appointment by obtaining the estimated time of arrival (ETA) and comparing the ETA with the appointment start time; 6) if the ETA is after appointment start time, Context Pack updates the state of the relationship between the user and that appointment to "Late"; and 7) the Context Server sends a notification to the Context Pack, which then forwards it to the user.

The example shown in FIG. 25 describes an example of how Context Pack uses external data sources and the Context server to determine the user's context and notify the user of any changes. The example is very simplistic in nature. In actual implementation, in accordance with an embodiment of the present invention, many more rules are applied before monitoring of appointments starts.

The example shown in FIG. 25 assumes that the user and an appointment entity are created in the Context Server. The Context Server provides a very basic framework to manage a context. The Context Pack isolates the complexities of the Context Server and provides a framework to build context-aware applications, based on users, location, schedule, traffic, and proximity, and the Context Pack determines availability and activity based the context.

In an embodiment of the present invention, the developer does not need to know the complicated graph representation of various entities, relationships, and states. Information is presented to the user in a very simplified manner. The Context Pack defines a Context Model that allows representation of a User's context related to location, schedule, traffic, and proximity.

In an embodiment of the present invention, one system purpose of the Context Pack is to sense change in user related data, interpret the data using user's

context, and present the data to the user on demand or by notification. FIG. 26 is a flow diagram of the flow of information to and from the Context Pack, in accordance with an embodiment of the present invention.

As shown in FIG. 26, data from various sources enters the Context Server through the Context Pack. The Client Applications then use the Context Pack to query data or receive notification of the data changes. The User Management Systems provide information about the users whose context is being managed and determined. The Device Inventory Systems provide information about the devices that the user owns (e.g., PDA, GPS, Cellular Telephone). The PIM Systems provide information about a user's schedule and optionally also provide additional information about the user. The PIM systems optionally also provide information about the Workgroups to which the user belongs.

In an embodiment of the present invention, Location Services provide a user's location information. The location information is generally tied to the location of the device that the user owns. Traffic and Route services provide directions and traffic information. These services provide the best possible route to a given destination and also estimate the travel time for the route. The service may also provide reports of incidents on the route. Geocoding services provide conversion between latitude/longitude location values to addresses or zip code. These services also provide reverse geocoding conversions.

In an embodiment of the present invention, Spatial Services provide functions for calculating proximity between two locations. Yellow Pages provide business locations (e.g., Restaurants, Shops). In an embodiment of the present invention, users are also able to provide information manually about their activity, availability, and location. The Client Applications, including the Alert Engine, query or subscribe for contextual data using the Context Pack. The Context Pack uses the Context Server services to obtain the required information and passes that instruction on to the client applications.

Overview of Context Pack

In an embodiment of the present invention, a Context Pack includes a set of subsystems that integrate with the Context Server to provide contextual information about particular data associated with the user. The basic data needed for determining a user's context includes the user's location and schedule. The location and schedule sensors provide data to the Context Server. The Interpreters interpret that data to determine the user's context. The Query and Event service provide access to the interpreter context. A different set of sensors, interpreters, model, query, and event services are provided for each set of functionality, be it, for example, location, schedule, ETA, workgroup, or availability. Each set of sensors, interpreters, query and event services forms a context pack. FIG. 27 shows a representative diagram of the Context Pack Layout, in accordance with an embodiment of the present invention.

As shown in FIG. 27, in an embodiment of the present invention, the Basic Pack handles the information about the user, the user's appointments, the user's location, and the appointments location. The Workgroup Pack handles information about users in a workgroup. Route (ETA) Pack handles route and direction information related to user traveling to an appointment or any other location. Proximity deals with information about the distance between users and location. Proximity also uses the Route (ETA) pack to determine time proximity. Activity Pack determines the user's and workgroup's activity. Availability pack determines user's and workgroup's availability.

FIG. 28 is a representative diagram of the high level external interfaces to the Context Pack system. The actors involved in the process for the diagram of FIG. 28 are provided in the table shown in FIG. 29.

The logical view of the static structure of the architecture in terms of its components, their interconnections, and the interfaces and operations offered by the components, in accordance with an embodiment of the present invention, will now be presented.

FIG. 30 presents a representative diagram of the overall architectural structure of an embodiment of the present invention. FIG. 30 shows a high level view of the Context Pack and its dependency to other systems and subsystems.

Each of the subsystems is explained in detail further below. Some important features of the architecture of an embodiment of the present invention include the following. In an embodiment of the present invention, the architecture is J2EE based. This architecture provides scalability and other advantages, as well as allowing portability across various J2EE application servers

In an embodiment of the present invention, JMS is used for communication among the sensors, infrastructure, and interpreters. Users are completely isolated from the Context Engine and model. The client application uses the query and the event service to access Context Information. Sensors use standard data format and JMS to update data into the context model.

FIG. 31 shows a representative diagram of the technology for each component in the Context Pack for an embodiment of the present invention.

In an embodiment of the present invention, the Client Application queries Context Pack data using the Query Service. The Query Services components are divided by the data that each query supports, as follows: 1) CoreQueryBean supports queries on the User, the user's location and appointment schedule (e.g., obtain a user's current location, obtain a user's current appointment, obtain a user's today's schedule); 2) ActivtyQueryBean supports queries on user's activity (e.g., is a user in a meeting?); 3) WorkgroupQueryBean supports queries on a workgroup (e.g., find all user's in Sales who are attending a meeting at a particular location); 4) ProximityQueryBean supports queries on a user's proximity to other users in the system or to a location (e.g., the location could be a location of an appointment or a business); and 5) AvailabilityQueryBean supports queries on user's availability; availability optionally is manually set by the user or is determined by the user's current activity (e.g., do not notify the user via telephone if the user is unavailable or in a meeting).

In an embodiment of the present invention, the QueryService depends on the Interpreters to interpret user's context (e.g., user's location could be provided by various devices). The Interpreter decides which location is the most accurate, or, if, for example, location is not available, uses the user's schedule for determining the user's most accurate location. This location is then used by the

Query Service to return a user's information. The QueryService also obtains proximity, activity, and availability information from the interpreter. For simple information, such as current appointment, the QueryService directly uses the Context Server to retrieve the information. The QueryService also uses external services, such as Geocoding Services, to convert location data (e.g., position is converted to an address).

FIG. 32 is a representative block diagram of an example query service subsystem and its dependencies, in accordance with an embodiment of the present invention. FIG. 33 provides a table of summary information relating to the query service subsystem, in accordance with an embodiment of the present invention. More detailed description of various components of the interface is provided in Appendix C. In an embodiment of the present invention, the interface is used by Client Applications to Query Context data.

In an embodiment of the present invention, client applications subscribe to receive Context Pack events using an event service. The Client application implements a ContextPackListener for each type of event and registers the Listener with the Event Service. The Event Service invokes a callback method on the Listener when an event occurs, thus notifying the client of the event. The Event Service components, in accordance with an embodiment of the present invention, include the following: 1) AppointmentSubscriber -- allows Client Applications to subscribe to Appointment changes (e.g., subscribe to a Late for Appointment event for a user); the application is notified when the user is late for any appointment; 2) ProximitySubscriber -- allows Client Applications to subscribe to proximity events; applications can subscribe to be notified when a user is located within or outside an area of a specified radius; 3) AvailabilitySubscriber -- allows Client Applications to subscribe to changes to User's availability (e.g., notify the application when a user is available for a meeting); 4) ActivitySubscriber -- allows Client Applications to subscribe to changes to User's activity (e.g., notify the application when the user is in a meeting).

In an embodiment of the present invention, the EventService uses the Context Servers Notification service to register for Context Events and converts

the events to appropriate notification callbacks to the Client Applications. A subscription by an application is converted to an equivalent registration on the Context Server Model (e.g., when an application subscribes to a Late for Appointment Event for a User, the Event Service registers changes to the state of relationship between a user and all appointments). In an embodiment of the present invention, the Event Service is notified when any change in the state occurs. The Event Service then gathers all the information related to the event (e.g., for appointment, it could be the appointment details, the traffic information for the route to the appointment.) The Event Service also depends on the Geocoding Service to convert position data.

FIG. 34 is a representative block diagram of the event service feature of the Context Pack, in accordance with an embodiment of the present invention. Detailed description of the Event Service interfaces is provided below.

Various aspects of several event service features of the present invention are also described in greater detail in Appendix C.

The Interpreter Subsystem of an embodiment of the present invention will now be described in greater detail. In general, the interpreter subsystem interprets data that is entered into the Context Pack system. The interpreter, in accordance with an embodiment of the present invention, performs the following functions: 1) interprets data on demand, when QueryService requests information or the interpreter registers for changes (e.g., QueryService requests user's location); and 2) registers for changes to context data and interprets and updates context data when the data changes (e.g., Interpreter registers for changes to a user's location); when the user's location changes, the interpreter calculates the user's proximity to a registered location and then updates the proximity state.

In an embodiment of the present invention, the interpreter subsystem supports the following interpreters (note: the architecture provides for extensibility and new interpreters can be easily added):

Location Interpreter interprets user location. A user's location can be provided by more than one device (e.g., a GPS receiver, cellular telephone). The location interpreter determines the most accurate location, based on location rules.

If device location is unavailable, the interpreter uses the user's schedule to approximately determine user's location.

Appointment Interpreter interprets Late for Appointment state. The interpreter determines if the user is late for appointment by calculating the ETA at the appointment location, based on user's current location and the traffic conditions, and determines if the user can reach the appointment in time.

Route Interpreter interprets route information by monitoring route data and incident reports and applies them to appropriate entities.

Proximity Interpreter interprets proximity information. This interpreter registers to listen for user location changes and then recalculates the proximity state of a user with a specified location.

In an embodiment of the present invention, the interpreter subsystem uses the EntityBeanWrapper to communicate with the Context Server. Interpreter Bridge acts as a bridge between the interpreter and Notification service. FIG. 40 contains a representative block diagram of an interpreter subsystem, in accordance with an embodiment of the present invention.

In an embodiment of the present invention, the infrastructure subsystem provides the infrastructure for the following functions: 1) communicate with the Context Server; 2) schedule data requests; 3) receive and request data from the sensor; 4) register and receive events from the Context Server.

In an embodiment of the present invention, the infrastructure subsystem includes the following components.

Controller controls the data in the context pack. Controller manages the lifecycle of the data in the context subsystem (e.g., when a user is added into the system, the controller requests the sensors to provide appointment information for the user). The Interpreters register with the controller to receive notification on changes to context data.

Scheduler schedules jobs (e.g., the scheduler is used by the controller to schedule user location requests).

ModelUpdater receives data from the sensors, converts the data to Context Information, and updates the context server using the EntityServiceWrapper.

In an embodiment of the present invention, all the infrastructure components communicate with the sensors and interpreters through JMS Queues.

FIG. 41 is a representative block diagram of an infrastructure subsystem, in accordance with an embodiment of the present invention.

In an embodiment of the present invention, the sensor subsystem inputs data into the Context Pack. Sensors write data in specified format into the ModelUpdaterQueue. These sensors can include, for example, device data sources, such as cellular telephone locating devices or GPS devices, or other data sources, such as repositories of data (e.g., databases on PCs, minicomputers, microcomputers, or mainframe computers). The server, as well as other portions of the system, may include or be located on processors, such as PCs, minicomputers, microcomputers, or mainframe computers. The sensors and server and/or other components may be coupled, using, for example, wired, wireless, or fiber optic links, and may be coupled via networks, such as the Internet or telephone networks.

In an embodiment of the present invention, Sensors are of three types: 1) synchronous sensors provide data when requested; 2) passive asynchronous sensors periodically push data into the Context Pack system; 3) active asynchronous sensors periodically push data into the Context Pack system. The Context Pack can also control the asynchronous data by subscribing and unsubscribing to the data.

FIG. 42 provides a representative block diagram of a sensor subsystem, in accordance with an embodiment of the present invention. As shown in FIG. 42, synchronous sensors listen to their respective topics for data requests from the controller. To update data, the sensors convert the data to the defined Context Pack format and send the data to the Model Updater Queue.

In an embodiment of the present invention, the Sync Location Sensor provides location information on request. Appointment sensor provides appointment location on request. A Route Sensor provides route information on request. An Async Location sensor pushes location data into the context pack

periodically or when the a user's location is updated. A User/Device sensor provides user and user device information on to the Context Pack.

In an embodiment of the present invention, sensors provide data in the form of XML. The Context Pack defines the XML DTD for location, appointment, route, and traffic information.

In an embodiment of the present invention, the Messaging System (Data Bus) is a JMS based system. The Messaging System acts as the conduit for data transfer between the sensors and interpreters to the Context Pack data model. The asynchronous nature of the messaging system allows the Context Pack to manage data handling without blocking or slowing down the clients that generate the data. The messaging system of an embodiment of the present invention includes the Topics and Queues shown in the table contained in FIG. 43.

In an embodiment of the present invention, a spatial service provides spatial functions, which allow efficient storage of location information, and provides useful APIs to perform proximity and other spatial operations.

In an embodiment of the present invention, a geocoding service provides conversion of position (e.g., latitude, longitude) location data to one or more addresses, and vice versa.

FIG. 44 presents a diagram of an example Context model used in a Context Pack, in accordance with an embodiment of the present invention. The context model is the representation of the context pack data on the Context Server. The state model describes the hierarchy of the states used in the context model.

FIG. 45 is a representative block diagram of a state model for use in accordance with an embodiment of the present invention.

FIG. 46 contains a flow diagram of an example distance proximity event, in accordance with an embodiment of the present invention. The example of FIG. 46 shows how the proximity of 5 miles for the separation of user1, user2, and user3 is handled.

FIG. 47 presents a flow diagram of an example time proximity event, in accordance with an embodiment of the present invention. The example of FIG. 47

shows how the proximity of 15 minutes for the separation of user1, user2, and user3 is handled.

FIG. 48 is a representative ER diagram showing the database or other repository schema for an example Context Pack, in accordance with an embodiment of the present invention. FIG. 49 shows a table of information for use in conjunction with the database schema of FIG. 48.

FIGs. 50-52 present flow diagrams of example context events, in accordance with embodiments of the present invention. FIG. 50 is an example user proximity event activity, in accordance with an embodiment of the present invention. FIG. 51 shows an example group proximity query, in accordance with an embodiment of the present invention. FIG. 52 contains an example user location updating activity, in accordance with an embodiment of the present invention.

FIGs. 53-54 present flow diagrams of example rule applications for location events, in accordance with embodiments of the present invention. FIG. 53 is an example flow diagram for handling of sensor specified location in the Context Pack, in accordance with an embodiment of the present invention. FIG. 54 shows an example flow diagram for location handling in the event service, in accordance with an embodiment of the present invention. FIG. 55 contains an example flow diagram for location handling in the query service, in accordance with an embodiment of the present invention.

FIG. 56 is a representative block diagram of a runtime view, including processes, threads, and remote objects, in accordance with an embodiment of the present invention.

FIG. 57 presents a representative flow diagram of a deployment view, including JVM nodes for a distributed objects model, a distributed objects model, and mapping of development jars to deployment jars, in accordance with an embodiment of the present invention.

The Context Pack can be deployed in many different ways, as it confirms to the J2EE 1.2 specification. The diagram shown in FIG. 57 displays one of the configurations. A simple configuration would be to bundle all the Enterprise Java

Beans into one .ear file and deploy it to a J2EE server. A cluster of J2EE Servers can provide Load Balancing and fail over.

It is thus clear that, in embodiments of the present invention, the architecture provides a clean interface to the user to query and subscribe to contextual data. Among other advantages, the architecture hides the developer from the underlying complexities of understanding context and presents the information in a simple data format. Extension points are provided so that developers can add new interpreters as needed, and sensors are completely isolated from the system.

In one embodiment of the present invention, the architecture uses the well-defined and popular J2EE framework. This provides a familiar and well-known technology as the basis for Context Aware application development. As the code conforms to J2EE 1.2 specifications, Context Aware applications can be developed and deployed on any of the many application servers that confirm to the J2EE 1.2 specification.

FIGs. 58 and 59 present context based information examples for a hand held device, in accordance with an embodiment of the present invention. In particular, in the example shown in FIGs. 58 and 59, a comparison is presented between a portal (FIG. 58) and a portal leveraging context information to determine relevant information for the user (FIG. 59).

Example embodiments of the present invention have now been described in accordance with the above advantages. It will be appreciated that these examples are merely illustrative of the invention. Many variations and modifications will be apparent to those skilled in the art.

Appendix A

Item			Description
User Profile			User Profile aggregates the personal information that is available on the user.
	Personal Profile		Home address, office location, Email address, available mobile devices for the user
	Role		Sales person, Analyst, Manager
	Workgroup		North America Sales, Engineering
Preferences			Preferences are where the user stores his specific preferences e.g., use large fonts etc.
	Presentational		Presentational specifies preferences that manipulate the layout of the information presented to the user (myahoo.com type customization).
	Informational		Informational specifies the preferences that manipulte the data that is given to the user (do not show my stock quotes at all).
Platform			Platform is where information about the device is extracted and stored.
	Host Characteristics		This is where the information about the device are extracted and stored.
		Device type	e.g., Palm III
		OS	e.g., Palm OS v3.5
		CPU	e.g., DragonBall
	Host Available Resources		
		CPU Load	e.g., CPU load is 78%
		Memory	e.g., Memory usages is 67%
		Power (Battery, powerline)	e.g., power line is in use, e.g., 10 minutes left on battery
		Input properties	e.g., touch screen
		Output properties	e.g., color screen
		Presentation	e.g., HTML browser
		Available Applications	e.g., A Client is installed
		Context Sensors	e.g., User heart rate sensor is available

Item			Description
Network			Network extracts and stores the characteristics of the network.
	Network QoS		Current QoS profile of the network
		Bandwidth	
		Latency	
		More QoS params.	
	Network Cost		Cost of the various features of the network. E.g., each alert message is $.25
	Network Coverage		A representation of the areas for which there is wireless data coverage.
Spatial			Spatial stores the information regarding location and physical positioning of the user.
	Position		
		Long/Lat	
		Street/City/State/Zip/Country	
	Elevation		e.g., 10,000 ft.
	Velocity		e.g., 45 MPH
	Orientation		e.g., Northwest (315 degrees)
Temporal			Stores the information regarding time.
	Year,Month,Date		
	Time of Day		
	Time Zone		
	Season		
	Moon State		
Environmental			Extracts and stores the information regarding the physical environment the user is experiencing.
	Weather		e.g., rain, e.g., fog, e.g., snow
	Air Quality		e.g., polluted
	Light		e.g., 40% light
Presence			Presence makes available the current constituents that are

Item			Description
			present. The constituents are defined in a user or a company profile.
	Constituents' Presence		E.g., similar to an application such as Yahoo Messenger (Yifat is online)
Proximate Constituents			In addition to presence, the proximity of constituents is stored here.
	Accessible Constituents		E.g., Free time. The accessible user may be busy or not.

Item			Description
Proximate Resources			This is where available resources are discovered/stored for the use of the application. E.g., Printers, screens.
PIM			Personal Information Manager entries are extracted and stored.
	Schedule		
	Tasks		
	Contacts		
	Reminders		
Route Information			This parameter is responsible for providing the time it will take to reach the next destination (usually specified in the PIM schedule).
	Time to Next Destination		
Physiological			
	Blood Pressure		
	Heart rate		
	Muscle Activity		

Appendix B

Class: BeanException

package: net.unwex.platform.activation.bean

Direct Known Subclasses: FatalException, UnavailableException

public abstract class BeanException

Extends: java.lang.RuntimeException

Defines an abstract runtime exception.

Class: FatalException

package: net.unwex.platform.activation.bean

public class FatalException

Extends: net.unwex.platform.activation.bean.BeanException

Defines an exception that a bean throws to indicate that it is permanently unavailable and must be destroyed.

When a bean is permanently unavailable and needs to be destroyed, something is severely wrong with the bean and no administrative action can be taken to correct it. A bean should log the error and any other details necessary to prevent a similar situation from reoccurring.

Class: UnavailableException

package: net.unwex.platform.activation.bean

public class UnavailableException

Extends: net.unwex.platform.activation.bean.BeanException

Defines an exception that a bean throws to indicate that it is permanently or temporarily unavailable.

When a bean is permanently unavailable, something is wrong with the bean, and it cannot operate until some action is taken. For example, the bean might

be configured incorrectly. A bean should log both the error and the corrective action that is needed.

A bean is temporarily unavailable if it cannot operate momentarily due to some system-wide problem. For example, a third-tier server might not be accessible, or there may be insufficient memory or disk storage to operate. A system administrator may need to take corrective action.

Interface: JiniBean

package: net.unwex.platform.activation.bean.jini

public interface JiniBean

Interface: JiniBeanAdmin

package: net.unwex.platform.activation.bean.jini

public interface JiniBeanAdmin

Interface: JiniBeanContainer

package: net.unwex.platform.activation.bean.jini

public interface JiniBeanContainer

Interface: Entity

package: net.unwex.platform.context

public interface Entity

The Entity class represents any person, place, or thing that the context engine monitors for state changes.

Class: EntityKey

package: net.unwex.platform.context

public final class EntityKey

Implements: java.io.Serializable

This class uniquely identifies an Entity

Interface: EntityService

package: net.unwex.platform.context

public interface EntityService

This is a JINI service that is the front-end to the Context Engine's persistence mechanism for Entities, Relationships, and State. It can be accessed by clients via a remote interface for the purpose of CRUD. Some of the significant functions of this service are the passing of events to the Notification Service and the handling of rollbacks for aborted transaction based updates.

Class: EnumerationState

package: net.unwex.platform.context

public abstract class EnumerationState

Extends: net.unwex.platform.context.SingleValueState

This class represents a State that has a finite set of defined state values.

Interface: Lease

package: net.unwex.platform.context

public interface Lease

A lease object that determines the life cycle of an object in the entity service.

Interface: Relationship

package: net.unwex.platform.context

public interface Relationship

The Relationship interface represents an association between two Entities. Just like in the real world, the relationship between entities can have states. For example, the statement "John is late for Flight 1043" shows that the two entities, John and Flight 1043, have a relationship. In this example, the State 'late' would be on the Relationship between John and Flight 1043. Relationships are either a parent/child association between two entities or merely a familiarity between the two. In addition, a Relationship can be of one or several types. The type of Relationship aids in identifying how two entities are associated (e.g., a User is scheduled for a Meeting).

Class: SingleValueState

package: net.unwex.platform.context

Direct Known Subclasses: EnumerationState

public abstract class SingleValueState

Extends: net.unwex.platform.context.State

This class represents a State that has a singular state value that has infinite possible values.

Class: State

package: net.unwex.platform.context

Direct Known Subclasses: SingleValueState

public abstract class State

Implements: java.io.Serializable

This class provides the contextual status information regarding an Entity or a Relationship between two Entities. The State only has one owner and is accessible through the owner's getState() methods, which return an Iterator. The State can be removed from its owner via the Iterator's remove() method, which will throw an UnsupportedOperationException if the State's owner is not locked.

Class: CatalogEntry

package: net.unwex.platform.context.catalog

public class CatalogEntry

Class: CatalogEntryLease

package: net.unwex.platform.context.catalog

public class CatalogEntryLease

Interface: CatalogService

package: net.unwex.platform.context.catalog

public interface CatalogService

CatalogService provides a central service for tracking the context states that are being published by the Context Engine. Each component that generates context states is responsible for registering the states it is tracking with this service. CatalogService may be used by administrators to determine which states are "live" in the Context Engine or might be used by clients to determine which states might be available before registering for state notification.

Class: EntityEvent

package: net.unwex.platform.context.event

public class EntityEvent

Extends: net.unwex.platform.context.event.Event

EntityEvent provides the event information associated with an Entity that is either created, changed or destroyed.

Class: Event

package: net.unwex.platform.context.event

Direct Known Subclasses: EntityEvent, RelationshipEvent, StateChangeEvent, StateEvent

public class Event

Implements: java.io.Serializable

Interface: NotificationListener

package: net.unwex.platform.context.event

public interface NotificationListener

Extends: java.rmi.Remote, java.io.Serializable

This remote interface is implemented by any context-aware client that wishes to receive notification of events from the Context Engine. The client passes a reference to the object that implements NotificationListener to the NotificationService, along with a description of the type of events it wishes to receive. NotificationListener represents the Observer role in the Observer pattern.

Interface: NotificationService

package: net.unwex.platform.context.event

public interface NotificationService

NotificationService is the central event registration service for the Context Engine. It is called by event producers (such as the EntityService) to make clients aware of changes in the domain model, and by observers in order to register to receive notification of such events.

This service, combined with the EntityService and NotificationListeners, represents a Mediator pattern implementation, in which the NotificationService acts as a ChangeManager.

Class: RegistrationPath

package: net.unwex.platform.context.event

public class RegistrationPath

Implements: java.io.Serializable

A representation of the chain of association between a root Entity or Relationship (that may represent a particular concrete object or a type template) and templates representing other objects in the model.

A Relationship or Entity is modeled by a RelationshipElement or an EntityElement that represents either a key (concrete) or a set of types (template).

RegistrationPaths are used when registering a listener for events. In order to be more specific about which types of sub-elements we are willing to receive events from, we add those element types to the path. Listeners are registered on the "generalized state" of a context object. That is, registration on a context object is tantamount to registration on all of the Entities, Relationships and their States that are reachable from that object by the matching strategy in use by the ContextMatcher. Typically, a path used for Registration will consist of a concrete root element (although the root may be a template) and one or more additional templates. There is no utility in specifying more than one concrete element (the root) in this type of path.

Examples:
Entity id="Mike" (all context relationships and states owned by Mike)

Entity id="Meeting1234"
State type="on_time" (is meeting on time?)

Entity id="Meeting1234"
Relationship type="attendee"
State type="on_time" (are all attendees on time?)

Entity id="Meeting1234"
Relationship type="attendee"
Entity type="person"
State type="location" (current location of all attendees)

RegistrationPaths can also be used when returning navigational information about the source of an Event to a registered listener during notification. Typically, this is not the same path as the path that was registered. The registered path may be a template, whereas the path sent during notification is concrete.

Path elements alternate between Entities (people, places, things) and Relationships (links between a source Entity and a target Entity), and may terminate with a State. Entities and Relationships can have State (hold State object references). Since State objects do not refer to other objects, they are the leaves of the context tree structure. If a State object is contained in a RegistrationPath, it must be the final object in the path.

If the root element is a RelationshipElement, the path can only contain an additional StateElement template. If the first element is an EntityElement, it can contain additional alternating RelationshipElement and EntityElement templates.

Class: RelationshipEvent

package: net.unwex.platform.context.event

public class RelationshipEvent

Extends: net.unwex.platform.context.event.Event

RelationshipEvent provides the event information associated with a Relationship that is either created, changed or destroyed.

Class: StateChangeEvent

package: net.unwex.platform.context.event

public class StateChangeEvent

Extends: net.unwex.platform.context.event.Event

Interface: Interpreter

package: net.unwex.platform.context.interpreter

public interface Interpreter

The Interpreter interface defines methods that clients use to interact with Interpreter services. The InterpreterClientProxy implements this interface. This interface provides methods for retrieving context state information from the Interpreter, for example.

Interface: InterpreterBean

package: net.unwex.platform.context.interpreter

public interface InterpreterBean

InterpreterBean extends both ContextBean and Interpreter interfaces and defines additional methods required by the InterpreterContainer to manage the life-cycle of a interpreter bean. Also, the InterpreterServerProxy intercepts client method invocations on the interpreter and redirects those calls to the interpreter bean via this interface.

Interface: InterpreterBeanAdmin

package: net.unwex.platform.context.interpreter

public interface InterpreterBeanAdmin

InterpreterBeanAdmin extends the ContextBeanAdmin interface and provides additional administrative methods supported by interpreter beans. Different types of interpreter beans require an admin interface that extends InterpreterBeanAdmin. For example, a location interpreter bean may allow an administrator to configure which users the interpreter is monitoring.

Interface: InterpreterContainer

package: net.unwex.platform.context.interpreter

public interface InterpreterContainer

InterpreterContainer extends the Container interface and defines additional methods that a InterpreterBean (which runs inside the container) require of its container.

Interface: Sensor

package: net.unwex.platform.context.sensor

public interface Sensor

The Sensor interface defines methods that clients use to interact with Sensor services.

Interface: SensorBean

package: net.unwex.platform.context.sensor

public interface SensorBean

Interface: SensorBeanAdmin

package: net.unwex.platform.context.sensor

public interface SensorBeanAdmin

SensorBeanAdmin provides administrative methods supported by sensor beans. Different types of sensor beans require an admin interface that extends SensorBeanAdmin. For example, a location sensor bean may allow an administrator to configure which users the sensor is monitoring.

Interface: SensorContainer

package: net.unwex.platform.context.sensor

public interface SensorContainer

Subsystem Detail for Context Engine Components

Subsystem: CatalogServer

Dependency Links

to Subsystem ContextCore

Contained Elements

Component CatalogServer.jar

Stereotype: executable

Subsystem: Container

Dependency Links

to Subsystem ContextCore

Contained Elements

Component Container-dl.jar

Stereotype: downloadable

Component Container.jar

Stereotype: library

Subsystem: ContextCore

Contained Elements

Component ContextCore.jar

Stereotype: library

Subsystem: EntityServer

Dependency Links

to Subsystem ContextCore

Contained Elements

Component EntityServer-dl.jar

Stereotype: downloadable

Component EntityServer.jar

Stereotype: executable

Subsystem: InterpreterContainer

Dependency Links

to Subsystem ContextCore

to Subsystem Container

Contained Elements

Component InterpreterServer.jar

Stereotype: executable

Subsystem: NotificationServer

Dependency Links

to Subsystem ContextCore

Contained Elements

Component NotificationServer.jar

Stereotype: executable

Subsystem: SensorContainer

Dependency Links

to Subsystem ContextCore

to Subsystem Container

Contained Elements

Component SensorServer.jar

Stereotype: executable

Appendix C

Abbreviations for Context Pack Architecture

CCP Core Context Pack (supports location and schedule only)

CP Context Pack

PIM Personal Information Manager (Exchange, Lotus)

ETA Estimated Time of Arrival

Query Interfaces

Interface: ActivityQuery

Method Summary

public String:

findActivityForUser(String userID, ActivityTemplate activityTemplate)

Find a user's activity specified by the Activity template

public User[]:

findUsersByActivity (UserTemplate userTemplate, ActivityTemplate activityTemplate)

Find all users who are/will perform the activity specified by the ActivityTemplate

Method Detail

findActivityForUser

public: String findActivityForUser(String userID, ActivityTemplate activityTemplate)

Find a user's activity specified by the Activity template

Parameter doc:

userID the user's Id

activityTemplate the Activity Template

Return doc:

the Activity

findUsersByActivity

public User[]: findUsersByActivity(UserTemplate userTemplate, ActivityTemplate activityTemplate)

Find all users who are/will perform the activity specified by the ActivityTemplate

Parameter doc:

userTemplate the user template

activityTemplate the Activity Template

Return doc:

an array of Users

Interface: AppointmentQuery

Field Summary

public final static int: ALL_USERS

All Users must be attendees of each appointment

public final static int: ANY_USER

Any of the specified user may be an attendee of each appointment

Method Summary

public Appointment[]: findAppointments (UserTemplate userTemplate, AppointmentTemplate appointmentTemplate, int userCondition)

Find all appointments for the users specified by the user template and filter the appointments based on the appointment template.

public User[]: findAttendees(AppointmentTemplate appointmentTemplate, int attendance)

Find all attendees for the appointments specified by the template.

Method Summary

public Appointment[]: findCurrentAppointment(String userID)

Find the current appointment for the user

public Appointment[]: findNextAppointment(String userId)

Find the next appointment for the user

public Appointment[]: findPreviousAppointment(String userID)

Find the previous appointment for the user

Field Detail

ALL_USERS

public final static int ALL_USERS = 0

All Users must be attendees of each appointment

ANY_USER

public final static int ANY_USER = 1

Any of the specified users may be an attendee of each appointment

Method Detail

findAppointments

public Appointment[] findAppointments(UserTemplate userTemplate, AppointmentTemplate appointmentTemplate, int userCondition)

Find all appointments for the users specified by the user template and filter the appointments based on the appointment template. The operation specifies an additional condition where any or all users are attendees of an appointment.

Parameter doc:

userTemplate the user template

appointmentTemplate the appointment template

userCondition ALL_USER or ANY_USER

Return doc:

An array of appointments

findAttendees

public User[] findAttendees(AppointmentTemplate appointmentTemplate, int attendance)

Find all attendees for the appointments specified by the template.

Parameter doc:

appointmentTemplate the Appointment Template

attendance ANY or appointment or ALL appointments

Return doc:

An array of Users

findCurrentAppointment

public Appointment[] findCurrentAppointment(String userID)

Find the current appointment for the user

Parameter doc:

userId the Id of the user

Return doc:

A list of appointments (Could be overlapping appointments)

findNextAppointment

public Appointment[] findNextAppointment(String userId)

Find the next appointment for the user

Parameter doc:

userId the Id of the user

Return doc:

A list of appointments (Could be overlapping appointments)

findPreviousAppointment

public Appointment[] findPreviousAppointment(String userID)

Find the previous appointment for the user

Parameter doc:

userId the Id of the user

Return doc:

A list of appointments (Could be overlapping appointments)

Interface: AvailabilityQuery

Method Summary

public User[]: findAvailableUsers(UserTemplate userTemplate, AvailabilityTemplate availabilityTemplate, Calendar time)

Find all users who satisfy the availability criteria.

Method Detail

findAvailableUsers

public User[] findAvailableUsers(UserTemplate userTemplate, AvailabilityTemplate availabilityTemplate, Calendar time)

Find all users who satisfy the availability criteria. The availability may be sometime in the future

Parameter doc:

time the time for which availability is queried. If null, the query applies to the current time.

userTemplate Filter criteria for the Users. If null then all users who satisfy the availability criteria are returned.

availabilityTemplate the availability criteria for selection

Return doc:

An array of Users

Interface: ProximityQuery

Method Summary

public float: findDistanceFrom (String userID, Location location)

Find the distance in meters between the user and a specified location

public User[]: findUsersWithinDistanceFromLocation (Location location, UserTemplate users, long distance)

Finds all the users within a specified distance of a location

public User[]: findUsersWithinDistanceFromUser (String userID, UserTemplate users, long distance)

Finds all the users within a specified distance of a user

Method Detail

findDistanceFrom

public float findDistanceFrom (String userID, Location location)

Find the distance in meters between the user and a specified location

Parameter doc:

userID the user

location the specified location

Return doc:

distance in meters

findUsersWithinDistanceFromLocation

public User[] findUsersWithinDistanceFromLocation(Location location, UserTemplate users, long distance)

Finds all the users within a specified distance of a location

Parameter doc:

users criteria for user selection. If null all the users within the distance are returned.

distance distance in meters

Return doc:

An array of users

findUsersWithinDistanceFromUser

public User[] findUsersWithinDistanceFromUser(String userID, UserTemplate users, long distance)

Finds all the users within a specified distance of a user

Parameter doc:

userID the user

users criteria for user selection. If null all the users within

the distance are returned.

distance distance in meters

Return doc:

An array of users

Interface: TimeProximityQuery

Method Summary

public long: findETA(String userID, Location destination)

Calculates the Estimated Travel Time between the user's location and the specified location

Method Detail

findETA

public long findETA(String userID, Location destination)

Calculates the Estimated Travel Time between the user's location and the specified location

Parameter doc:

userID the User

location the destination

Return doc:

Travel time in milliseconds

Interface: UserQuery

Method Summary

public User[]: findUser(UserTemplate user, Calendar time)

Find a user based on the criteria specified in the UserTemplate.

Method Detail

findUser

public User[] findUser(UserTemplate user, Calendar time)

Find a user based on the criteria specified in the UserTemplate. The time is used to lookup up users based on future locations (e.g., find all users at location IBM at 10.00 am tomorrow).

Parameter doc:

user UserTemplate that specifies the query criteria

time Time of the future location

Return doc:

List of users satisfying the Query

Event Service Features

public class: ActivitySubscriber -- provides an API to subscribe to asynchronously notifications when user's activity changes to certain activity or generally changes. FIG. 35 provides summary information for the ActivitySubscriber feature, in accordance with an embodiment of the present invention.

Method Detail

subscribeToUserActivity

public static ContextPackRemoteEventListener subscribeToUserActivity(String[] userID, ActivityTemplate filterTemplate, boolean recurring)

throws UserNotFoundException,
ApplicationException,
SystemException

Get asynchronously notifications when user's activity changes to certain activity(value) or generally changes

Parameters:

userID - An array contains User IDs

recurring - Defines whether the event will be fired once, or infinite number of times - until unsubscribe is called. Set false to get the event only once

filterTemplate - Description of Parameter

Returns: The returned object is a remote listener object that will process remote events, and will fire the event to the application if applicable. The returned object must be kept alive by the application, in order to keep the subscription alive. Keep alive means to keep a reference to this object from within the application. The remote listener also responsible to create a Context Pack Event object and populate it with all the information associated with this event.

Throws:

UserNotFoundException - A user with the provided User ID cannot be found

SystemException - Could be a result of not finding one of the services required to fulfill this task, or a low level exception thrown by one of the services

ApplicationException - Description of Exception

Class: AppointmentSubscriber

public class AppointmentSubscriber -- Provides an API to subscribe to obtain asynchronously notifications related to user's appointments schedule. The different types of subscriptions are: 1) event when an appointment property is changed, for a particular User; 2) event when an appointment property is changed, for a particular appointment; and 3) event when a particular User is evaluated as Late for an appointment.

The method summary for Appointment Subscriber, in accordance with an embodiment of the present invention, is provided in FIG. 36.

subscribeToAppointmentChanges

public static ContextPackRemoteEventListener subscribeToAppointmentChanges (String[] appointmentID)
throws AppointmentNotFoundException,
SystemException,
ApplicationException

Get asynchronously notifications when an Appointment changes

Parameters:

appointmentID - An array contains Appointment IDs

Returns: The returned object is a remote listener object that will process remote events, and will fire the event to the application if applicable. The returned object must be kept alive by the application, in order to keep the subscription alive. Keep alive means to keep a reference to this object from within the application. The remote listener also responsible to create a Context Pack Event object and populate it with all the information associated with this event.

Throws:

SystemException - Could be a result of not finding one of the services required to fulfill this task, or a low level exception thrown by one of the services

AppointmentNotFoundException - Description of Exception

ApplicationException - Description of Exception

subscribeToUserAppointmentChanges

public static ContextPackRemoteEventListener subscribeToUserAppointmentChanges (String[] userID, Calendar startTime, Calendar endTime)
throws UserNotFoundException,

ApplicationException,
SystemException

Get asynchronously notifications when an Appointment is changed for a User.

Parameters:

userID - An array contains User IDs.

startTime - The start/end time defines the interesting time window for the interesting appointments.

endTime - The start/end time defines the interesting time window for the interesting appointments.

Returns: The returned object is a remote listener object that will process remote events, and will fire the event to the application if applicable. The returned object must be kept alive by the application, in order to keep the subscription alive. Keep alive means to keep a reference to this object from within the application. The remote listener also responsible to create a Context Pack Event object and populate it with all the information associated with this event.

Throws:

UserNotFoundException - A user with the provided User ID cannot be found

SystemException - Could be a result of not finding one of the services required to fulfill this task, or a low level exception thrown by one of the services.

ApplicationException - An application exception.

subscribeToUserLateToAppointment

public static ContextPackRemoteEventListener
subscribeToUserLateToAppointment (String[] userID, String[] appointmentID)
throws UserNotFoundException,

ApplicationException,
SystemException

Get asynchronously notifications when a User is evaluated to be late for a meeting

Parameters:

userID - An array contains User IDs. At least one user should be defined.

appointmentID - An array contains Appointment IDs. If null, all appointments assumed. If not null, only the specified appointments will be monitored

Returns: The returned object is a remote listener object that will process remote events, and will fire the event to the application if applicable. The returned object must be kept alive by the application, in order to keep the subscription alive. Keep alive means to keep a reference to this object from within the application. The remote listener also responsible to create a Context Pack Event object and populate it with all the information associated with this event.

Throws:

UserNotFoundException - A user with the provided User ID cannot be found

SystemException - Could be a result of not finding one of the services required to fulfill this task, or a low level exception thrown by one of the services

ApplicationException - Description of Exception

Class: AvailabilitySubscriber

public class AvailabilitySubscriber -- provides an API to subscribe to get asynchronously notifications when user's availability changes to certain value or generally changes. FIG. 37 provides a method summary table for the

AvailabilitySubscriber feature, in accordance with an embodiment of the present invention.

subscribeToUserAvailability

public static ContextPackRemoteEventListener subscribeToUserAvailability (String[] userID, AvailabilityTemplate filterTemplate, boolean recurring)

throws UserNotFoundException,
ApplicationException,
SystemException

Get asynchronously notifications when user's availability changes to certain availability(value) or generally changes

Parameters:

userID - An array contains User IDs

recurring - Defines whether the event will be fired once, or infinite number of times - until unsubscribe is called. Set false to get the event only once

availabilityValue - If set to null that means that any change in the user's availability state will cause an event to be fired. If not null then the event will be fired only when the state is changed to this value.

Returns: The returned object is a remote listener object that will process remote events, and will fire the event to the application if applicable. The returned object must be kept alive by the application, in order to keep the subscription alive. Keep alive means to keep a reference to this object from within the application. The remote listener also responsible to create a Context Pack Event object and populate it with all the information associated with this event.

Throws:

UserNotFoundException - A user with the provided User ID cannot be found

SystemException - Could be a result of not finding one of the services required to fulfill this task, or a low level exception thrown by one of the services

Class: TimeProximitySubscriber

public class TimeProximitySubscriber -- provides an API to subscribe to get asynchronously notifications on the travel time between User(s) and User, or between User(s) and a Location. The event could be fired when - a) User(s) are WITHIN a travel time to location (or user); b) User(s) are OUTSIDE a travel time to location (or user); or c) User(s) state turned from WITHIN travel time to location (or user) to OUTSIDE travel time to location or vice versa. FIG. 38 contains a table of field summary information for the TimeProximitySubscriber feature, in accordance with an embodiment of the present invention. FIG. 39 contains a table of method summary information for the TimeProximitySubscriber feature, in accordance with an embodiment of the present invention.

ANY

public final static int ANY -- a subscription type that sets the event to be fired whenever the estimated travel time cross the line between the WITHIN travel time to the OUTSIDE travel time or vice versa.

OUTSIDE_REGION

public final static int OUTSIDE_REGION -- a subscription type that sets the event to be fired only when users are identified to be outside an estimated travel time from a Location (or user).

WITHIN_REGION

public final static int WITHIN_REGION -- a subscription type that sets the event to be fired only when users are identified to be within an estimated travel time from a Location (or user).

subscribeToTravelTimeProximityFromLocation

public static ContextPackRemoteEventListener subscribeToTravelTimeProximityFromLocation (String[] userID, Location location, int minutes, int changeType, boolean recurring)
throws UserNotFoundException, ApplicationException, SystemException

Get asynchronously notifications when user(s) travel time to Location match a criteria

Parameters:

minutes - The travel time that the application is interested in.

recurring - Defines whether the event will be fired once, or infinite number of times - until unsubscribe is called. Set false to get the event only once

changeType - the type of change that should cause the event to be fired.

userID - one or more users.

location - The location.

Returns:

Throws:

UserNotFoundException - A user with the provided User ID cannot be found

SystemException - Could be a result of not finding one of the services required to fulfill this task, or a low level exception thrown by one of the services

ApplicationException - Description of Exception

subscribeToTravelTimeProximityFromUser

public static ContextPackRemoteEventListener subscribeToTravelTimeProximityFromUser (String[] userID, String user, int minutes, int changeType, boolean recurring)

throws UserNotFoundException,
ApplicationException,
SystemException

Get asynchronously notifications when user(s) travel time to other User match a given criteria

Parameters:

minutes - The travel time that the application is interested in.

recurring - defines whether the event will be fired once, or infinite number of times - until unsubscribe is called. Set false to get the event only once.

changeType - The type of change that should cause the event to be fired.

userID - One or more users.

user - The user.

Returns:

Throws:

UserNotFoundException - A user with the provided User ID cannot be found

SystemException - Could be a result of not finding one of the services required to fulfill this task, or a low level exception thrown by one of the services

ApplicationException - Description of Exception

Data Functions

Data Request

The following dtd defines the format of a generic request that is sent by the controller to a sensor, in accordance with an embodiment of the present invention.

```
<?xml version="1.0" encoding= "iso-8859-1"?>
<!-- The request element -->
<!ELEMENT request (criteria)>
<!ATTLIST request
type (query | subscribe | unsubscribe) #REQUIRED
>
<!ELEMENT criteria (criterion*)>
<!ELEMENT criterion EMPTY>
<!ATTLIST criterion
type (name | value) #REQUIRED
>
```

Data Response

The following dtd defines the format of the data that is provided by a sensor, in accordance with an embodiment of the present invention. Specific data is embedded inside the response element.

```
<?xml version= "1.0" encoding= "iso-8859-1"?>
<!-- The response element -->
<!ELEMENT response ANY>
<!ATTLIST response
type (update | delete) #REQUIRED
>
```

Appointment Data Response

The following dtd defines the format of the data an Appointment sensor provides, in accordance with an embodiment of the present invention.

```
<?xml version="1.0" encoding="UTF-8"?>
<!ELEMENT appointment (title, location, last-update-time, start-time, end-time,
attendees)>
<!ATTLIST appointment
id CDATA #REQUIRED
>
<!ELEMENT appointments (appointment)>
<!ELEMENT attendees (attendee)>
<!ELEMENT attendee (user-id, invite-type)>
<!ELEMENT end-time (#PCDATA)>
<!ELEMENT invite-type (#PCDATA)>
<!ELEMENT last-update-time (#PCDATA)>
<!ELEMENT location (#PCDATA)>
<!ELEMENT start-time (#PCDATA)>
<!ELEMENT title (#PCDATA)>
<!ELEMENT user-id (#PCDATA)>
```

Location Response

The following dtd defines the format of data that a location sensor provides, in accordance with an embodiment of the present invention.

```
<!ENTITY % street-address-file SYSTEM "street-address.dtd">
%street-address-file;
<!-- The locations element -->
<!ELEMENT locations (location)*>
```

```
<!-- The location element -->
<!ELEMENT location (source-id, date-time, duration, (logical-location | street-address | postal-location | spatial-location))>
<!--
    The uniqe identifier for a wireless handset being located,
i.e., the source IP or the mobile ID.
-->
<!ELEMENT source-id (#PCDATA)>
<!-- The date-time stamp - either from the reading or created by the initial xslt -->
<!ELEMENT date-time (#PCDATA)>
<!-- The duration of the validity of the reading >
<!ELEMENT duration (#PCDATA)>
<!--
    Logical location indicates a landmark or name of a known boundary or
zone near or containing the geographic location.
>
<!ELEMENT logical-location (#PCDATA)>
<!--
The spatial location data set
-->
<!ELEMENT spatial-location (position, precision?, ground-speed?, track-angle?, magnetic-variation?, fix-quality?, direction?)>
<!--
The geopositional information
-->
<!ELEMENT position (latitude, longitude, elevation?, geoid-height?)>
```

<!ELEMENT latitude (#PCDATA)>

<!ELEMENT longitude (#PCDATA)>

<!-- The altitude of the object above sea-level -->

<!ELEMENT elevation (#PCDATA)>

<!-- The height of the object above ground level -->

<!ELEMENT geoid-height (#PCDATA)>

<!-- The precision (standard deviation) -->

<!ELEMENT precision (#PCDATA)>

<!-- The fix-quality: invalid | GPS | DGPS | estimated -->

<!ELEMENT fix-quality (#PCDATA)>

<!--The magnetic variation; degrees off magnetic north -->

<!ELEMENT magnetic-variation (#PCDATA)>

<!-- The track angle; angle source is facing off north -->

<!ELEMENT track-angle (#PCDATA)>

<!-- The speed (m/s) -->

<!ELEMENT ground-speed (#PCDATA)>

<!-- The direction -->

<!ELEMENT direction (#PCDATA)>

Route Request

The following dtd defines the format of data request made by the Controller to a Route Sensor, in accordance with an embodiment of the present invention.

<?xml version="1.0" encoding="UTF-8"?>

<!-- request for route information -->

<!ELEMENT request (route)>

<!-- route has an origin and a destination-->

<!ELEMENT route (origin-location, destination-location)>

<!-- route has a key which is internally generated -->

<!ATTLIST route

key CDATA #REQUIRED

>

<!-- the origin location of the route -->

<!ELEMENT origin-location (location)>

<!--route destination location of the route -->

<!ELEMENT destination-location (location)>

<!-- the location can be defined as a position or an address>

<!ELEMENT location (position | street-address)>

<!-- position is made up of a latitude and longitude-->

<!ELEMENT position (latitude, longitude)>

<!-- latitude value -->

<!ELEMENT latitude (#PCDATA)>

<!--longitude value-->

<!ELEMENT longitude (#PCDATA)>

<!ELEMENT street-address (line1, line2?, city, state-province, county?, postal-location)>

<!ELEMENT line1 (#PCDATA)>

<!ELEMENT line2 (#PCDATA)>

<!ELEMENT city (#PCDATA)>

<!ELEMENT state-province (#PCDATA)>

<!ELEMENT county (#PCDATA)>

<!--

The postal code and country

```
-->
<!ELEMENT postal-location (postal-code, country-code)>
<!ELEMENT postal-code (#PCDATA)>
<!ELEMENT country-code (#PCDATA)>
```

Route Response

The following dtd defines the format of the route information that a route sensor provides, in accordance with an embodiment of the present invention.

```
?xml version="1.0" encoding="iso-8859-1"?>
<!-- edited with XML Spy v3.5 NT (http://www.xmlspy.com) by dbhat (Unwired
Express) -->
<!-- The response element -->
<!ELEMENT response (route-info)>
<!ATTLIST response
type (update | delete) #REQUIRED
>
<!-- the route information -->
<!ELEMENT route-info (travel-time, distance, directions, source)>
<!-- the travel time for the route in hours, minutes -->
<!ELEMENT travel-time (hour, minute)>
<!-- hour value -->
<!ELEMENT hour (#PCDATA)>
<!-- minute value -->
<!ELEMENT minute (#PCDATA)>
<!-- distance of the route in meters -->
<!ELEMENT distance (meters)>
```

```
<!-- mile value -->
<!ELEMENT meters (#PCDATA)>
<!-- the directions for the route, consists of one or more segments-->
<!ELEMENT directions (segment)+>
<!-- segment consists of the distance of the segment, the average speed
    over this segment and the actual travel time. Static routing engines
   provide the default travel time-->
<!ELEMENT segment (description, distance, speed, travel-time)>
<!-- the internal (source specific id of the segment), may be used to refer back-->
<!ATTLIST segment
        id CDATA #REQUIRED
>
<!--description of the segment ( eg. name of the highway )-->
<!ELEMENT description (#PCDATA)>
<!-- speed in kph-->
<!ELEMENT speed (kilometer-per-hour)>
<!-- kph value -->
<!ELEMENT kilometer-per-hour (#PCDATA)>
<!-- the source of this information eg. SmartRoute, TrafficCast -->
<!ELEMENT source (#PCDATA)>
```

WHAT IS CLAIMED IS:

1. A method for providing context-relevant information, comprising:

collecting context specific information;

determining information needs relating to the context specific information collected; and

providing delivery information to a platform, wherein the delivery information is formatted based on the platform, the collected context specific information, and the determined information needs.

2. The method of Claim 1, wherein the platform includes an application interface.

3. The method of Claim 1, wherein the platform includes a platform device.

4. The method of Claim 3, wherein the platform device is selected from a group consisting of a personal computer, a minicomputer, a microcomputer, a main frame computer, a personal digital assistant, a mobile telephone, a cellular telephone, and a pager.

5. The method of Claim 3, wherein the platform device comprises a hand-held device.

6. The method of Claim 1, wherein the context specific information includes information for a user.

7. The method of Claim 1, wherein the context specific information includes information for a device.

8. The method of Claim 1, wherein the context specific information includes at least one selected from a group consisting of location information, personal information manager information, presence information, travel information, device usage information, network information, workgroup information, role information, skill information, application information, user settings information, device settings information, and web services information.

9. The method of Claim 1, wherein the context specific information is collected from an information source.

10. The method of Claim 1, wherein the context specific information is collected for context parameters.

11. The method of Claim 10, wherein the context parameters include implicit context parameters and explicit context parameters.

12. The method of Claim 8, wherein the location information is selected from a group consisting of carrier based information, geographical positioning system information, Wifi information, Bluetooth information, and services information.

13. The method of Claim 8, wherein the personal information manager information is selected from a group consisting of applications information and services information.

14. The method of Claim 8, wherein the presence information is selected from a group consisting of applications information and services information.

15. The method of Claim 8, wherein the travel information is selected from a group consisting of proximity information, direction information, flight information, weather information, and traffic information.

16. The method of Claim 1, wherein determining information needs relating to the context specific information collected includes:

determining a user's situation and intent.

17. The method of Claim 1, wherein determining information needs relating to the context specific information collected includes:

determining a device situation.

18. The method of Claim 16, wherein the user's situation and intent are obtained from analysis information.

19. The method of Claim 18, wherein the analysis information includes relevant information.

20. The method of Claim 19, wherein the relevant information is selected from a group consisting of relevant information, relevant actions, and relevant method of delivery information.

21. The method of Claim 19, wherein the relevant information is identified from available information.

22. The method of Claim 21, wherein the relevant information is identified from static context.

23. The method of Claim 21, wherein the relevant information is identified from dynamic context.

24. The method of Claim 21, wherein the relevant information is identified from preference information.

25. The method of Claim 24, wherein the preference information includes historic behavior information.

26. The method of Claim 21, wherein the relevant information is determined using user situation information.

27. The method of Claim 21, wherein the relevant information is determined using device situation information.

28. The method of Claim 21, wherein the relevant information is determined using user intent information.

29. The method of Claim 18, wherein the analysis information includes analyzed location information, event status information, availability information, device information, activity information, application information, and proximity information.

30. The method of Claim 1, wherein the delivery information includes at least one selected from a group consisting of automatically entered data, voice information, navigation information, and presentation information.

31. The method of Claim 1, wherein providing delivery information to a platform includes:

providing an alert.

32. The method of Claim 1, wherein collecting context specific information includes:

obtaining information from a plurality of applications.

33. The method of Claim 32, wherein each of the plurality of applications includes a relevant application portion for the delivery information, and wherein providing delivery information to a platform includes:

providing a consolidated interface, the consolidated interface including the relevant application portion for each of the plurality of applications.

34. The method of Claim 33, wherein the consolidated interface is formatted for the platform.

35. The method of Claim 1, wherein providing delivery information to a platform includes:

synchronizing information for the platform.

36. The method of Claim 1, wherein providing delivery information to a platform includes:

providing a menu of options.

37. The method of Claim 1, wherein providing delivery information to a platform includes:

providing smart network services.

38. The method of Claim 1, further comprising:

providing context and system services.

39. The method of Claim 38, wherein the context and system services include at least one selected from a group consisting of administration services, security services, privacy services, user preferences, logical location repository services, context history services, new context discovery services, radius proximity services, positioning services, and geocoding services.

40. A method for providing context-relevant information, the method comprising:

obtaining links to information for a plurality of entities;

identifying states for the plurality of entities;

identifying relationships among the plurality of entities;

receiving predetermined criteria for providing information relating to the entities; and

delivering context-relevant information to at least one platform, wherein the context-relevant information is determined based on the predetermined criteria, the states of the entities, and the relationship among the entities.

41. The method of Claim 40, further comprising:

identifying states for the relationships.

42. The method of Claim 41, wherein obtaining links to information includes:

interfacing with at least one sensor.

43. The method of Claim 42, wherein the information is received from the at least one sensor, and wherein obtaining links to information includes:

applying interpreters to the information received from the at least one sensor.

44. The method of Claim 43, wherein the information is received from the interpreters.

45. The method of Claim 40, wherein the plurality of entities are selected from a predetermined set of entities.

46. The method of Claim 40, wherein the states for the plurality of entities are selected from a predetermined set of states.

47. The method of Claim 40, wherein the relationships among the plurality of entities are selected from a predetermined set of relationships.

48. A system for providing context-relevant information, comprising:

at least one network;

a delivery platform coupled to each of the at least one network;

a server; and

at least one context data source coupled to the server;

wherein the server collects context parameters from the at least one context data source;

wherein the server includes a context engine for analyzing the collected context parameters; and

wherein the server provides context actions/effects using the collected and analyzed context parameters.

49. The system of Claim 48, wherein the at least one network includes the Internet.

50. The system of Claim 48, wherein the at least one network includes a cellular telephone network.

51. The system of Claim 48, wherein the delivery platform is selected from a group consisting of a personal computer, a minicomputer, a microcomputer, a main frame computer, a personal digital assistant, a mobile telephone, a cellular telephone, and a pager.

52. A system for providing context-relevant information, comprising:

means for collecting context specific information;

means for determining information needs relating to the context specific information collected; and

means for providing delivery information to a platform, wherein the delivery information is formatted based on the platform, the collected context specific information, and the determined information needs.

FIG. 1

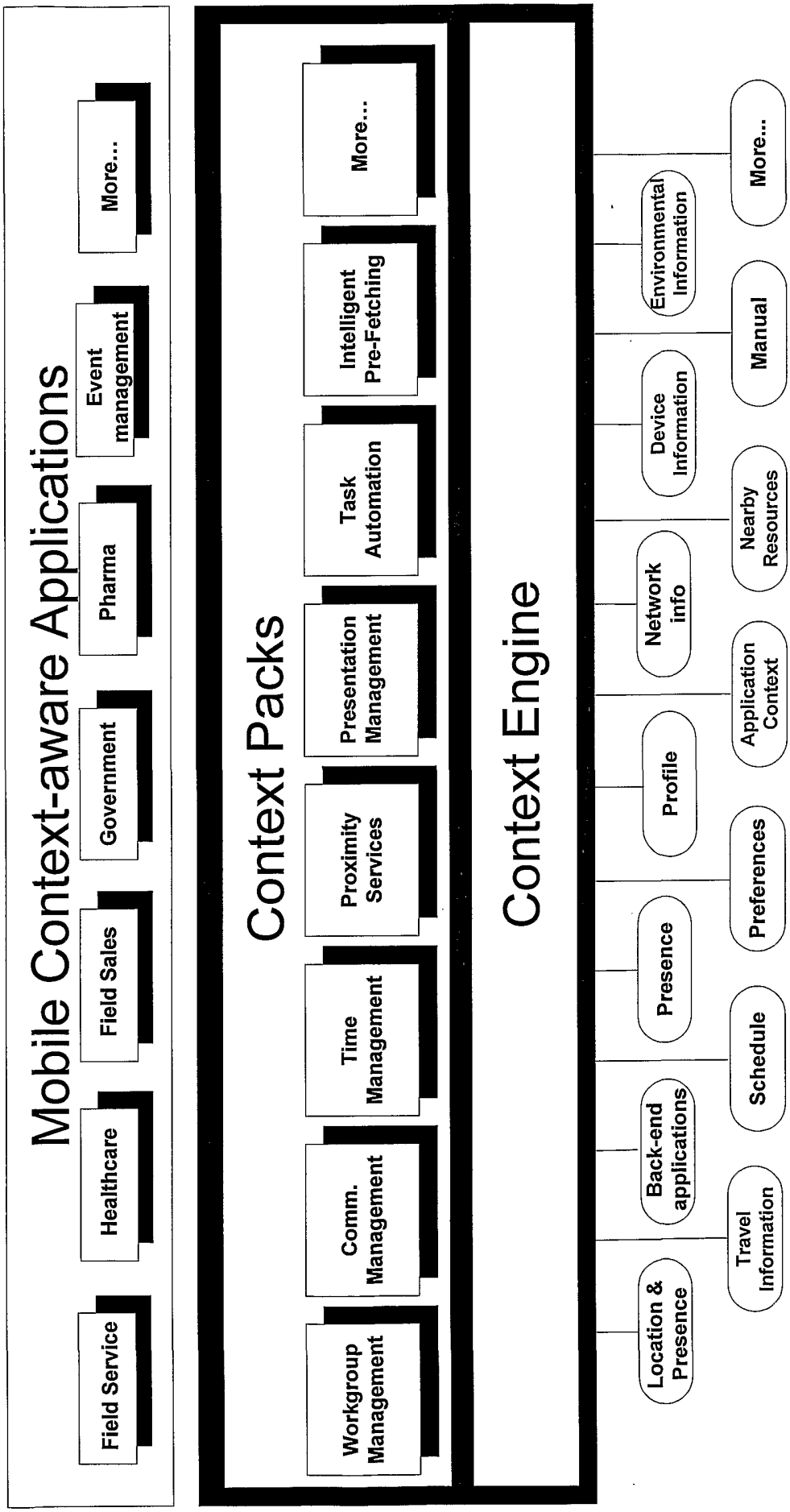
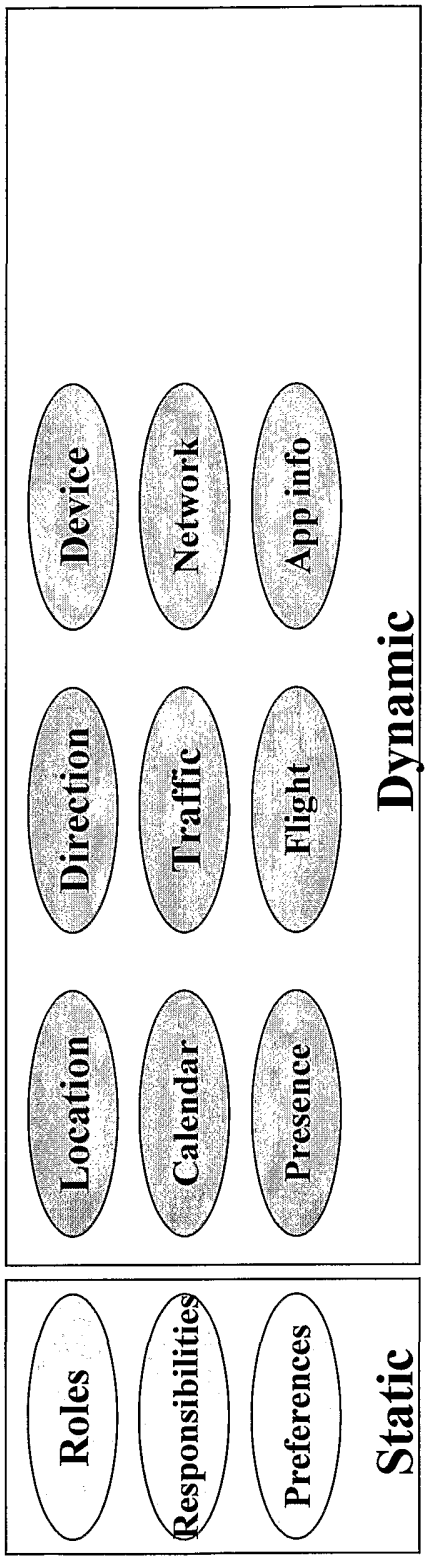

Context Packs
Mobile Context-aware Applications
Field Service
Healthcare
Field Sales
Government
Pharma
Event management
More...
Context Packs
Workgroup Management
Comm. Management
Time Management
Proximity Services
Presentation Management
Task Automation
Intelligent Pre-Fetching
More...
Context Engine
Location & Presence
Travel Information
Back-end applications
Schedule
Presence
Preferences
Profile
Application Context
Network info
Nearby Resources
Device Information
Manual
Environmental Information
More...

FIG. 2


Roles
Responsibilities
Preferences
Static
Location
Calendar
Presence
Direction
Traffic
Flight
Device
Network
App info
Dynamic

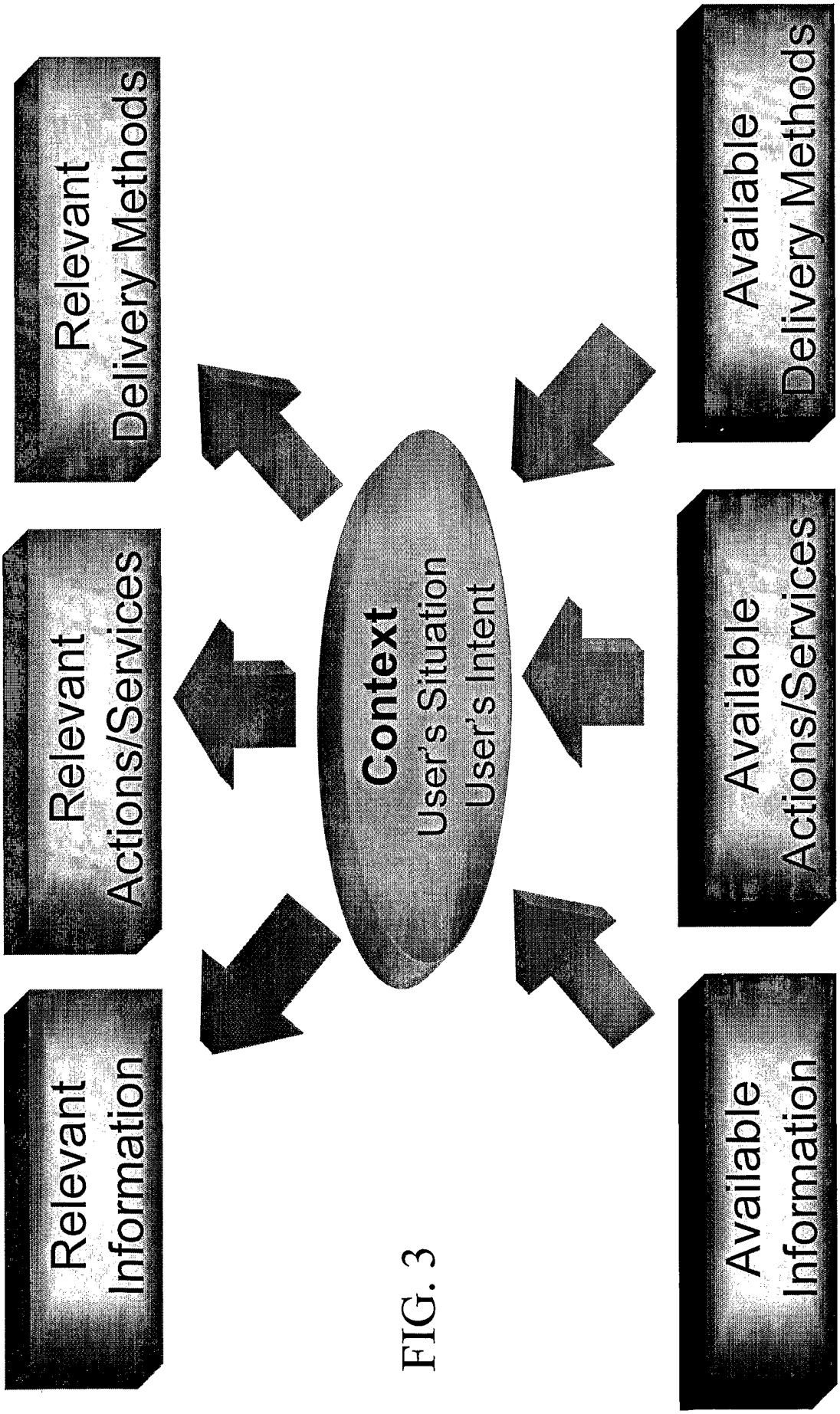

Relevant Information
Relevant Actions/Services
Relevant Delivery Methods
Context
User's Situation
User's Intent
Available Information
Available Actions/Services
Available Delivery Methods

FIG. 3

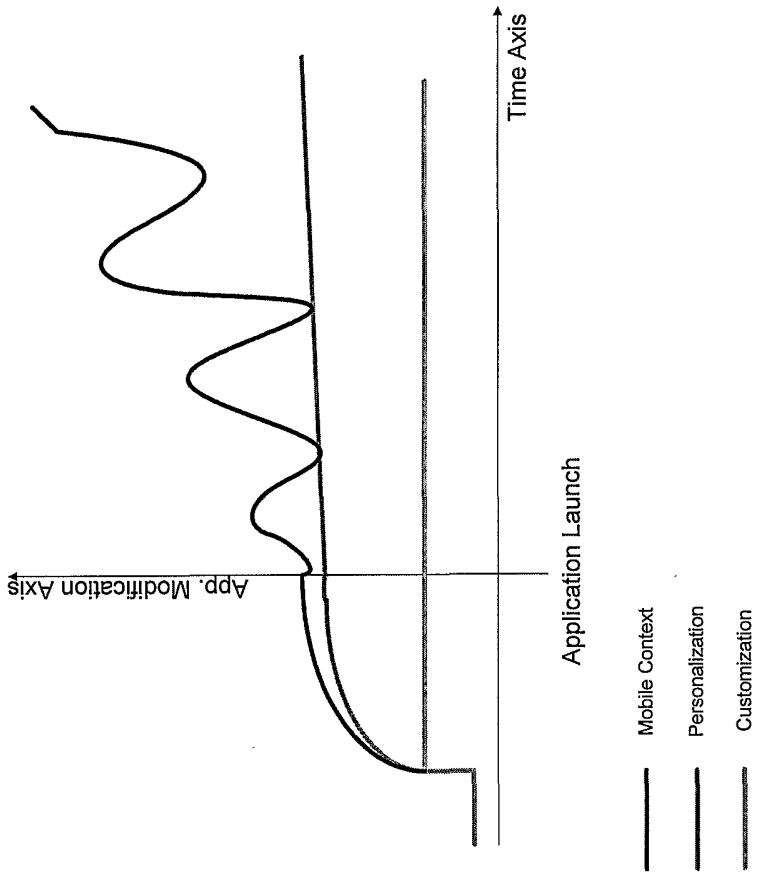

App. Modification Axis
Time Axis
Application Launch
Mobile Context
Personalization
Customization

FIG. 4

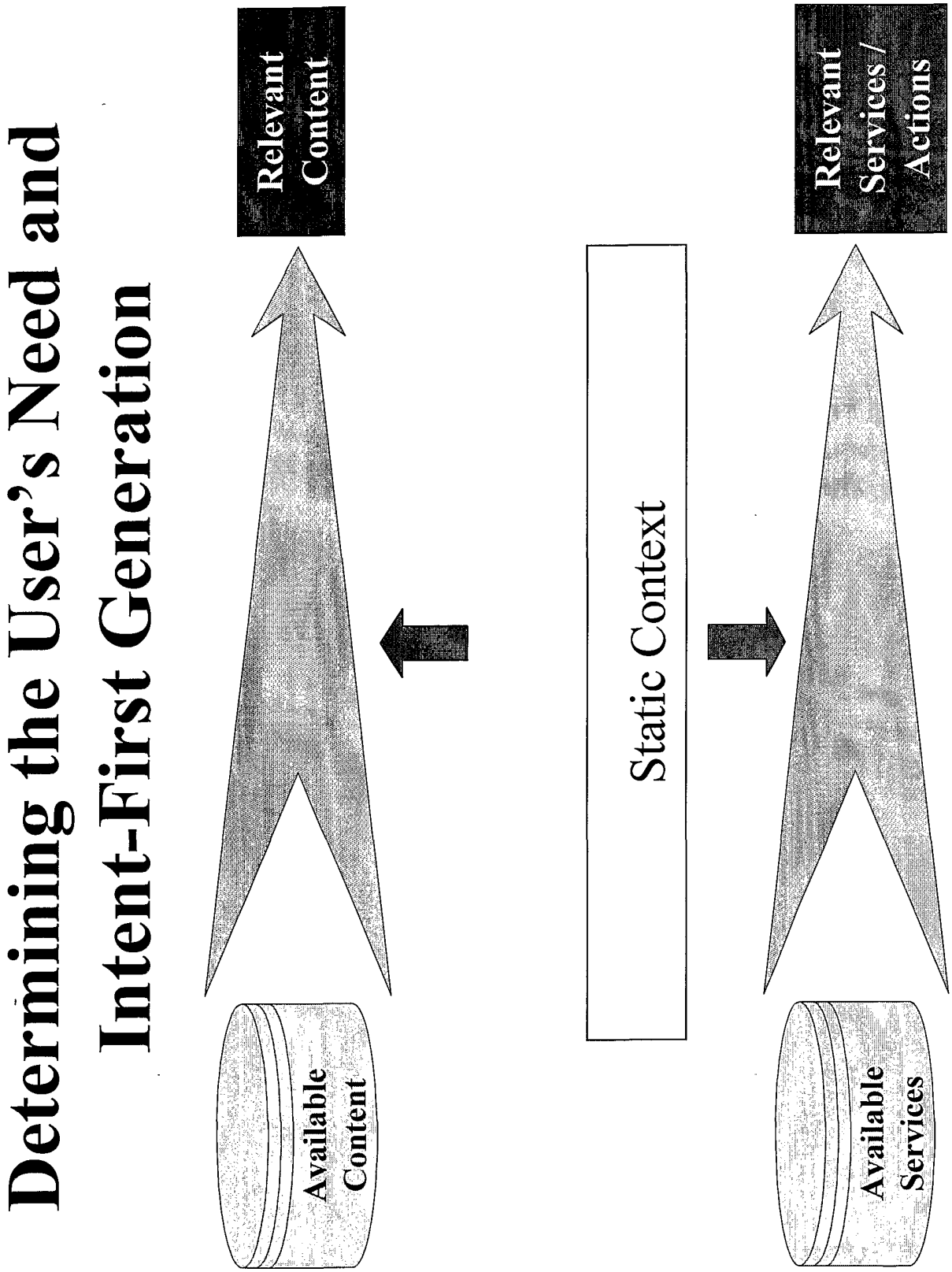

Determining the User's Need and Intent-First Generation
Relevant Content
Available Content
Static Context
Relevant Services / Actions
Available Services

FIG. 5

FIG. 6

Determining the User's Need and Intent-Next Generation

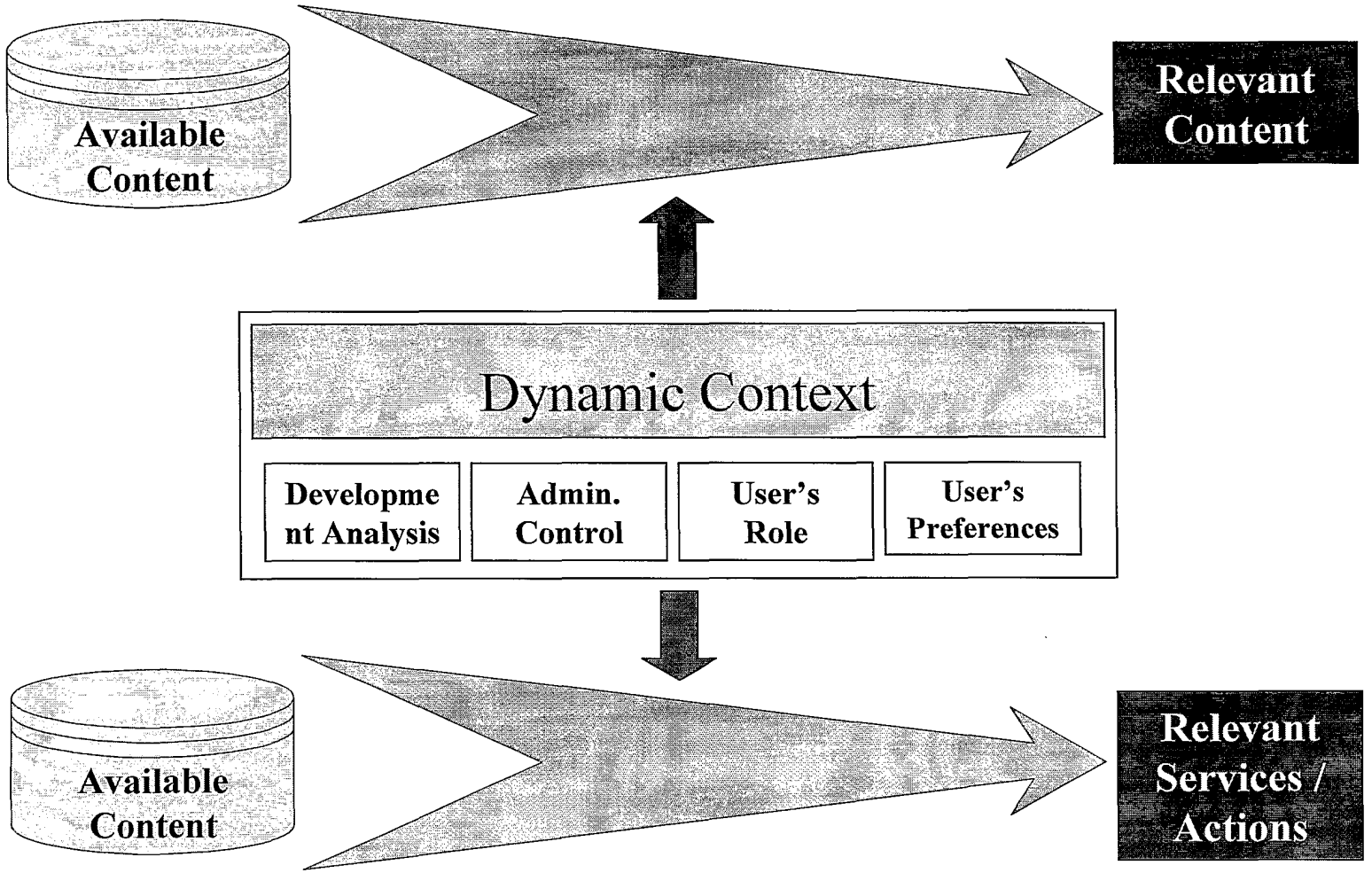
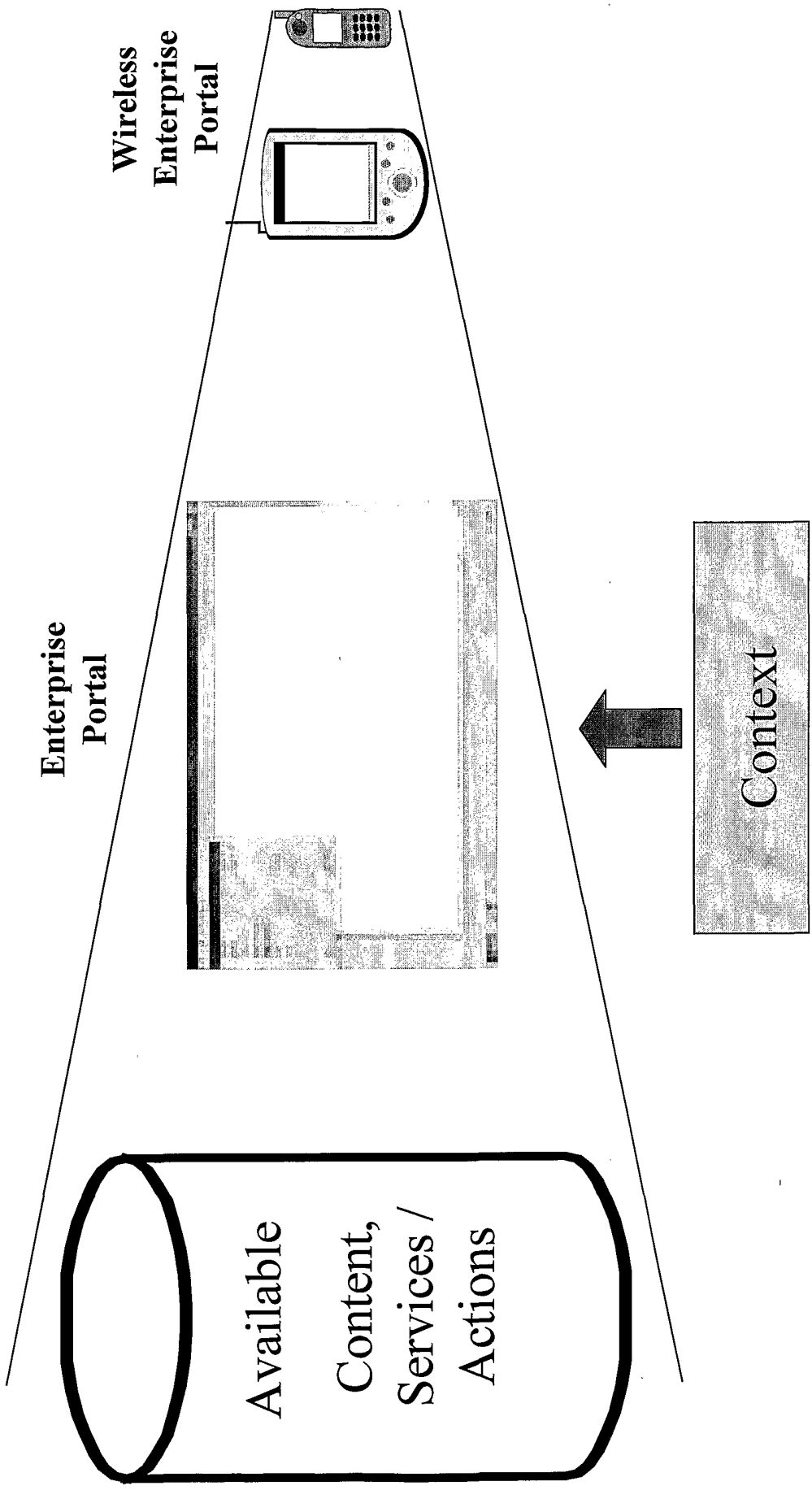


FIG. 7


Wireless and Wired Portals
Wireless Enterprise Portal
Enterprise Portal
Context
Available Content, Services / Actions

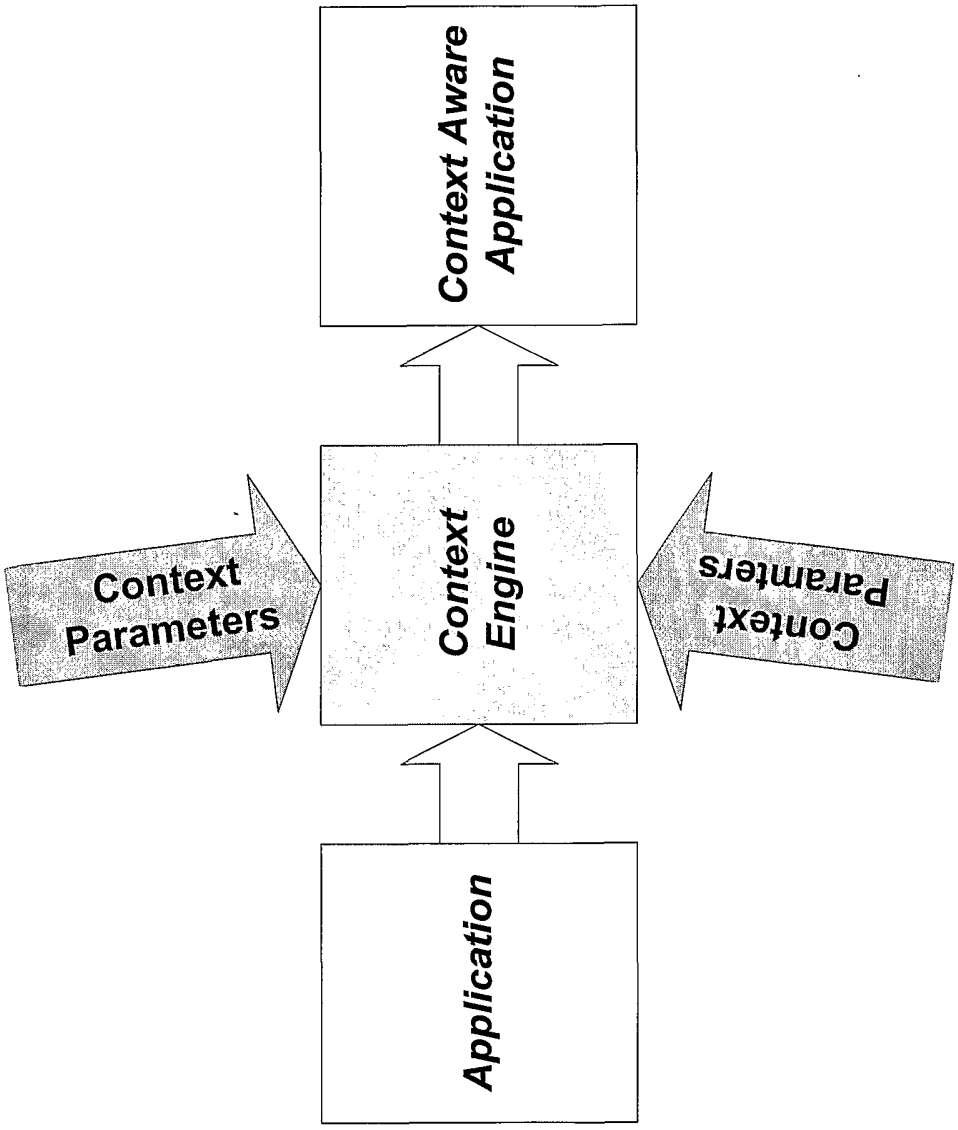

Context Aware Application
Context Engine
Context Parameters
Context Parameters
Application

FIG. 8

FIG. 9

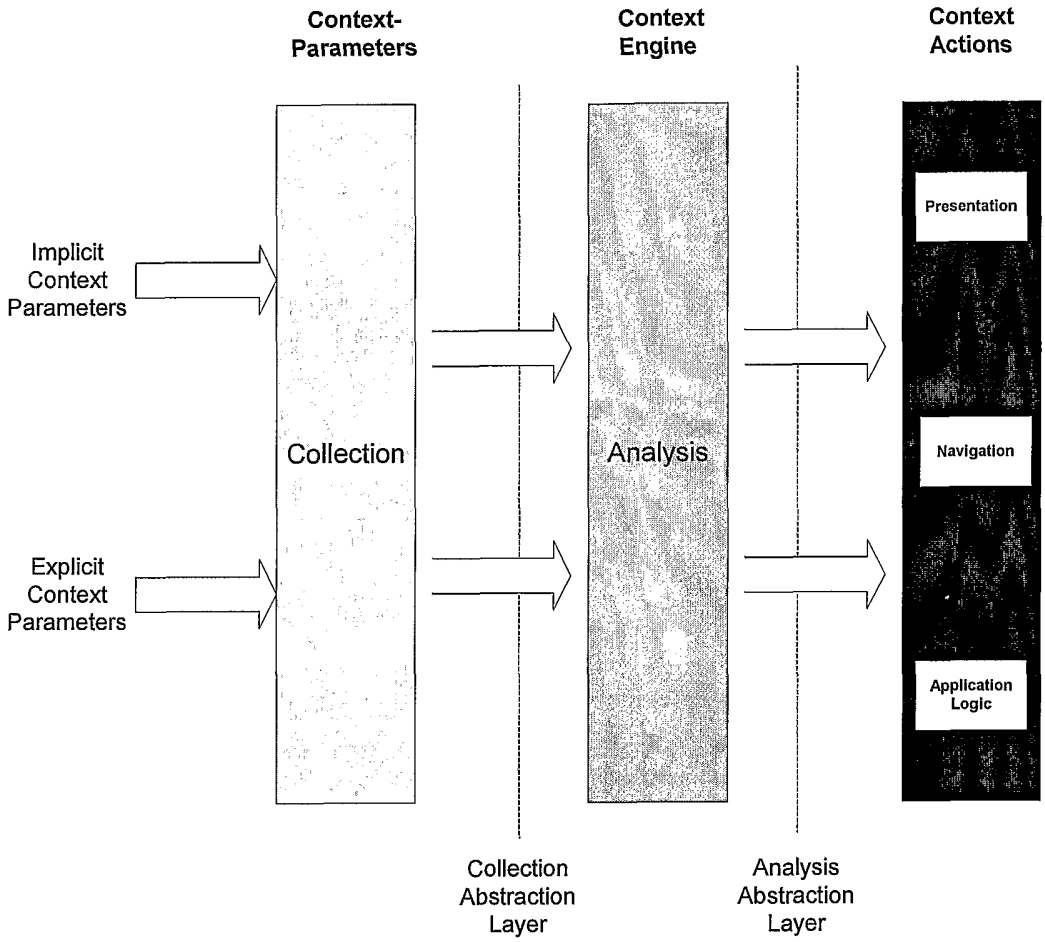

Context-
Parameters
Context
Engine
Context
Actions
Implicit
Context
Parameters
Explicit
Context
Parameters
Collection
Analysis
Presentation
Navigation
Application
Logic
Collection
Abstraction
Layer
Analysis
Abstraction
Layer

FIG. 10

Context Awareness Map

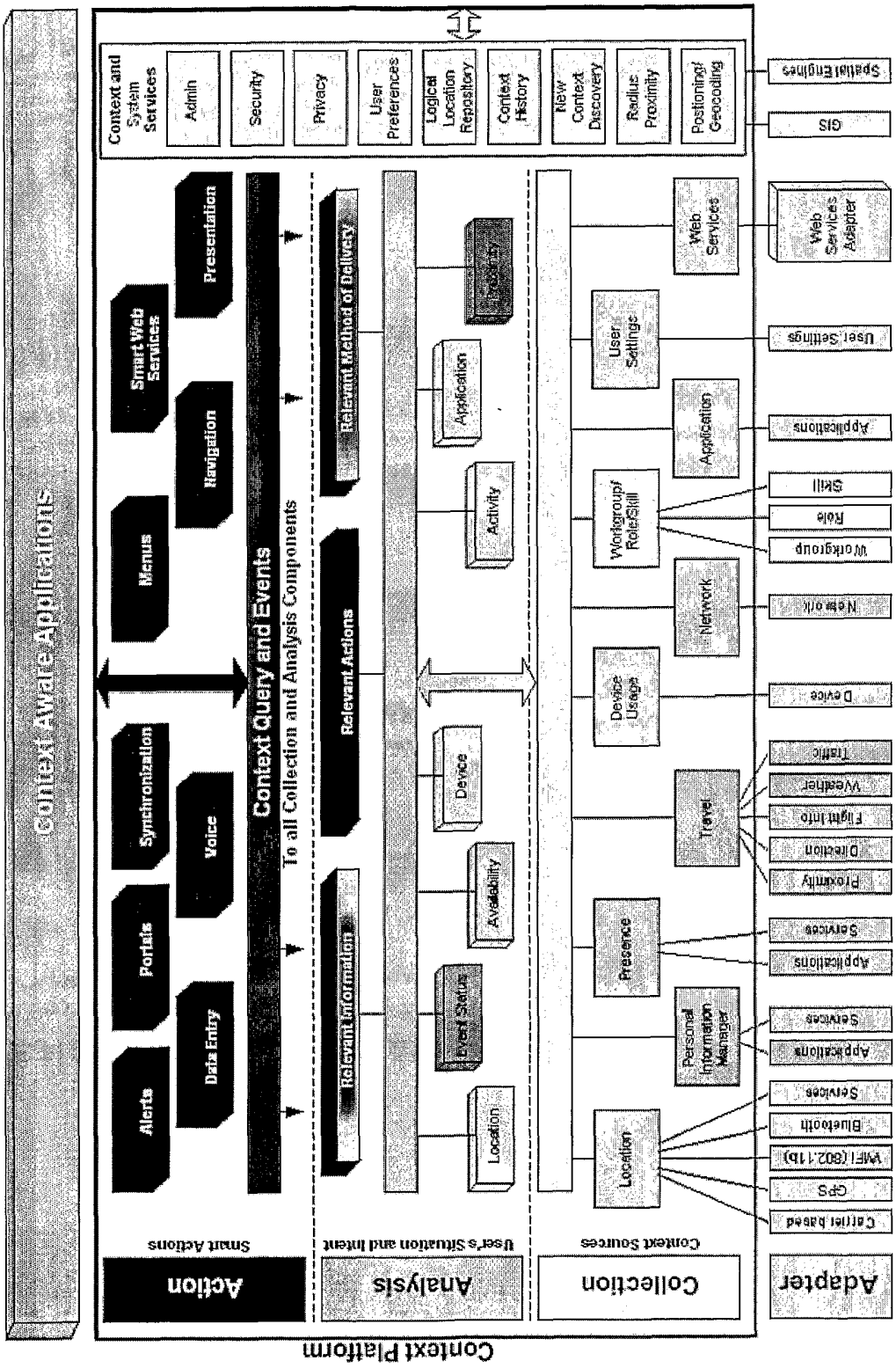
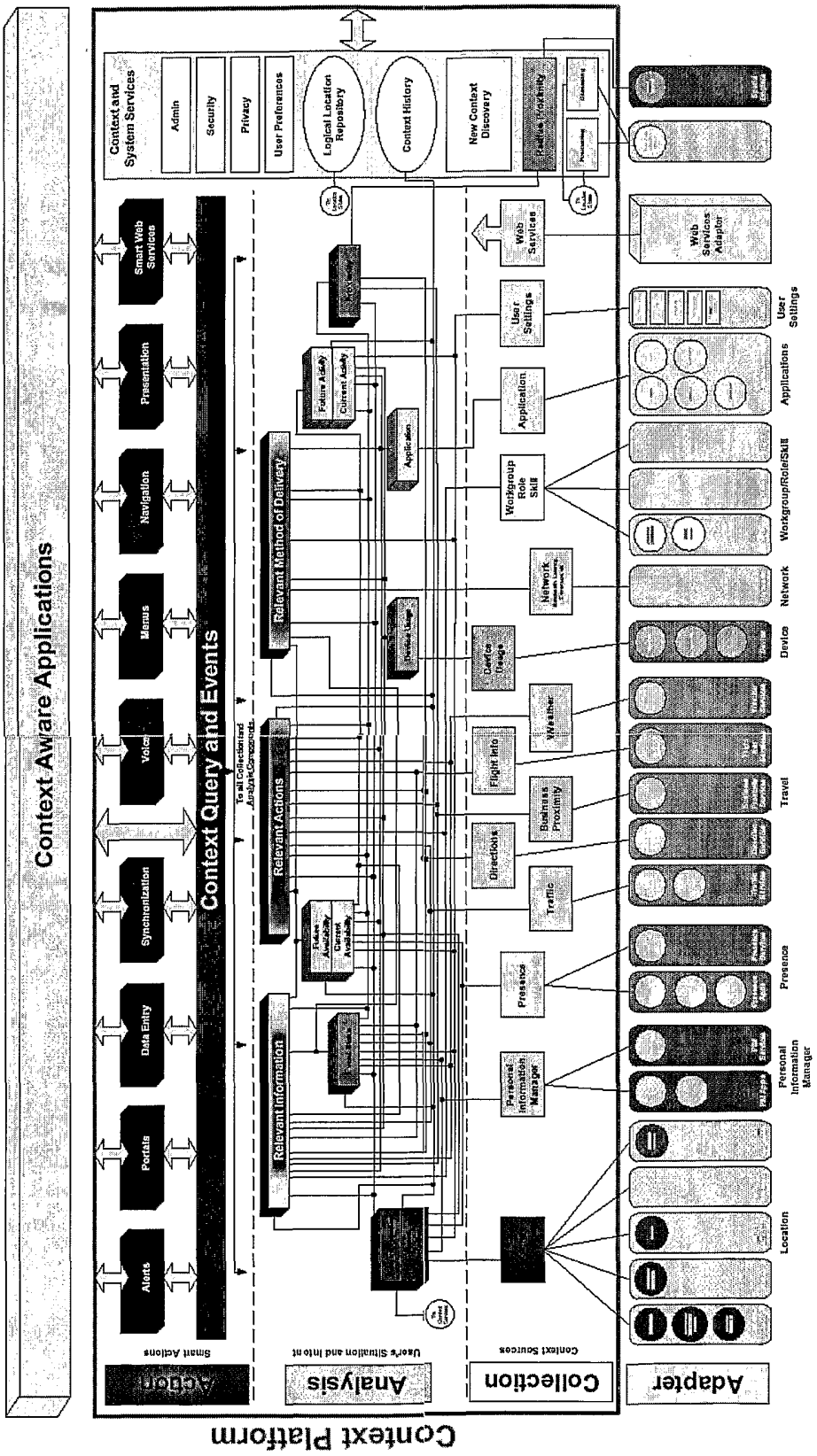


FIG. 11


Context Aware Applications
Context Platform
Context and System Services
Admin
Security
Privacy
User Preferences
Logical Location Repository
Context History
New Context Discovery
Context Query and Events
Alerts
Portals
Data Entry
Synchronization
Voice
Menus
Navigation
Presentation
Smart Web Services
Relevant Information
Relevant Method of Delivery
Relevant Actions
Smart Actions
User's Situation and Intent
Context Sources
Action
Analysis
Collection
Adapter
Web Services
User Settings
Application
Workgroup Role Skill
Network
Device
Traffic
Directions
Business Proximity
Flight Info
Weather
Presence
Personal Information Manager
Location
Travel
Applications
Workgroup/Role/Skill

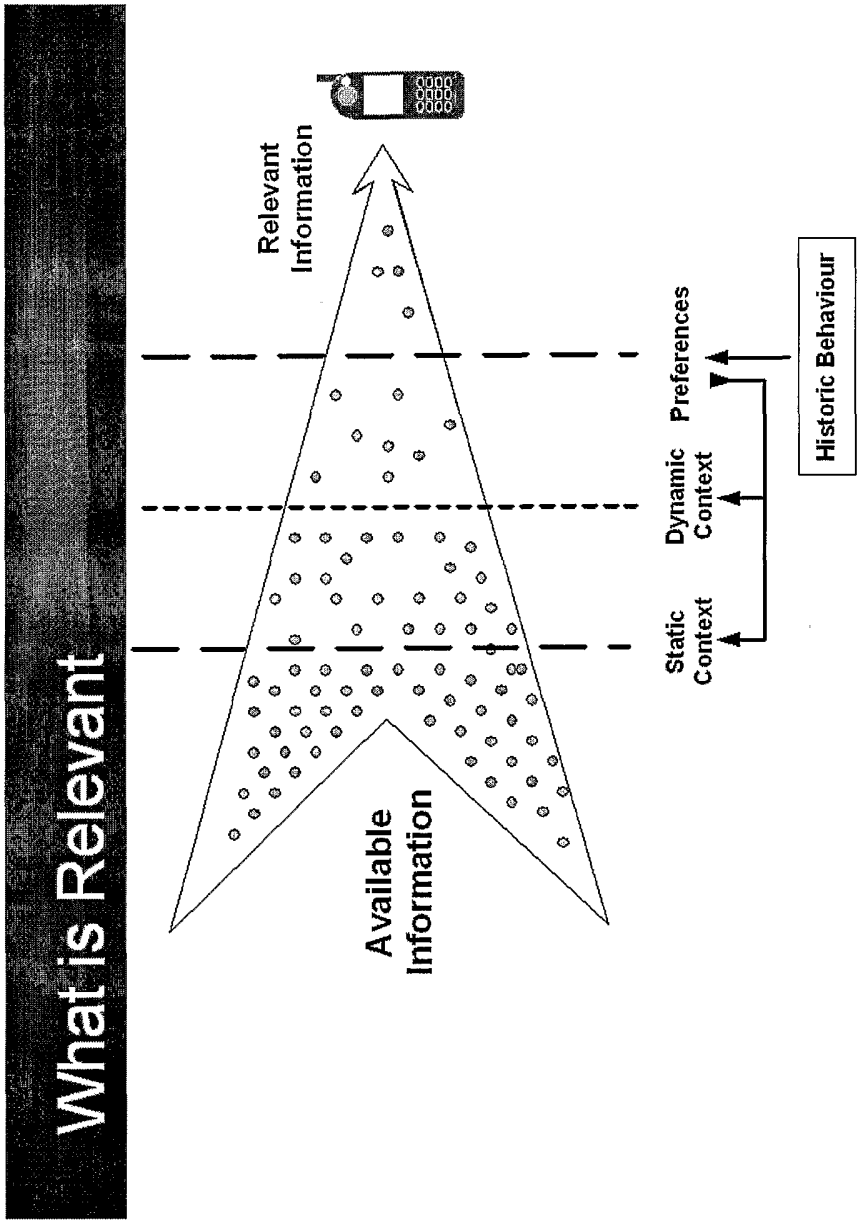

What is Relevant
Relevant Information
Available Information
Static Context
Dynamic Context
Preferences
Historic Behaviour

FIG. 12

FIG. 13

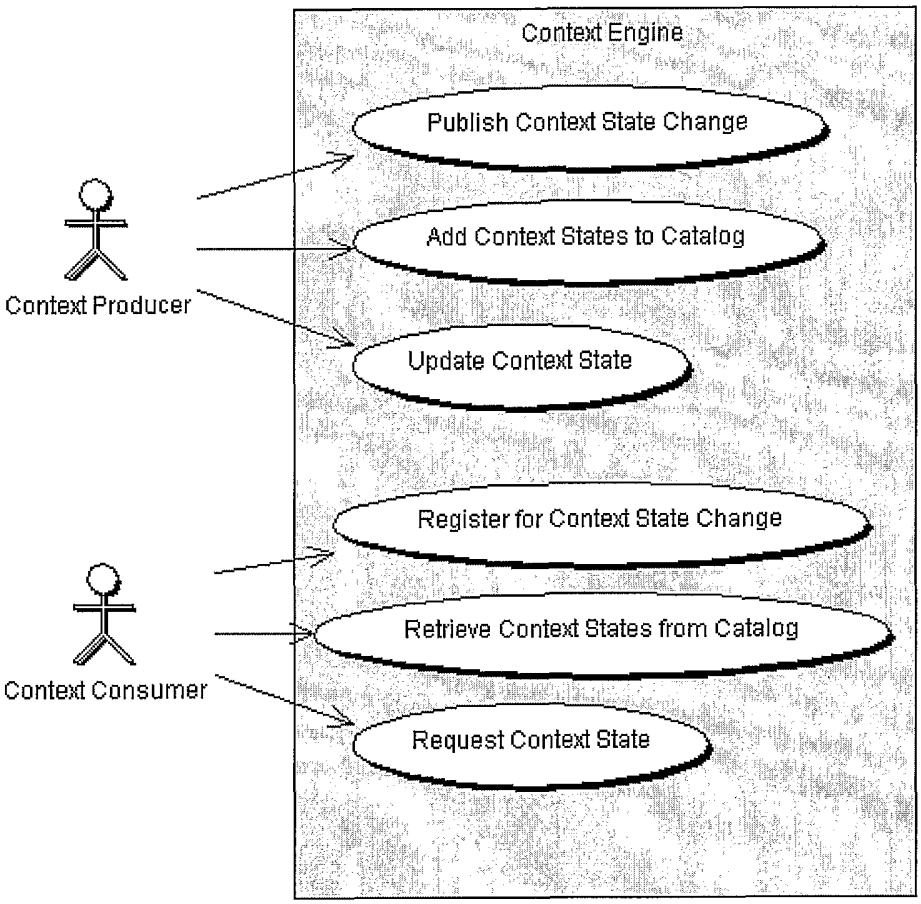

Context Engine
Publish Context State Change
Add Context States to Catalog
Update Context State
Register for Context State Change
Retrieve Context States from Catalog
Request Context State
Context Producer
Context Consumer

FIG. 14

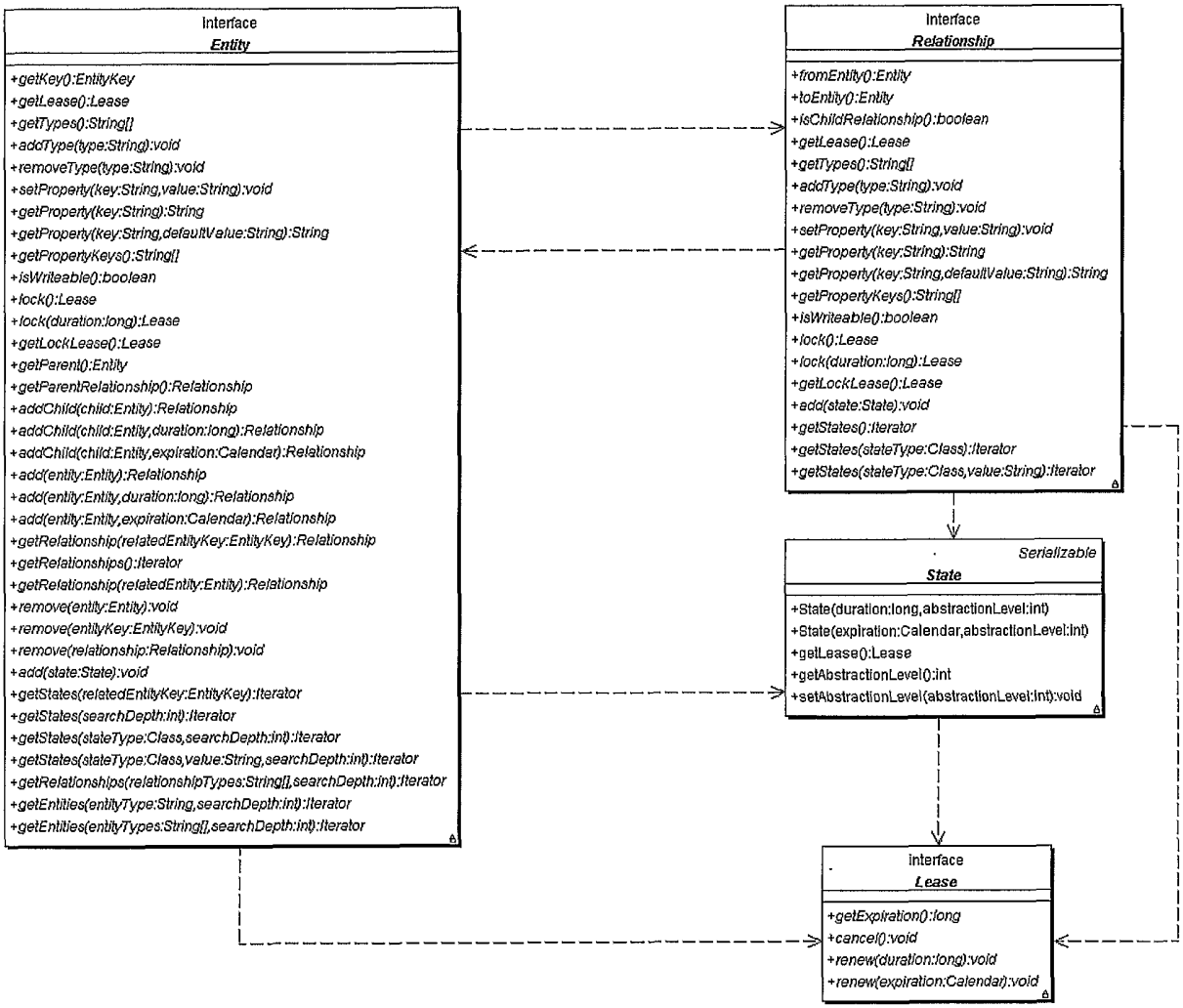

Interface
Entity
+getKey():EntityKey
+getLease():Lease
+getTypes():String[]
+addType(type:String):void
+removeType(type:String):void
+setProperty(key:String,value:String):void
+getProperty(key:String):String
+getProperty(key:String,defaultValue:String):String
+getPropertyKeys():String[]
+isWriteable():boolean
+lock():Lease
+lock(duration:long):Lease
+getLockLease():Lease
+getParent():Entity
+getParentRelationship():Relationship
+addChild(child:Entity):Relationship
+addChild(child:Entity,duration:long):Relationship
+addChild(child:Entity,expiration:Calendar):Relationship
+add(entity:Entity):Relationship
+add(entity:Entity,duration:long):Relationship
+add(entity:Entity,expiration:Calendar):Relationship
+getRelationship(relatedEntityKey:EntityKey):Relationship
+getRelationships():Iterator
+getRelationship(relatedEntity:Entity):Relationship
+remove(entity:Entity):void
+remove(entityKey:EntityKey):void
+remove(relationship:Relationship):void
+add(state:State):void
+getStates(relatedEntityKey:EntityKey):Iterator
+getStates(searchDepth:int):Iterator
+getStates(stateType:Class,searchDepth:int):Iterator
+getStates(stateType:Class,value:String,searchDepth:int):Iterator
+getRelationships(relationshipTypes:String[],searchDepth:int):Iterator
+getEntities(entityType:String,searchDepth:int):Iterator
+getEntities(entityTypes:String[],searchDepth:int):Iterator
Interface
Relationship
+fromEntity():Entity
+toEntity():Entity
+isChildRelationship():boolean
+getLease():Lease
+getTypes():String[]
+addType(type:String):void
+removeType(type:String):void
+setProperty(key:String,value:String):void
+getProperty(key:String):String
+getProperty(key:String,defaultValue:String):String
+getPropertyKeys():String[]
+isWriteable():boolean
+lock():Lease
+lock(duration:long):Lease
+getLockLease():Lease
+add(state:State):void
+getStates():Iterator
+getStates(stateType:Class):Iterator
+getStates(stateType:Class,value:String):Iterator
Serializable
State
+State(duration:long,abstractionLevel:int)
+State(expiration:Calendar,abstractionLevel:int)
+getLease():Lease
+getAbstractionLevel():int
+setAbstractionLevel(abstractionLevel:int):void
Interface
Lease
+getExpiration():long
+cancel():void
+renew(duration:long):void
+renew(expiration:Calendar):void

FIG. 15

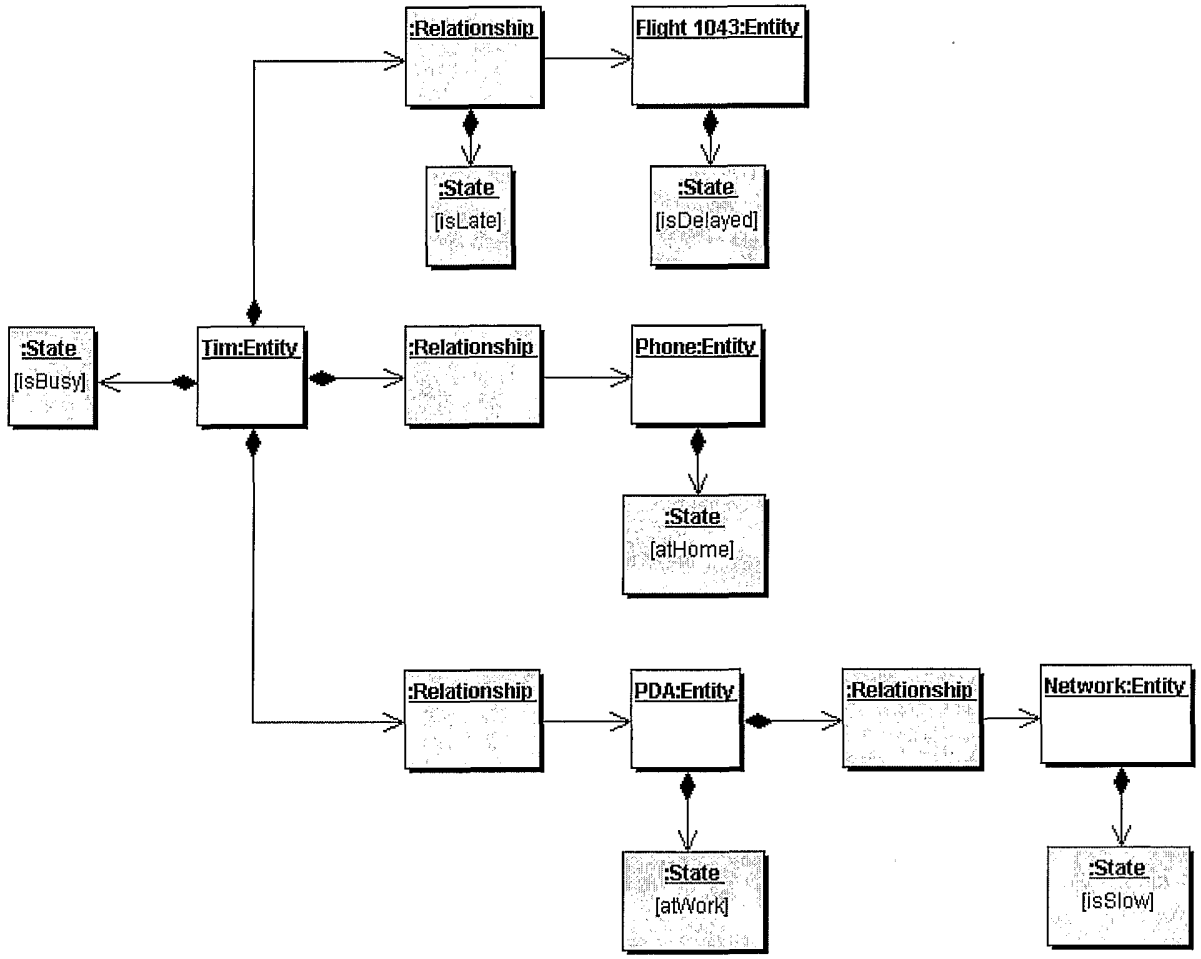

:Relationship
Flight 1043:Entity
:State
[isLate]
:State
[isDelayed]
:State
[isBusy]
Tim:Entity
:Relationship
Phone:Entity
:State
[atHome]
:Relationship
PDA:Entity
:Relationship
Network:Entity
:State
[atWork]
:State
[isSlow]

FIG. 16

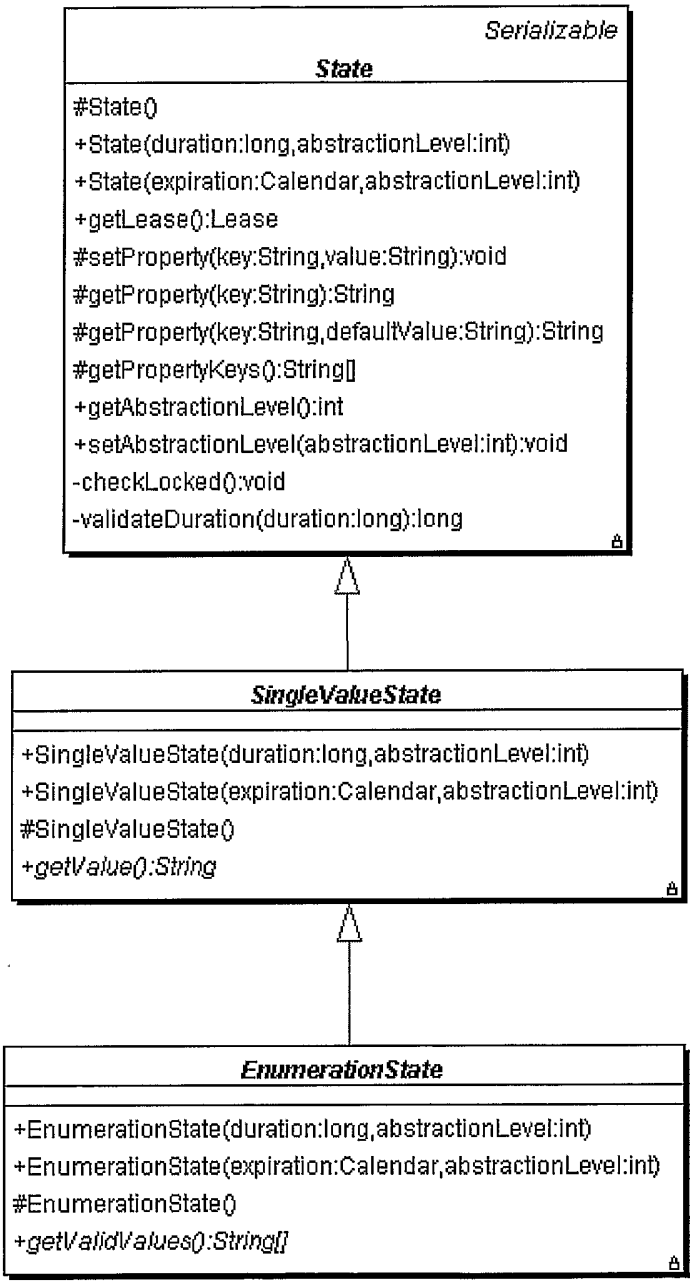

Serializable
State
#State()
+State(duration:long,abstractionLevel:int)
+State(expiration:Calendar,abstractionLevel:int)
+getLease():Lease
#setProperty(key:String,value:String):void
#getProperty(key:String):String
#getProperty(key:String,defaultValue:String):String
#getPropertyKeys():String[]
+getAbstractionLevel():int
+setAbstractionLevel(abstractionLevel:int):void
-checkLocked():void
-validateDuration(duration:long):long
SingleValueState
+SingleValueState(duration:long,abstractionLevel:int)
+SingleValueState(expiration:Calendar,abstractionLevel:int)
#SingleValueState()
+getValue():String
EnumerationState
+EnumerationState(duration:long,abstractionLevel:int)
+EnumerationState(expiration:Calendar,abstractionLevel:int)
#EnumerationState()
+getValidValues():String[]

FIG. 17

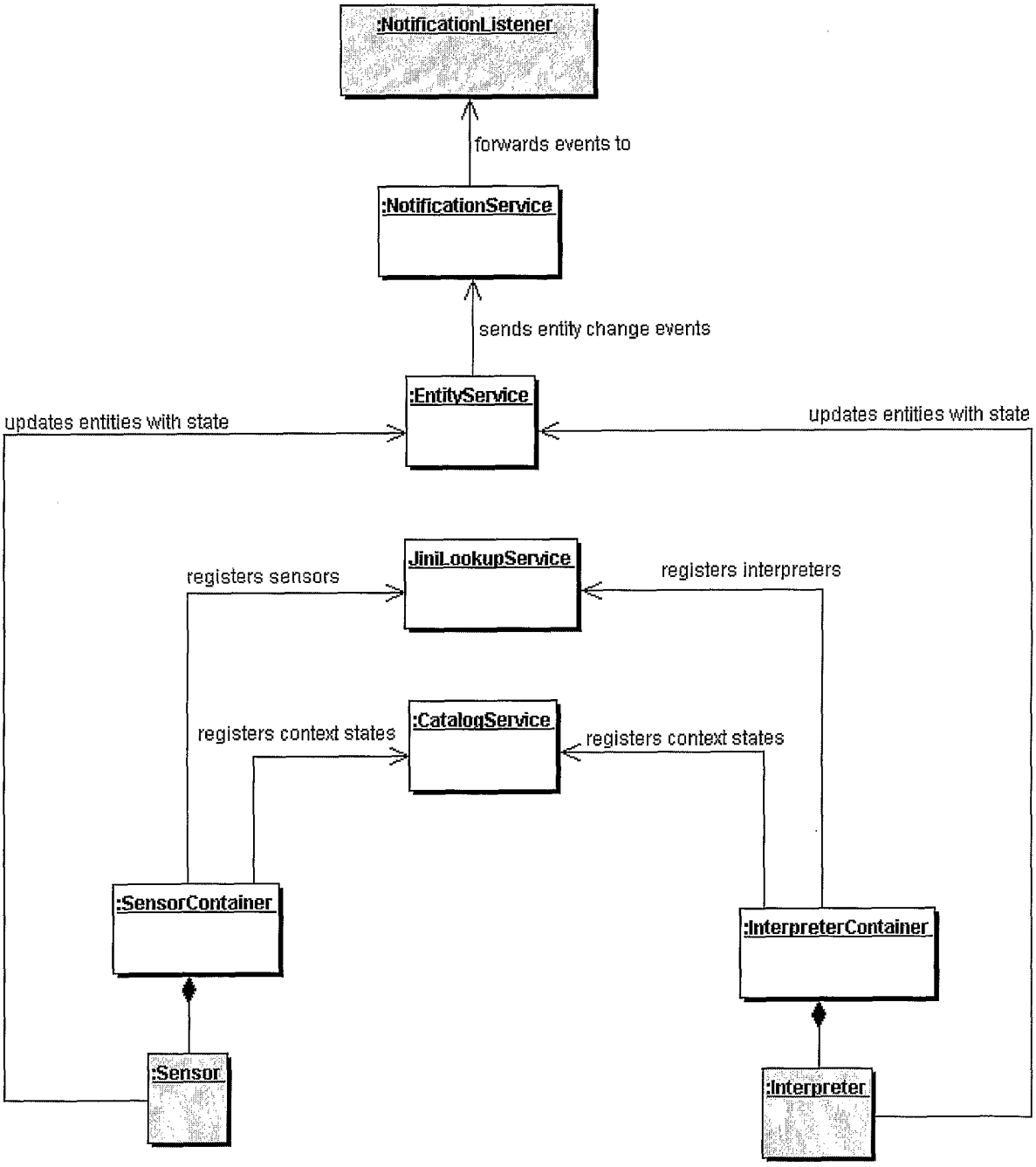

:NotificationListener
forwards events to
:NotificationService
sends entity change events
:EntityService
updates entities with state
updates entities with state
:JiniLookupService
registers sensors
registers interpreters
:CatalogService
registers context states
registers context states
:SensorContainer
:InterpreterContainer
:Sensor
:Interpreter

FIG. 18

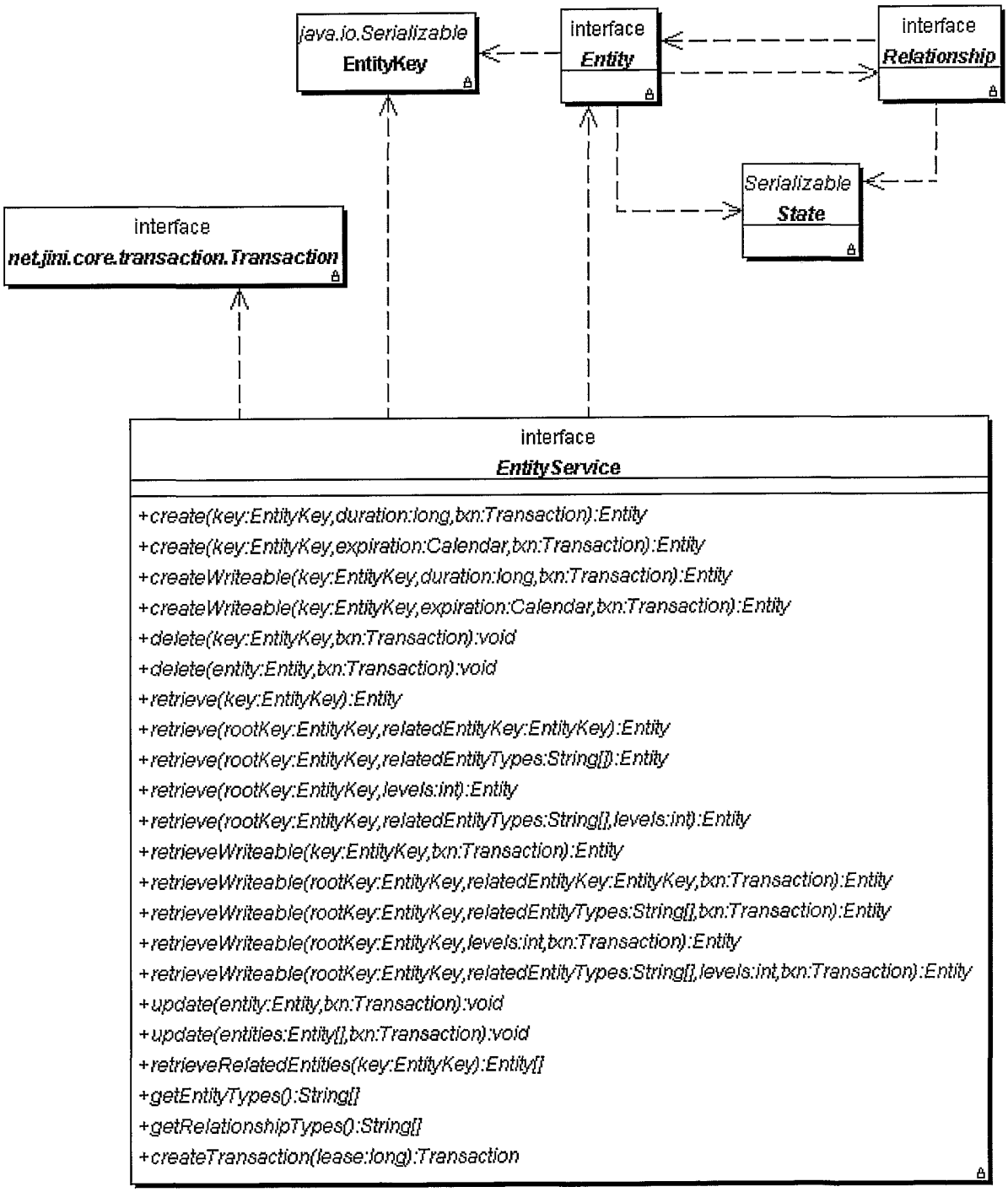

java.io.Serializable
EntityKey
interface
Entity
interface
Relationship
Serializable
State
interface
net.jini.core.transaction.Transaction
interface
EntityService
+create(key:EntityKey,duration:long,txn:Transaction):Entity
+create(key:EntityKey,expiration:Calendar,txn:Transaction):Entity
+createWriteable(key:EntityKey,duration:long,txn:Transaction):Entity
+createWriteable(key:EntityKey,expiration:Calendar,txn:Transaction):Entity
+delete(key:EntityKey,txn:Transaction):void
+delete(entity:Entity,txn:Transaction):void
+retrieve(key:EntityKey):Entity
+retrieve(rootKey:EntityKey,relatedEntityKey:EntityKey):Entity
+retrieve(rootKey:EntityKey,relatedEntityTypes:String[]):Entity
+retrieve(rootKey:EntityKey,levels:int):Entity
+retrieve(rootKey:EntityKey,relatedEntityTypes:String[],levels:int):Entity
+retrieveWriteable(key:EntityKey,txn:Transaction):Entity
+retrieveWriteable(rootKey:EntityKey,relatedEntityKey:EntityKey,txn:Transaction):Entity
+retrieveWriteable(rootKey:EntityKey,relatedEntityTypes:String[],txn:Transaction):Entity
+retrieveWriteable(rootKey:EntityKey,levels:int,txn:Transaction):Entity
+retrieveWriteable(rootKey:EntityKey,relatedEntityTypes:String[],levels:int,txn:Transaction):Entity
+update(entity:Entity,txn:Transaction):void
+update(entities:Entity[],txn:Transaction):void
+retrieveRelatedEntities(key:EntityKey):Entity[]
+getEntityTypes():String[]
+getRelationshipTypes():String[]
+createTransaction(lease:long):Transaction

FIG. 19

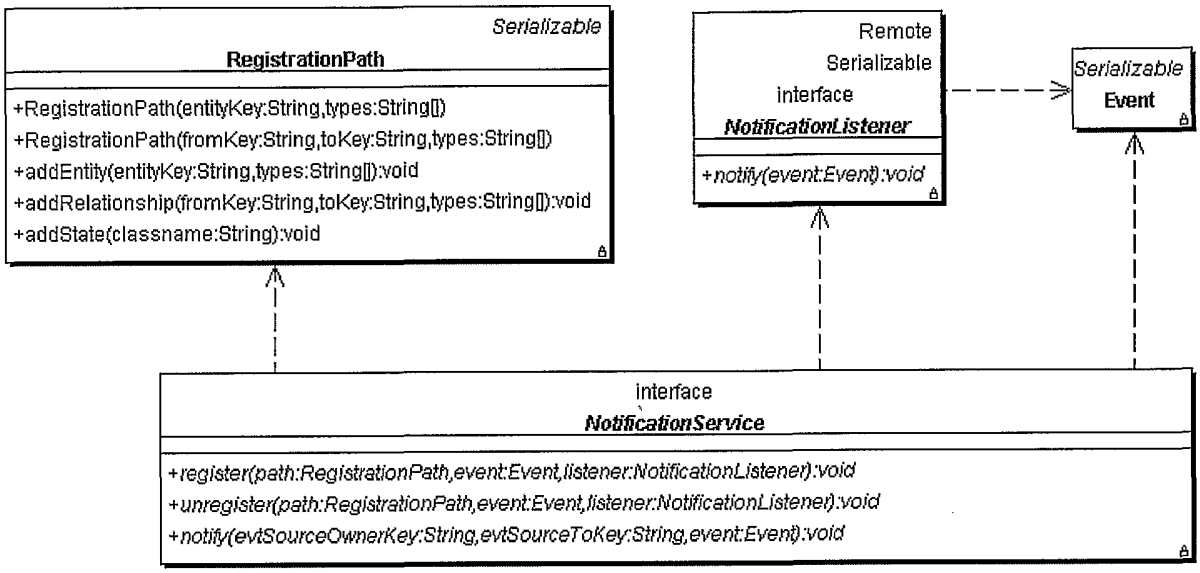

Serializable
RegistrationPath
+RegistrationPath(entityKey:String,types:String[])
+RegistrationPath(fromKey:String,toKey:String,types:String[])
+addEntity(entityKey:String,types:String[]):void
+addRelationship(fromKey:String,toKey:String,types:String[]):void
+addState(classname:String):void
Remote
Serializable
interface
NotificationListener
+notify(event:Event):void
Serializable
Event
interface
NotificationService
+register(path:RegistrationPath,event:Event,listener:NotificationListener):void
+unregister(path:RegistrationPath,event:Event,listener:NotificationListener):void
+notify(evtSourceOwnerKey:String,evtSourceToKey:String,event:Event):void

FIG. 20

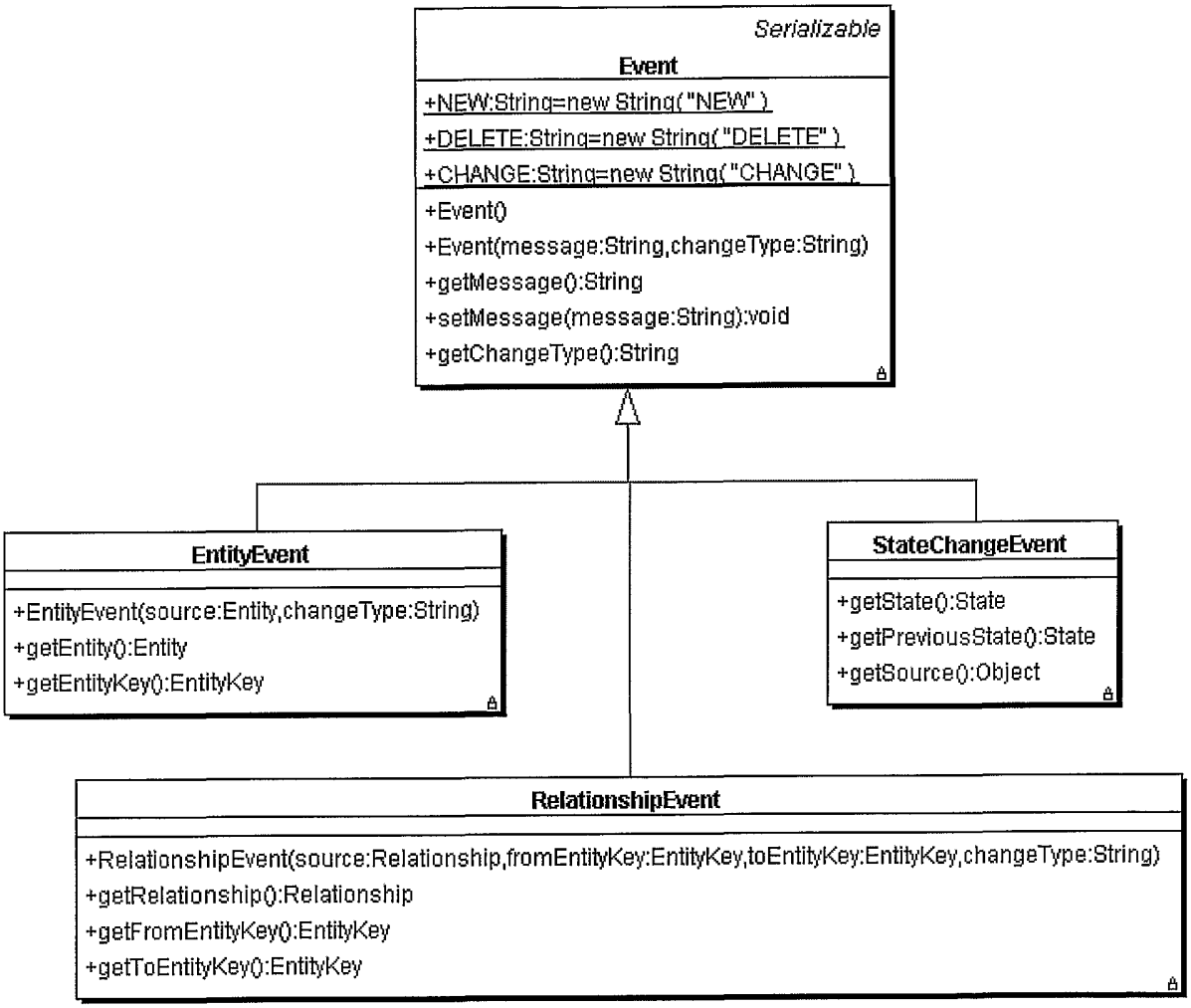

Serializable
Event
+NEW:String=new String("NEW")
+DELETE:String=new String("DELETE")
+CHANGE:String=new String("CHANGE")
+Event()
+Event(message:String,changeType:String)
+getMessage():String
+setMessage(message:String):void
+getChangeType():String
EntityEvent
+EntityEvent(source:Entity,changeType:String)
+getEntity():Entity
+getEntityKey():EntityKey
StateChangeEvent
+getState():State
+getPreviousState():State
+getSource():Object
RelationshipEvent
+RelationshipEvent(source:Relationship,fromEntityKey:EntityKey,toEntityKey:EntityKey,changeType:String)
+getRelationship():Relationship
+getFromEntityKey():EntityKey
+getToEntityKey():EntityKey

FIG. 21

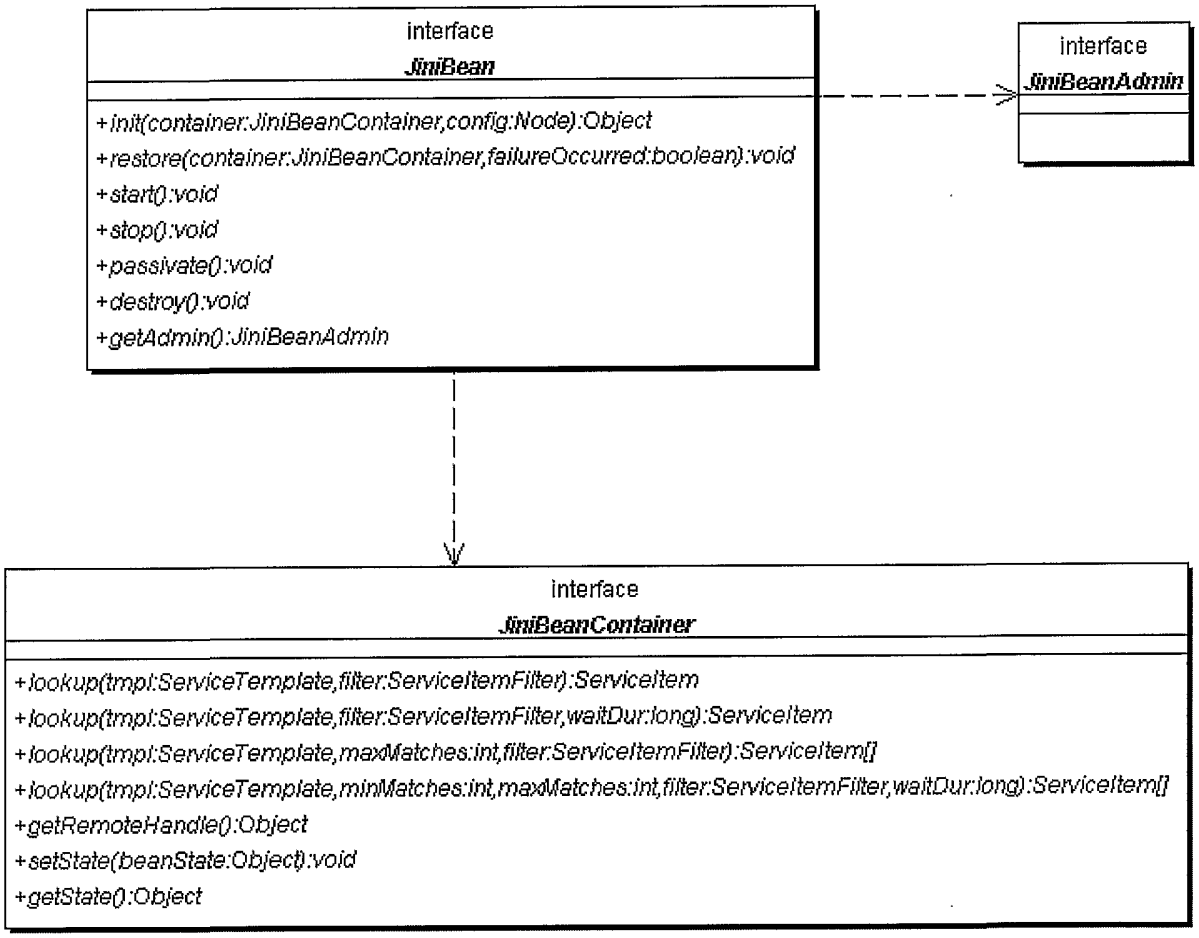

interface
JiniBean
+init(container:JiniBeanContainer,config:Node):Object
+restore(container:JiniBeanContainer,failureOccurred:boolean):void
+start():void
+stop():void
+passivate():void
+destroy():void
+getAdmin():JiniBeanAdmin
interface
JiniBeanAdmin
interface
JiniBeanContainer
+lookup(tmpl:ServiceTemplate,filter:ServiceItemFilter):ServiceItem
+lookup(tmpl:ServiceTemplate,filter:ServiceItemFilter,waitDur:long):ServiceItem
+lookup(tmpl:ServiceTemplate,maxMatches:int,filter:ServiceItemFilter):ServiceItem[]
+lookup(tmpl:ServiceTemplate,minMatches:int,maxMatches:int,filter:ServiceItemFilter,waitDur:long):ServiceItem[]
+getRemoteHandle():Object
+setState(beanState:Object):void
+getState():Object

FIG. 22

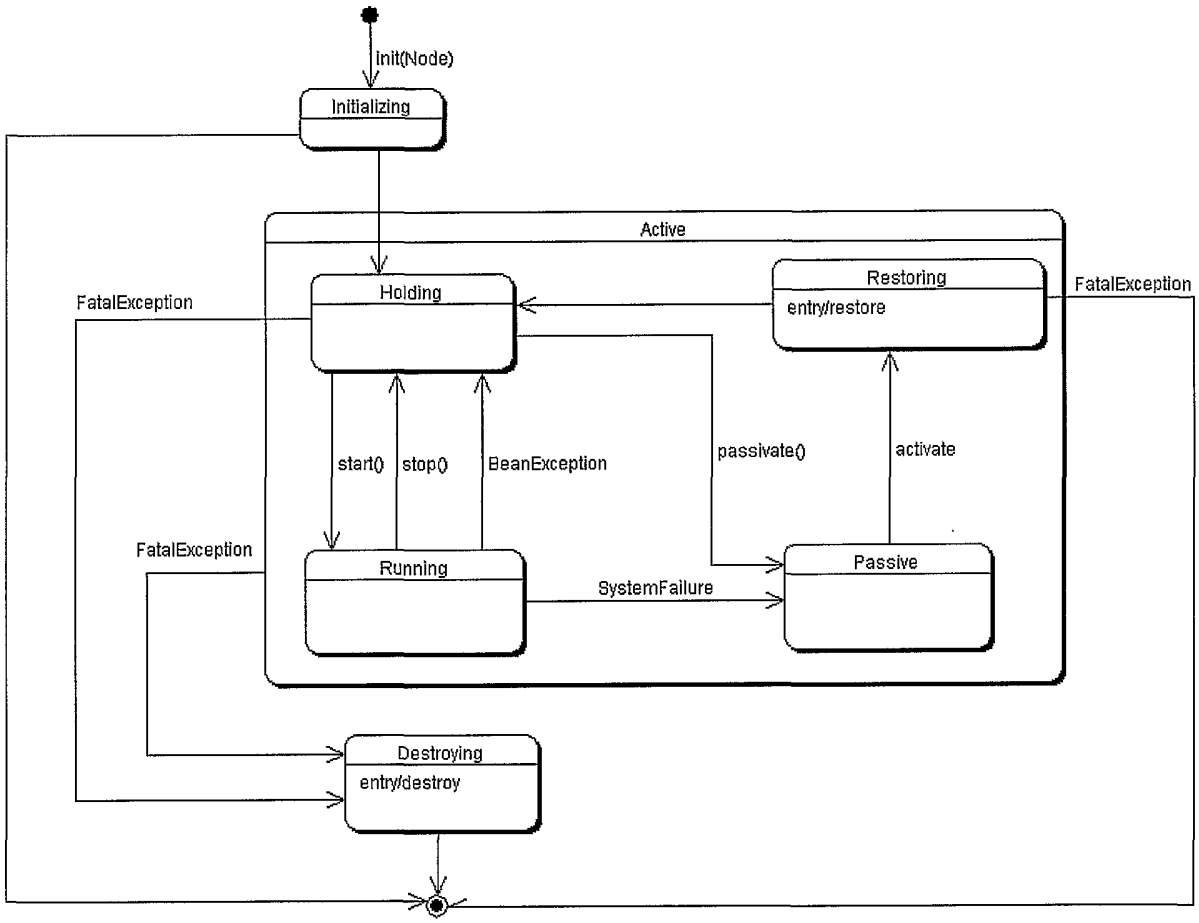

init(Node)
Initializing
Active
Holding
Restoring
entry/restore
FatalException
FatalException
start()
stop()
BeanException
passivate()
activate
FatalException
Running
SystemFailure
Passive
Destroying
entry/destroy

FIG. 23

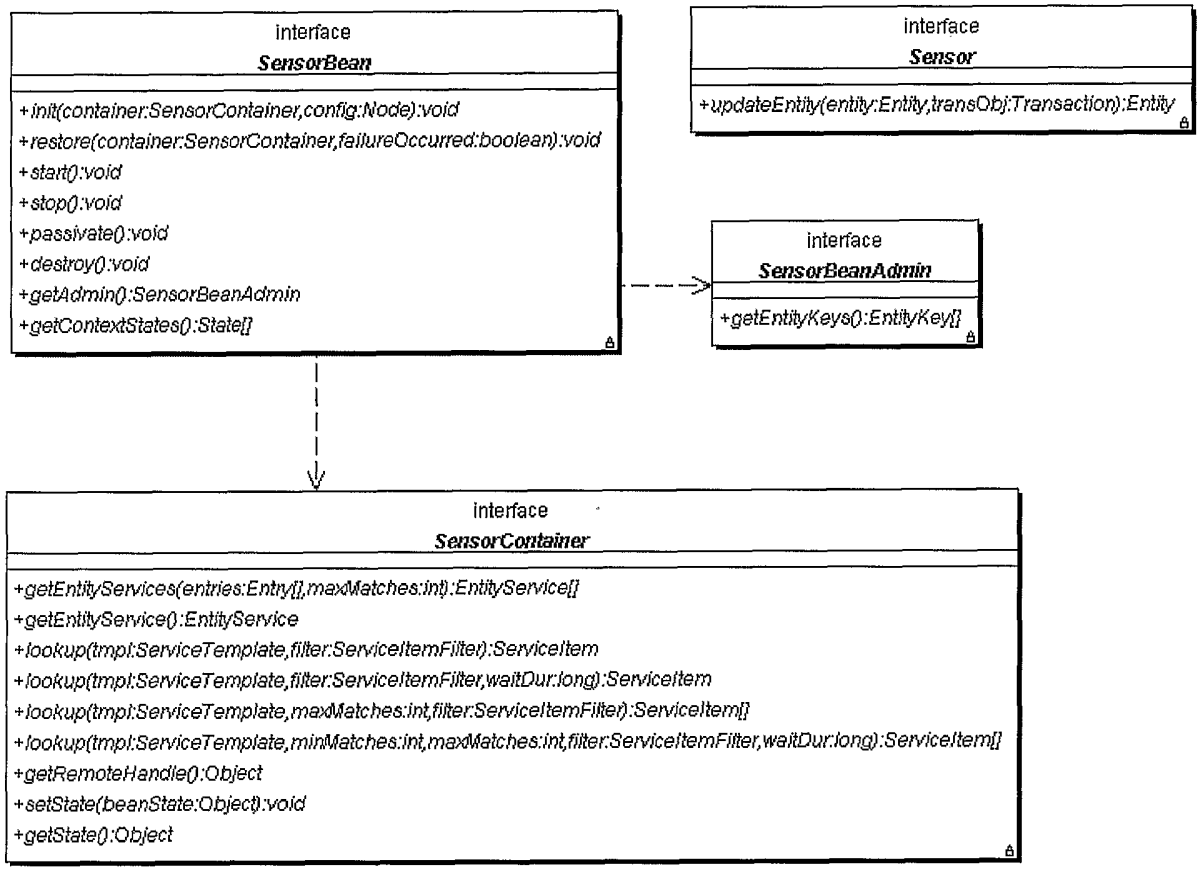

interface
SensorBean
+init(container:SensorContainer,config:Node):void
+restore(container:SensorContainer,failureOccurred:boolean):void
+start():void
+stop():void
+passivate():void
+destroy():void
+getAdmin():SensorBeanAdmin
+getContextStates():State[]
interface
Sensor
+updateEntity(entity:Entity,transObj:Transaction):Entity
interface
SensorBeanAdmin
+getEntityKeys():EntityKey[]
interface
SensorContainer
+getEntityServices(entries:Entry[],maxMatches:int):EntityService[]
+getEntityService():EntityService
+lookup(tmpl:ServiceTemplate,filter:ServiceItemFilter):ServiceItem
+lookup(tmpl:ServiceTemplate,filter:ServiceItemFilter,waitDur:long):ServiceItem
+lookup(tmpl:ServiceTemplate,maxMatches:int,filter:ServiceItemFilter):ServiceItem[]
+lookup(tmpl:ServiceTemplate,minMatches:int,maxMatches:int,filter:ServiceItemFilter,waitDur:long):ServiceItem[]
+getRemoteHandle():Object
+setState(beanState:Object):void
+getState():Object

FIG. 24

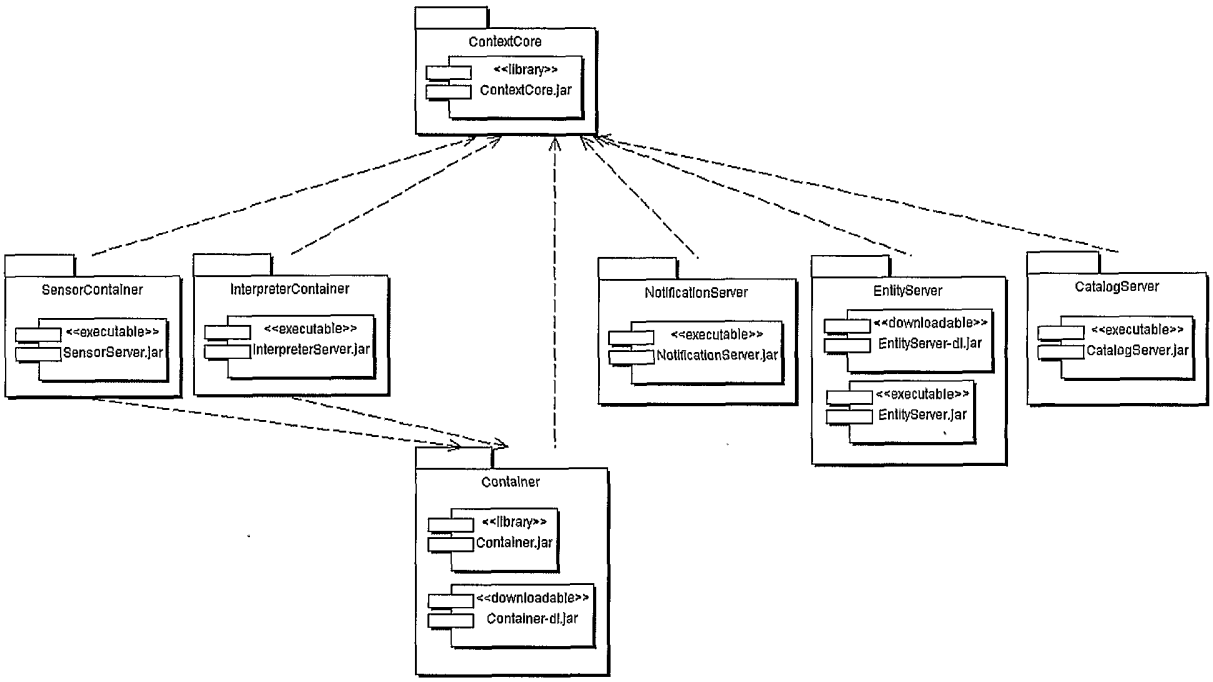

ContextCore
<<library>>
ContextCore.jar
SensorContainer
<<executable>>
SensorServer.jar
InterpreterContainer
<<executable>>
InterpreterServer.jar
NotificationServer
<<executable>>
NotificationServer.jar
EntityServer
<<downloadable>>
EntityServer-dl.jar
<<executable>>
EntityServer.jar
CatalogServer
<<executable>>
CatalogServer.jar
Container
<<library>>
Container.jar
<<downloadable>>
Container-dl.jar

FIG. 25

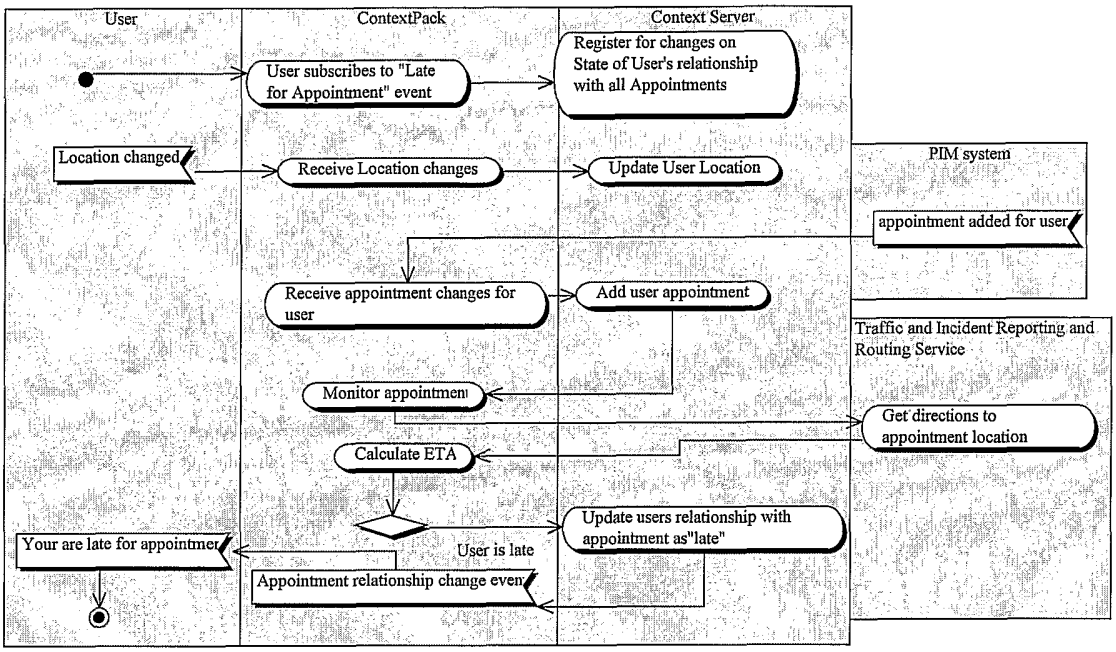

User
ContextPack
Context Server
User subscribes to "Late for Appointment" event
Register for changes on State of User's relationship with all Appointments
Location changed
Receive Location changes
Update User Location
PIM system
appointment added for user
Receive appointment changes for user
Add user appointment
Traffic and Incident Reporting and Routing Service
Monitor appointment
Get directions to appointment location
Calculate ETA
Update users relationship with appointment as"late"
Your are late for appointment
User is late
Appointment relationship change event

FIG. 26

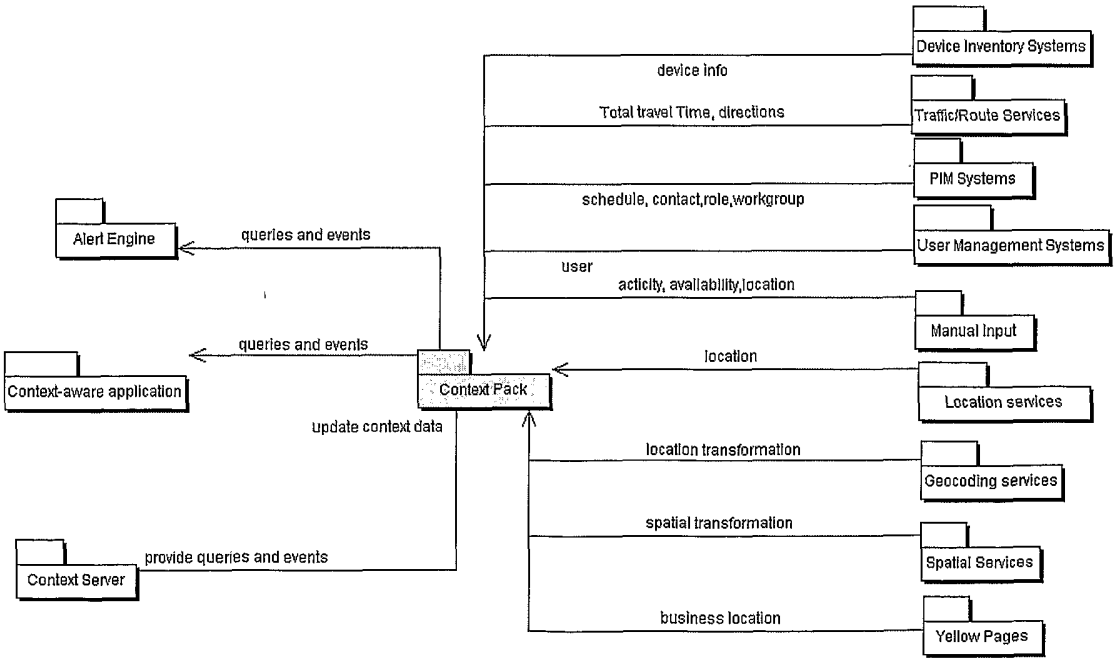

Device Inventory Systems
device info
Total travel Time, directions
Traffic/Route Services
PIM Systems
schedule, contact,role,workgroup
Alert Engine
queries and events
User Management Systems
user
acticity, availability,location
Manual Input
queries and events
location
Context-aware application
Context Pack
Location services
update context data
location transformation
Geocoding services
spatial transformation
provide queries and events
Spatial Services
Context Server
business location
Yellow Pages

FIG. 27

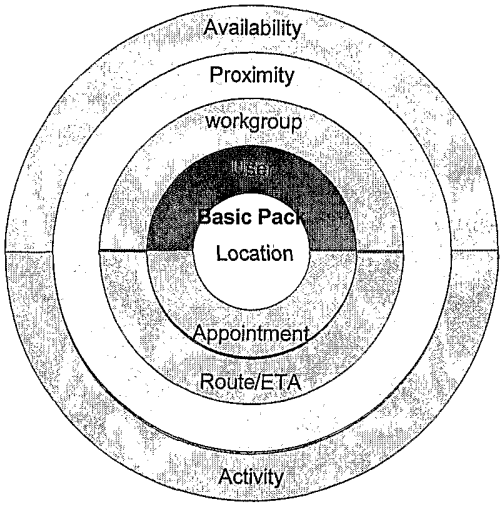

Availability
Proximity
workgroup
User
Basic Pack
Location
Appointment
Route/ETA
Activity

FIG. 28

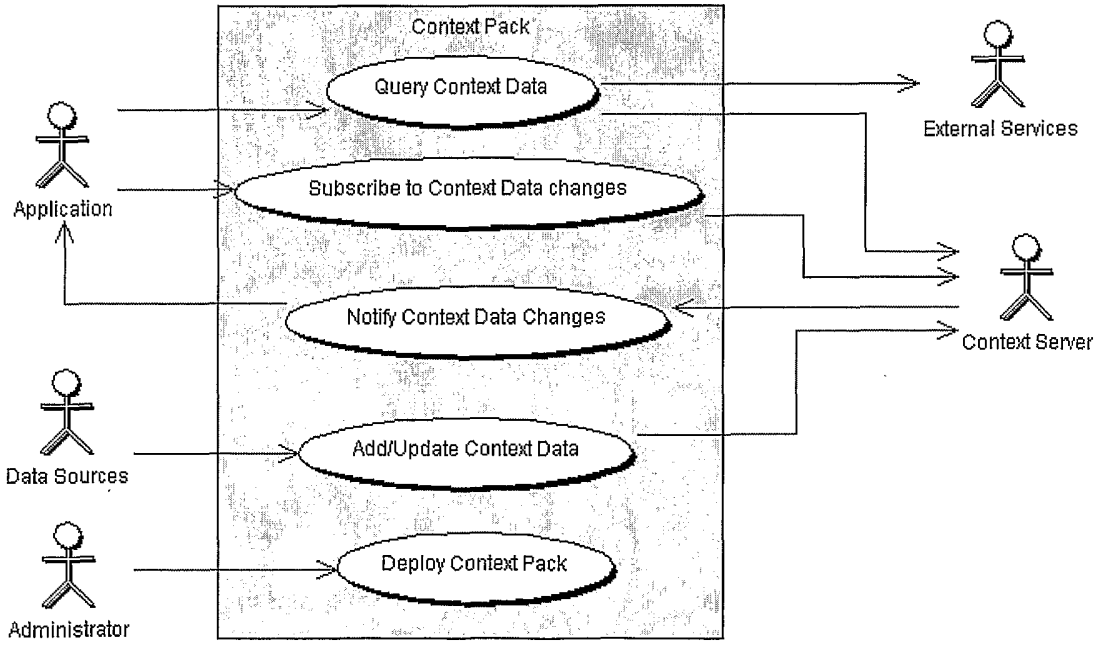

Context Pack
Query Context Data
Subscribe to Context Data changes
Notify Context Data Changes
Add/Update Context Data
Deploy Context Pack
Application
Data Sources
Administrator
External Services
Context Server

FIG. 29

Actor	Description
Application	A context aware application queries context data from the context pack. It also subscribes to Context change events and receives notifications from the Context Pack.
Data Sources	Various data sources provide data to the context pack. Examples of data sources include location services, Calendaring services, etc.
Administrator	Administrator deploys the context pack. Administrator needs to have access to and knowledge of the tools to deploy the context packs.
External Services	External services provide data transformation. Examples include Spatial, Geocoding, Traffic and direction services
Context Server	Context Server provides the platform for managing context data.

FIG. 33

Summary	
ActivityQueryBean	This interface allows queries on users activity
AppointmentQueryBean	This interface provides queries for appointment contextual data.
AvailabilityQueryBean	This interface provides the availability of the user
ProximityQueryBean	This interface provides proximity information between two locations.
TimeProximityQueryBean	This Query provides Proximity based on the Estimated travel time.
UserQueryBean	This interface provides queries for users based on a UserTemplate.

FIG. 30

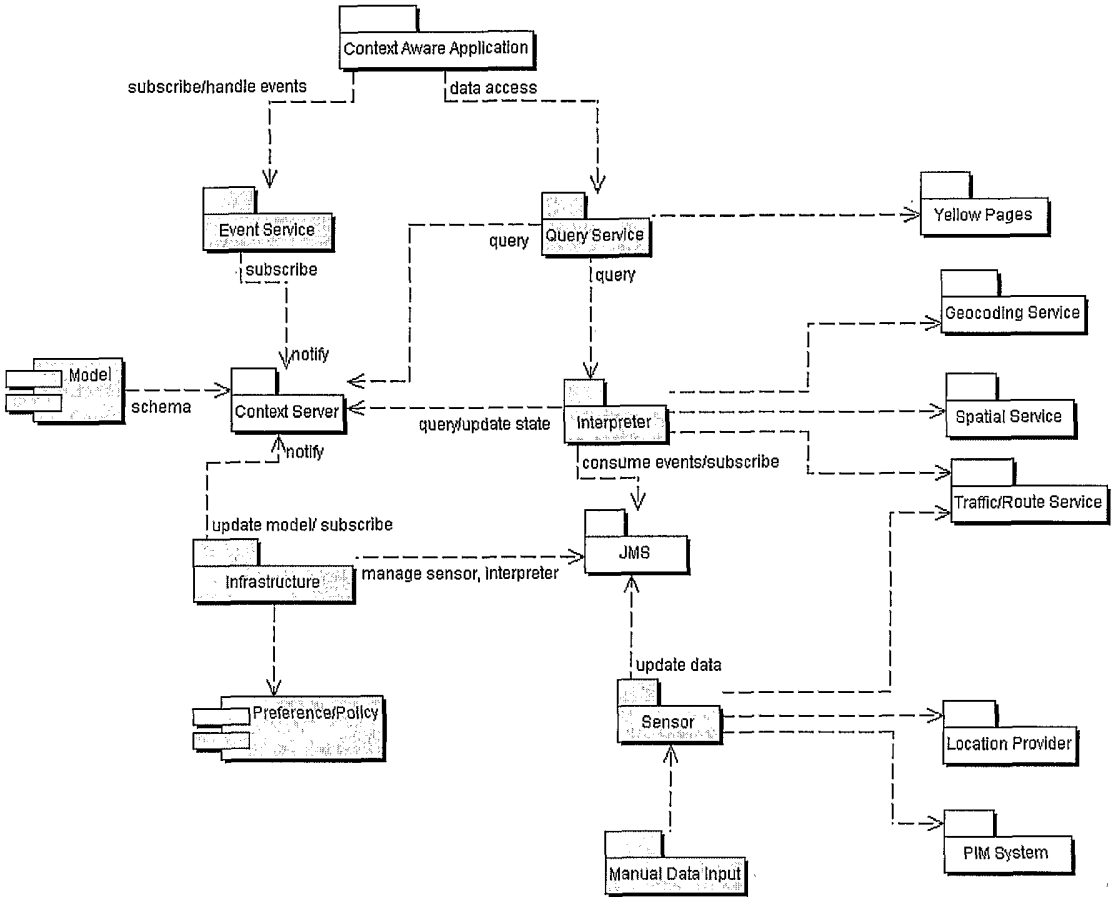

Context Aware Application
subscribe/handle events
data access
Event Service
Query Service
Yellow Pages
query
subscribe
query
Geocoding Service
notify
Model
schema
Context Server
query/update state
Interpreter
Spatial Service
notify
consume events/subscribe
Traffic/Route Service
update model/ subscribe
JMS
Infrastructure
manage sensor, interpreter
update data
Preference/Policy
Sensor
Location Provider
PIM System
Manual Data Input

FIG. 31

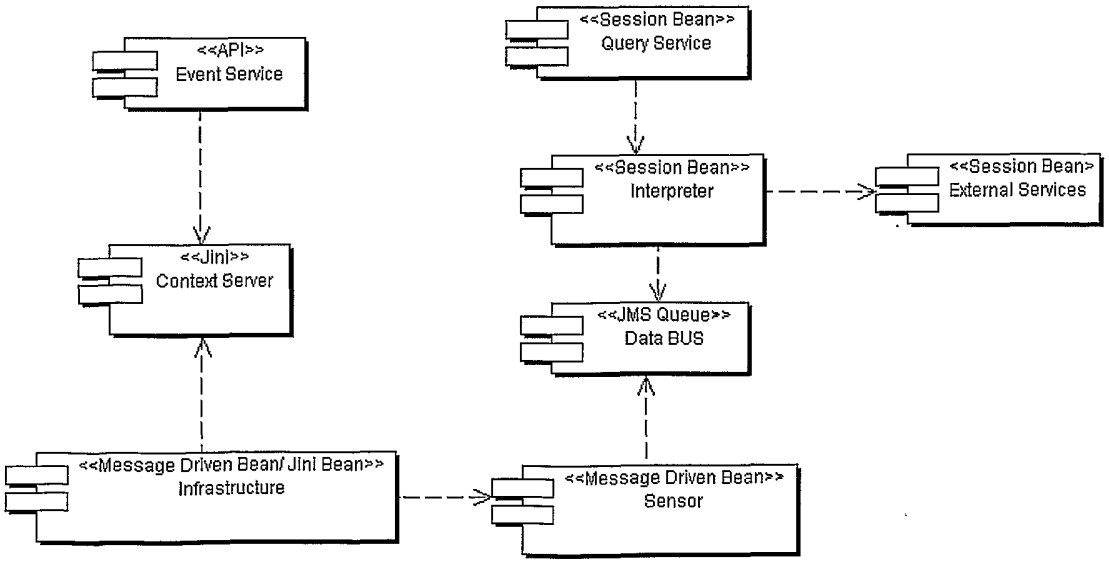

<<API>>
Event Service
<<Session Bean>>
Query Service
<<Session Bean>>
Interpreter
<<Session Bean>>
External Services
<<Jini>>
Context Server
<<JMS Queue>>
Data BUS
<<Message Driven Bean/ Jini Bean>>
Infrastructure
<<Message Driven Bean>>
Sensor

FIG. 32

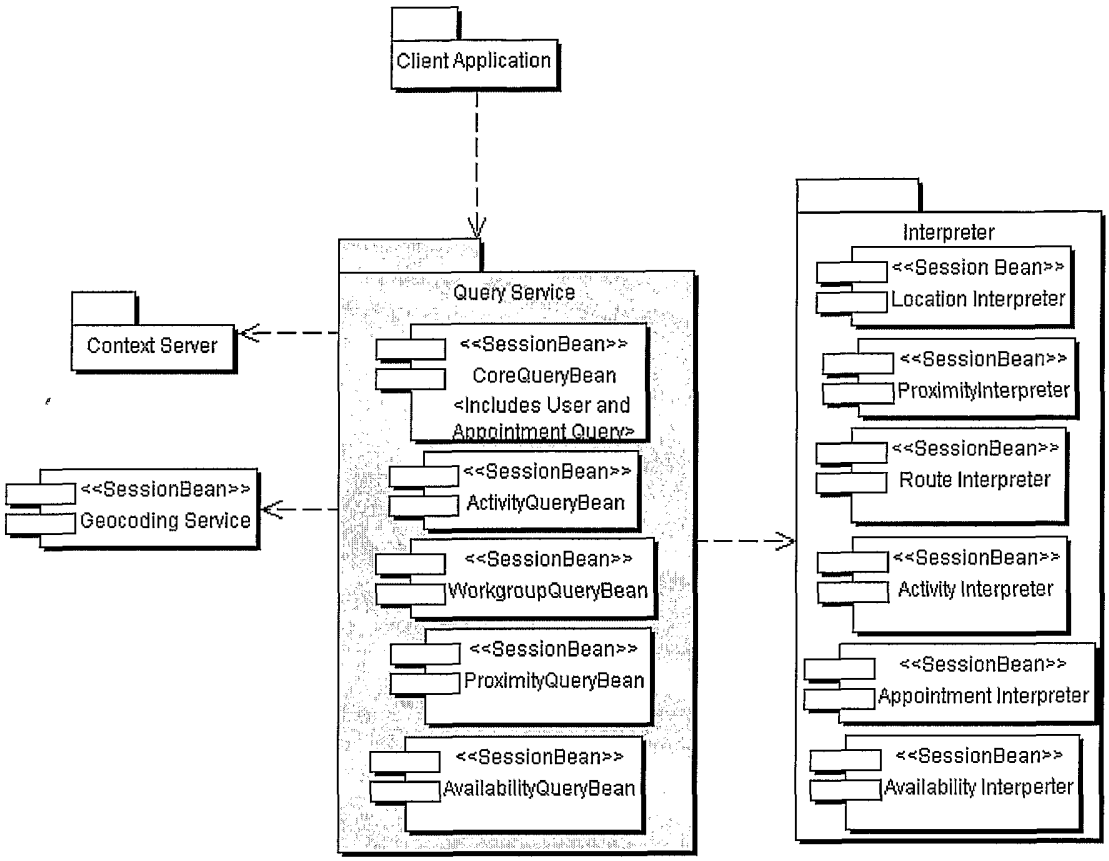

Client Application
Query Service
Context Server
<<SessionBean>>
Geocoding Service
<<SessionBean>>
CoreQueryBean
<Includes User and
Appointment Query>
<<SessionBean>>
ActivityQueryBean
<<SessionBean>>
WorkgroupQueryBean
<<SessionBean>>
ProximityQueryBean
<<SessionBean>>
AvailabilityQueryBean
Interpreter
<<Session Bean>>
Location Interpreter
<<SessionBean>>
ProximityInterpreter
<<SessionBean>>
Route Interpreter
<<SessionBean>>
Activity Interpreter
<<SessionBean>>
Appointment Interpreter
<<SessionBean>>
Availability Interperter

FIG. 34

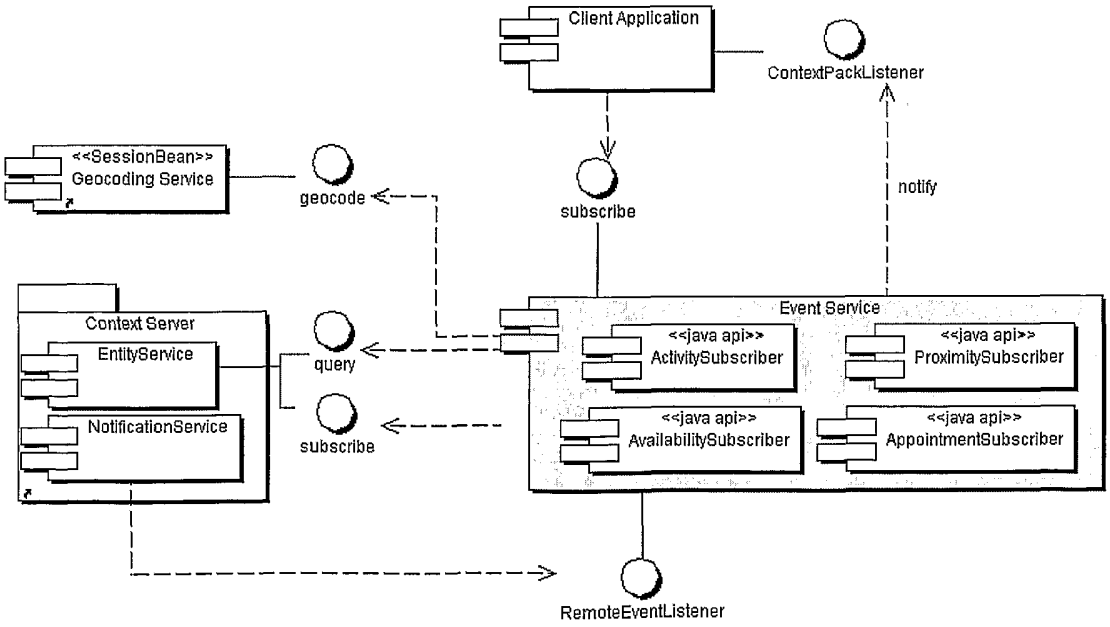

Client Application
ContextPackListener
<<SessionBean>>
Geocoding Service
geocode
subscribe
notify
Context Server
EntityService
NotificationService
query
subscribe
Event Service
<<java api>>
ActivitySubscriber
<<java api>>
ProximitySubscriber
<<java api>>
AvailabilitySubscriber
<<java api>>
AppointmentSubscriber
RemoteEventListener

FIG. 35

static ContextPackRemoteEventListener	**subscribeToUserActivity**(String[] userID, ActivityTemplate filterTemplate, boolean recurring) Get asynchronously notifications when user's activity changes to certain activity(value) or generally changes

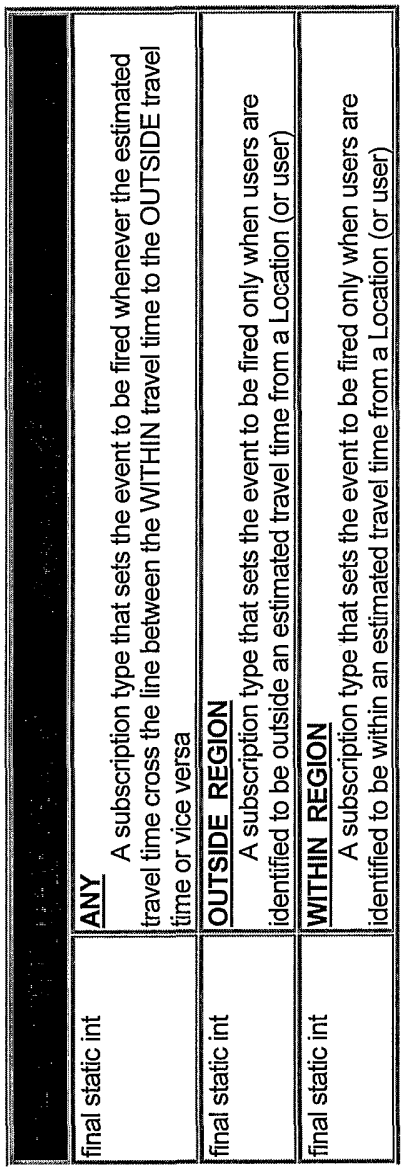
FIG. 36

static ContextPackRemoteEventListener	**subscribeToAppointmentChanges**(String[] appointmentID) Get asynchronously notifications when an Appointment changes
static ContextPackRemoteEventListener	**subscribeToUserAppointmentChanges**(String[] userID, Calendar startTime, Calendar endTime) Get asynchronously notifications when an Appointment is changed for a User.
static ContextPackRemoteEventListener	**subscribeToUserLateToAppointment**(String[] userID, String[] appointmentID) Get asynchronously notifications when a User is evaluated to be late for a meeting

FIG. 37

static ContextPackRemoteEventListener	**subscribeToUserAvailability**(String[] userID, AvailabilityTemplate filterTemplate, boolean recurring) Get asynchronously notifications when user's availability changes to certain availability(value) or generally changes

FIG. 38



final static int	**ANY** A subscription type that sets the event to be fired whenever the estimated travel time cross the line between the WITHIN travel time to the OUTSIDE travel time or vice versa
final static int	**OUTSIDE_REGION** A subscription type that sets the event to be fired only when users are identified to be outside an estimated travel time from a Location (or user)
final static int	**WITHIN_REGION** A subscription type that sets the event to be fired only when users are identified to be within an estimated travel time from a Location (or user)

FIG. 39

static ContextPackRemoteEventListener	**subscribeToTravelTimeProximityFromLocation**(String[] userID, Location location, int minutes, int changeType, boolean recurring) Get asynchronously notifications when user(s) travel time to Location match a criteria
static ContextPackRemoteEventListener	**subscribeToTravelTimeProximityFromUser**(String[] userID, String user, int minutes, int changeType, boolean recurring) Get asynchronously notifications when user(s) travel time to other User match a criteria

FIG. 40

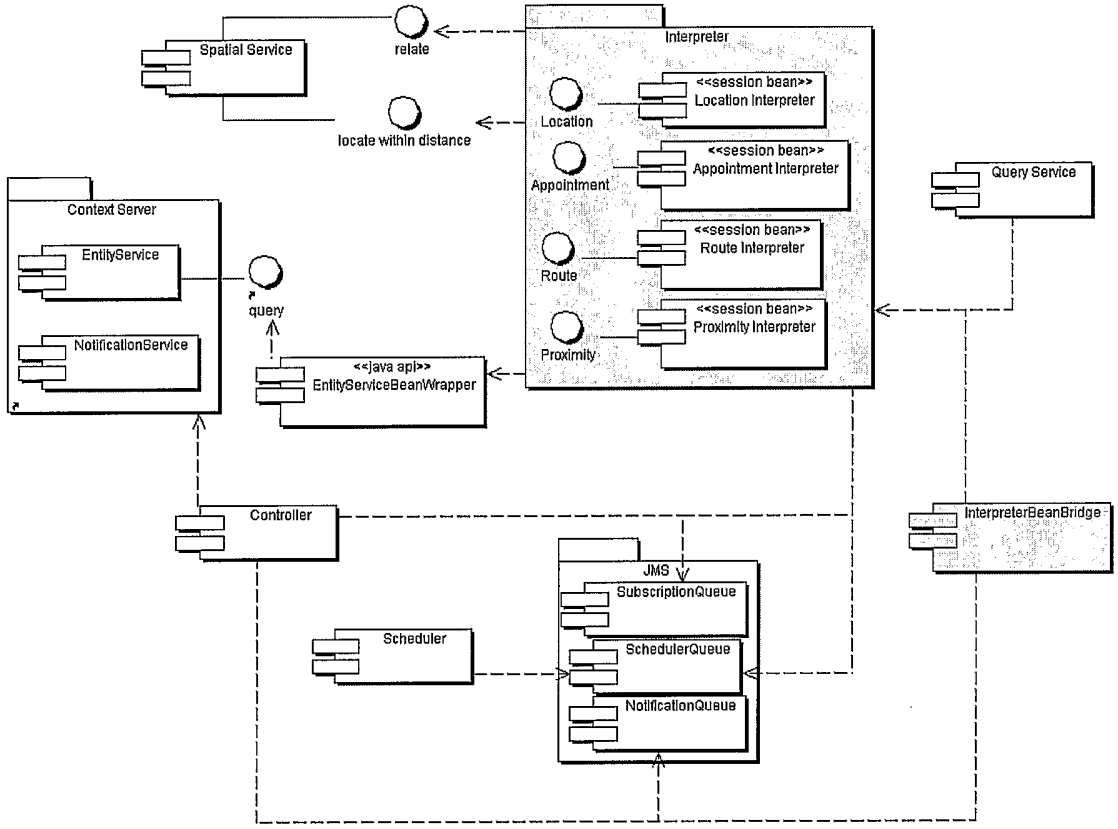

Spatial Service
relate
locate within distance
Interpreter
Location
<<session bean>>
Location Interpreter
Appointment
<<session bean>>
Appointment Interpreter
Route
<<session bean>>
Route Interpreter
Proximity
<<session bean>>
Proximity Interpreter
Query Service
Context Server
EntityService
NotificationService
query
<<java api>>
EntityServiceBeanWrapper
Controller
InterpreterBeanBridge
JMS
SubscriptionQueue
SchedulerQueue
NotificationQueue
Scheduler

FIG. 41

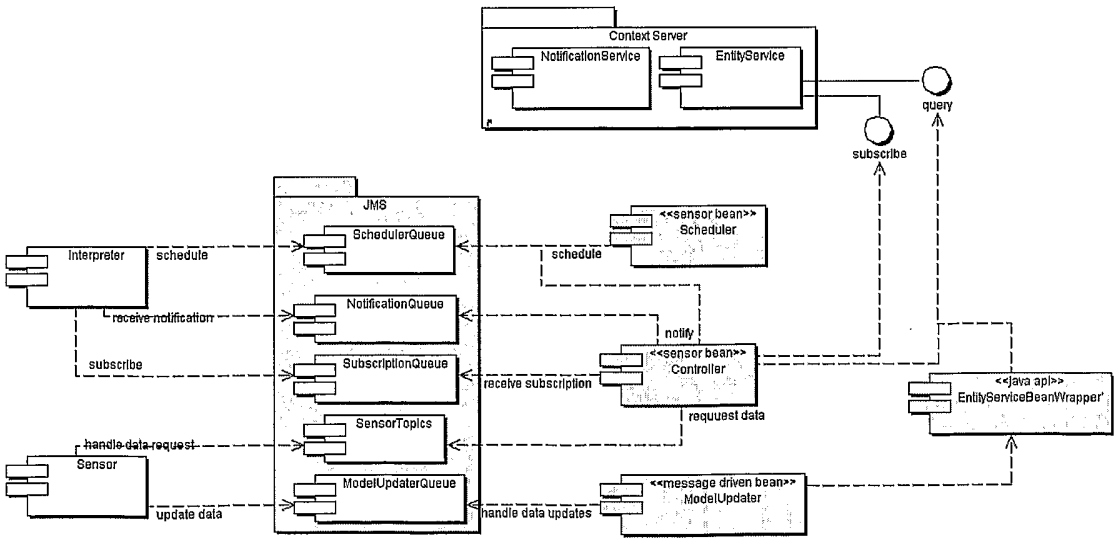

Context Server
NotificationService
EntityService
query
subscribe
JMS
SchedulerQueue
NotificationQueue
SubscriptionQueue
SensorTopics
ModelUpdaterQueue
Interpreter
schedule
receive notification
subscribe
handle data request
Sensor
update data
<<sensor bean>>
Scheduler
schedule
notify
<<sensor bean>>
Controller
receive subscription
requuest data
<<java api>>
EntityServiceBeanWrapper
<<message driven bean>>
ModelUpdater
handle data updates

FIG. 42

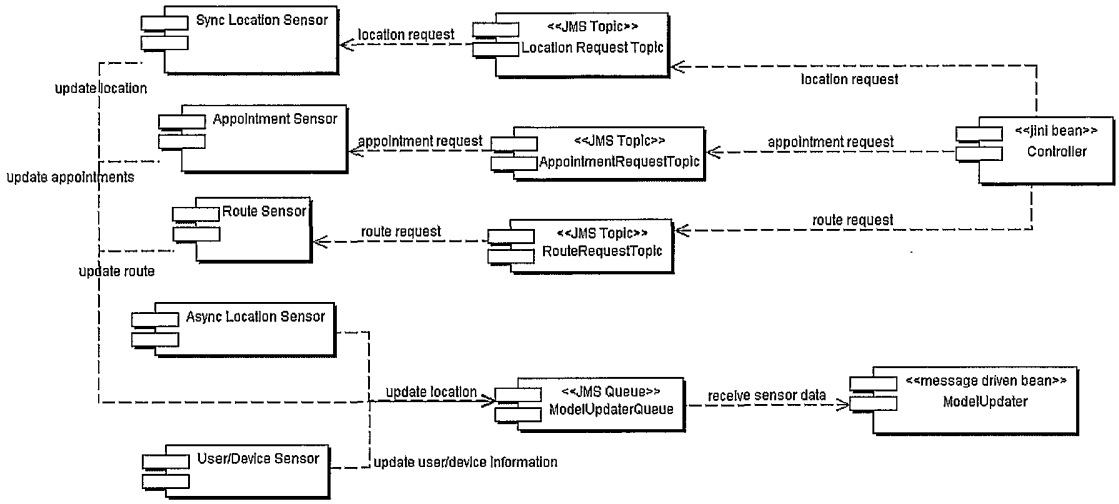

Sync Location Sensor
location request
<<JMS Topic>>
Location Request Topic
location request
update location
Appointment Sensor
appointment request
<<JMS Topic>>
AppointmentRequestTopic
appointment request
<<jini bean>>
Controller
update appointments
Route Sensor
route request
<<JMS Topic>>
RouteRequestTopic
route request
update route
Async Location Sensor
update location
<<JMS Queue>>
ModelUpdaterQueue
receive sensor data
<<message driven bean>>
ModelUpdater
User/Device Sensor
update user/device information

FIG. 44

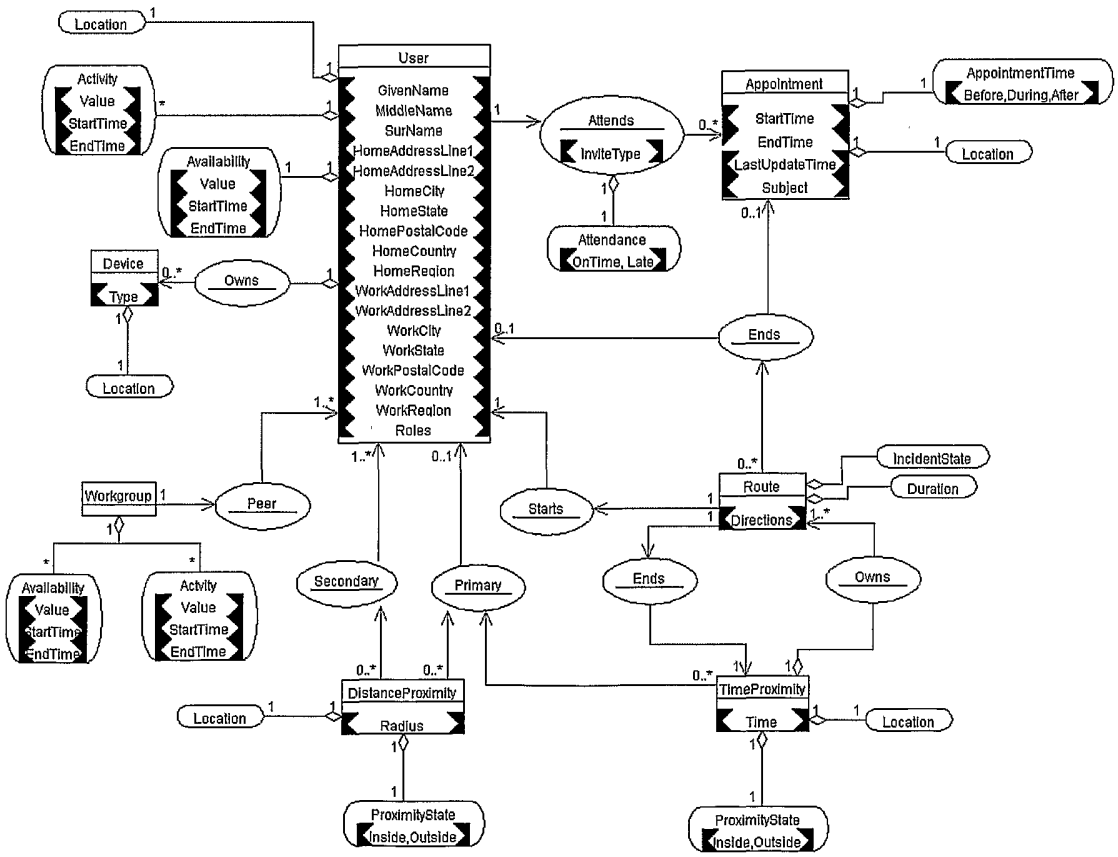

Location
User
Activity
Value
StartTime
EndTime
GivenName
MiddleName
SurName
HomeAddressLine1
HomeAddressLine2
HomeCity
HomeState
HomePostalCode
HomeCountry
HomeRegion
WorkAddressLine1
WorkAddressLine2
WorkCity
WorkState
WorkPostalCode
WorkCountry
WorkRegion
Roles
Attends
InviteType
Appointment
StartTime
EndTime
LastUpdateTime
Subject
AppointmentTime
Before,During,After
Location
Attendance
OnTime, Late
Availability
Value
StartTime
EndTime
Device
Type
Owns
Location
Ends
Workgroup
Peer
Starts
Route
Directions
IncidentState
Duration
Availability
Value
StartTime
EndTime
Activity
Value
StartTime
EndTime
Secondary
Primary
Ends
Owns
DistanceProximity
Radius
Location
TimeProximity
Time
Location
ProximityState
Inside,Outside
ProximityState
Inside,Outside

FIG. 43

No.	Destination	Description
1.	net.unwex.contextpack.infrastructure.ModelUpdaterQueue	Sensors write data from external source into this queue
2.	net.unwex.contextpack.sensor.LocationTopic	Controller sends location requests on this topic
3.	net.unwex.contextpack.sensor.CalendarTopic	Controller sends calendar (appointment) requests on this topic
4.	net.unwex.contextpack.sensor.RouteTopic	Controller sends Route requests on this topic
5.	com.unwex.contextpack.interpreter.InterpreterQueue	Controller communicates with the interpreter using this queue

FIG. 49

Table	Description
UE_CPSP_USER_PRDFND_LOCATIONS	This table stores all the predefined locations for a user.
UE_CPSP_PRDFND_LOCATIONS	This table stores all the predefined locations for the Context Pack System. It also acts as a cache for data that is obtained from external systems
US_CPSP_ADDRESSES	This table stores address information
US_CPSP_APPOINTMENTS	This table stores appointment information.
UE_CPSP_USERS_LOCATION	This table stores users location
UE_CPSP_ATTENDEES	This table stores attendee information for appointments.

FIG. 45

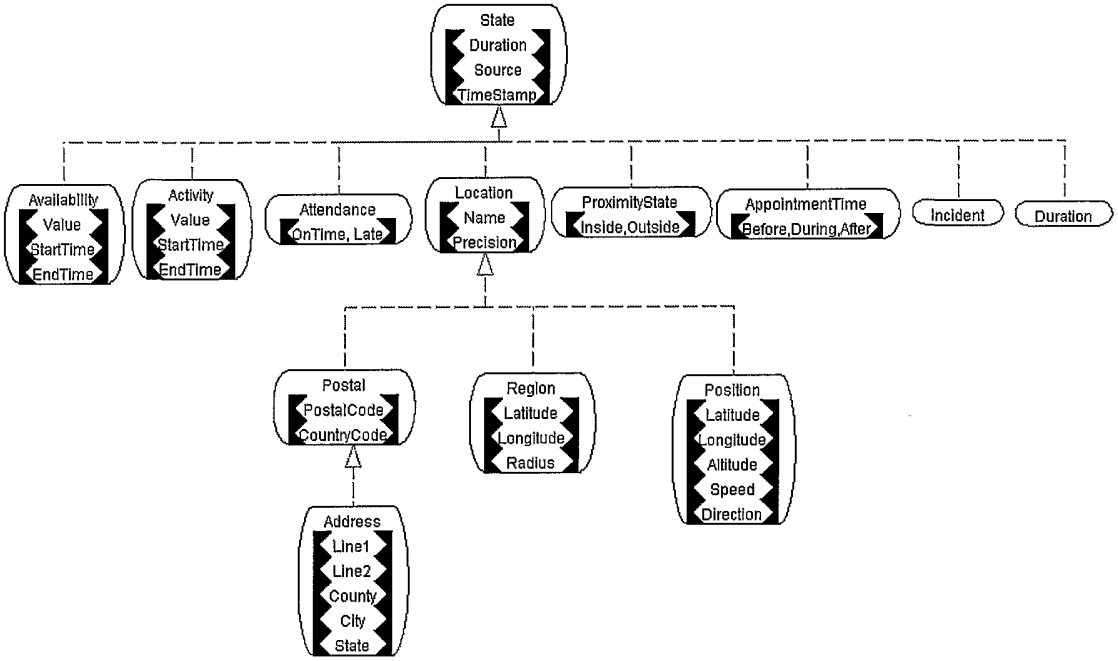

State
Duration
Source
TimeStamp
Availability
Value
StartTime
EndTime
Activity
Value
StartTime
EndTime
Attendance
OnTime, Late
Location
Name
Precision
ProximityState
Inside,Outside
AppointmentTime
Before,During,After
Incident
Duration
Postal
PostalCode
CountryCode
Region
Latitude
Longitude
Radius
Position
Latitude
Longitude
Altitude
Speed
Direction
Address
Line1
Line2
County
City
State

FIG. 46

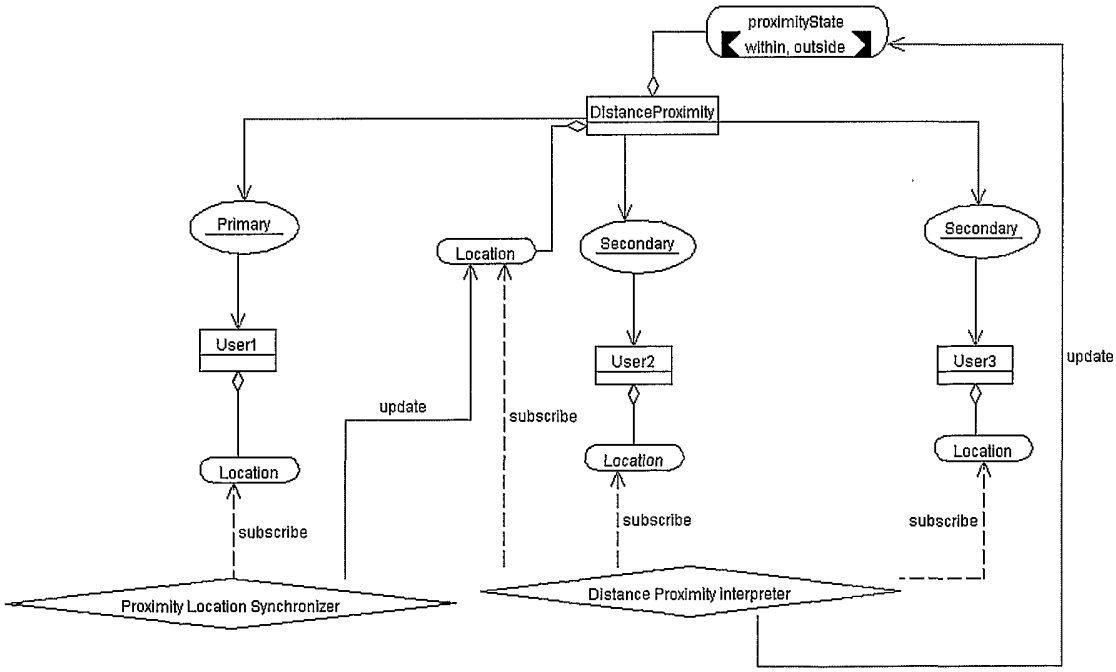

proximityState
within, outside
DistanceProximity
Primary
User1
Location
subscribe
Proximity Location Synchronizer
update
Location
subscribe
Secondary
User2
Location
subscribe
Distance Proximity Interpreter
Secondary
User3
Location
subscribe
update

FIG. 47

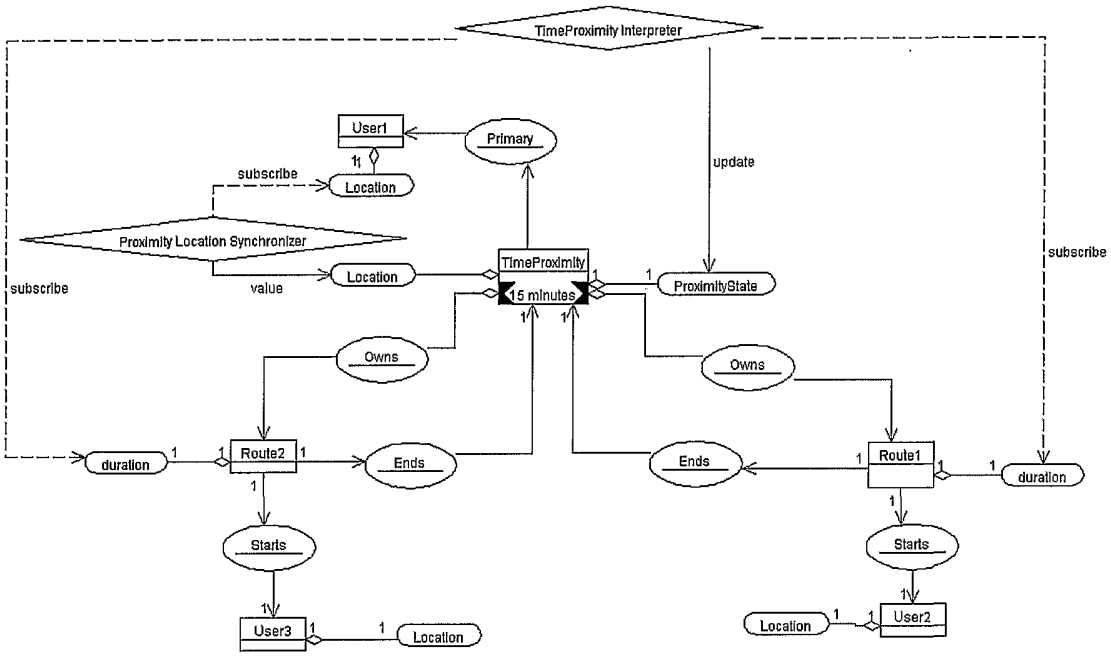

TimeProximity Interpreter
User1
Primary
1
1
subscribe
Location
update
Proximity Location Synchronizer
subscribe
value
Location
TimeProximity
15 minutes
ProximityState
subscribe
Owns
Owns
duration
1
Route2
1
Ends
Ends
Route1
duration
Starts
Starts
User3
Location
Location
User2

FIG. 48

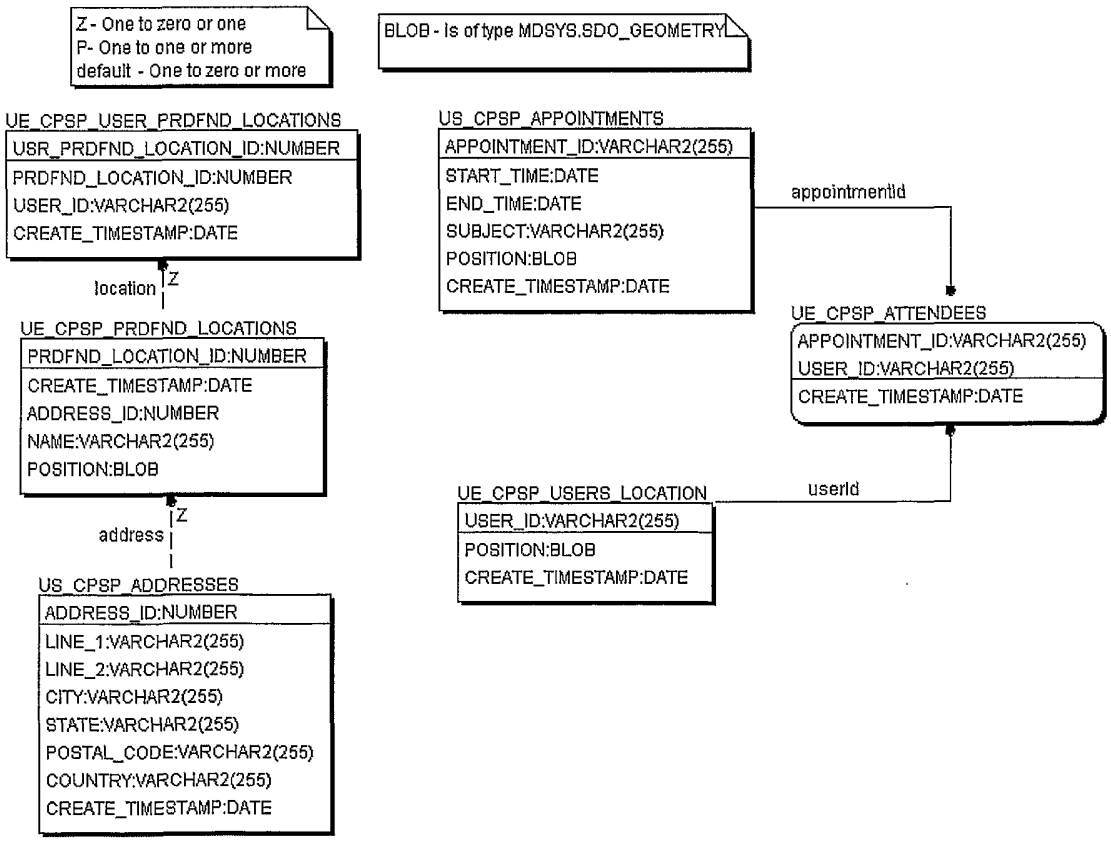

Z - One to zero or one
P- One to one or more
default - One to zero or more
BLOB - Is of type MDSYS.SDO_GEOMETRY
UE_CPSP_USER_PRDFND_LOCATIONS
USR_PRDFND_LOCATION_ID:NUMBER
PRDFND_LOCATION_ID:NUMBER
USER_ID:VARCHAR2(255)
CREATE_TIMESTAMP:DATE
location
Z
UE_CPSP_PRDFND_LOCATIONS
PRDFND_LOCATION_ID:NUMBER
CREATE_TIMESTAMP:DATE
ADDRESS_ID:NUMBER
NAME:VARCHAR2(255)
POSITION:BLOB
address
Z
US_CPSP_ADDRESSES
ADDRESS_ID:NUMBER
LINE_1:VARCHAR2(255)
LINE_2:VARCHAR2(255)
CITY:VARCHAR2(255)
STATE:VARCHAR2(255)
POSTAL_CODE:VARCHAR2(255)
COUNTRY:VARCHAR2(255)
CREATE_TIMESTAMP:DATE
US_CPSP_APPOINTMENTS
APPOINTMENT_ID:VARCHAR2(255)
START_TIME:DATE
END_TIME:DATE
SUBJECT:VARCHAR2(255)
POSITION:BLOB
CREATE_TIMESTAMP:DATE
appointmentId
UE_CPSP_ATTENDEES
APPOINTMENT_ID:VARCHAR2(255)
USER_ID:VARCHAR2(255)
CREATE_TIMESTAMP:DATE
UE_CPSP_USERS_LOCATION
USER_ID:VARCHAR2(255)
POSITION:BLOB
CREATE_TIMESTAMP:DATE
userId

FIG. 50

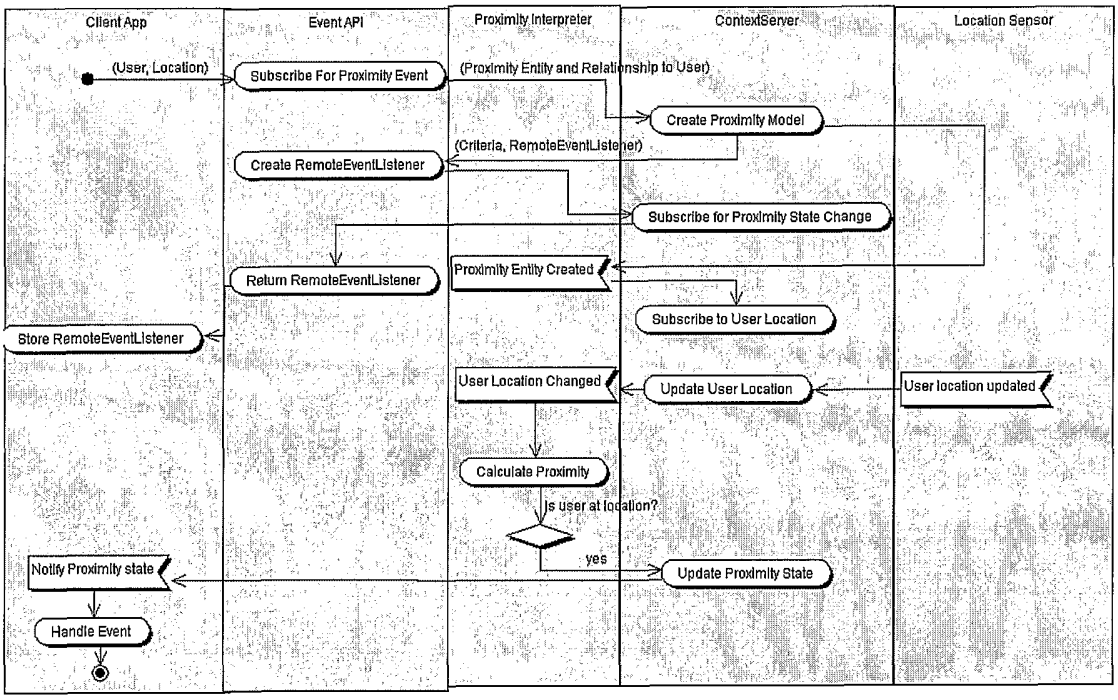

Client App
Event API
Proximity Interpreter
ContextServer
Location Sensor
(User, Location)
Subscribe For Proximity Event
(Proximity Entity and Relationship to User)
Create Proximity Model
(Criteria, RemoteEventListener)
Create RemoteEventListener
Subscribe for Proximity State Change
Return RemoteEventListener
Proximity Entity Created
Subscribe to User Location
Store RemoteEventListener
User Location Changed
Update User Location
User location updated
Calculate Proximity
Is user at location?
yes
Notify Proximity state
Update Proximity State
Handle Event

FIG. 51

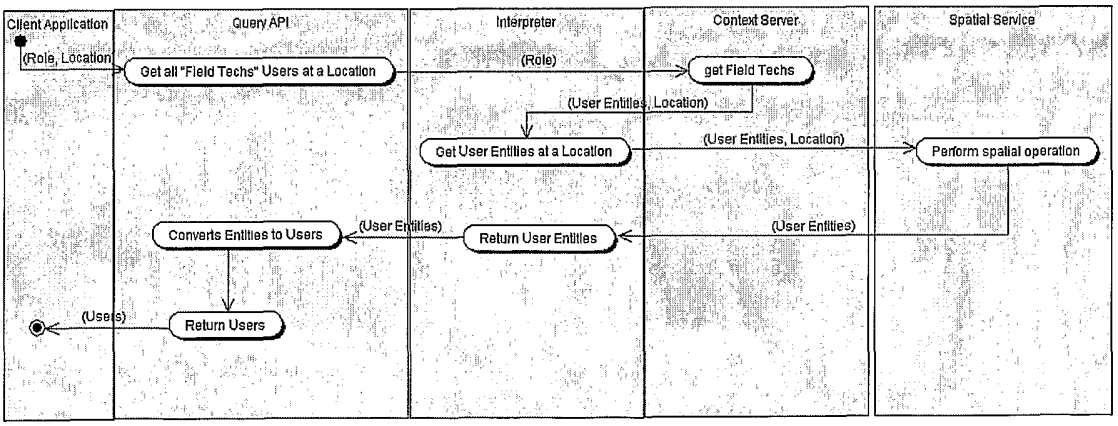

Client Application
Query API
Interpreter
Context Server
Spatial Service
(Role, Location)
Get all "Field Techs" Users at a Location
(Role)
get Field Techs
(User Entities, Location)
Get User Entities at a Location
(User Entities, Location)
Perform spatial operation
Converts Entities to Users
(User Entities)
Return User Entities
(User Entities)
(Users)
Return Users

FIG. 52

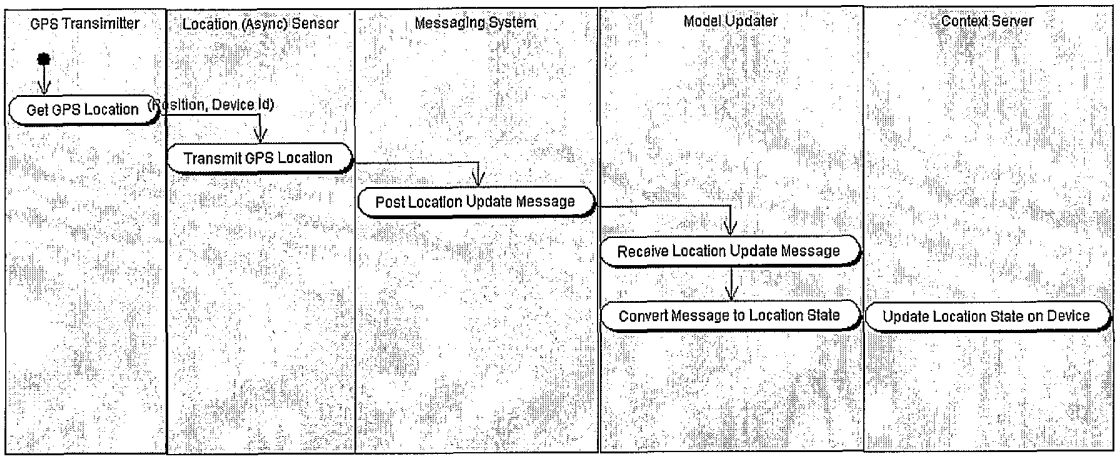

GPS Transmitter
Location (Async) Sensor
Messaging System
Model Updater
Context Server
Get GPS Location
(Position, Device Id)
Transmit GPS Location
Post Location Update Message
Receive Location Update Message
Convert Message to Location State
Update Location State on Device

FIG. 53

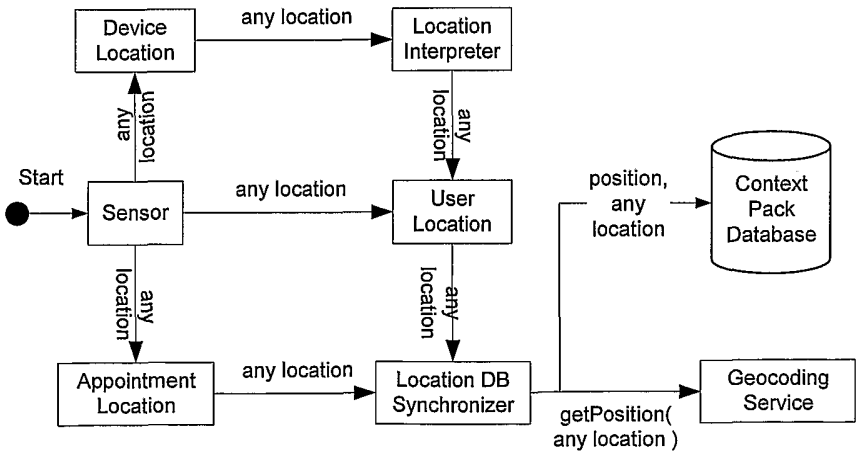

Device Location
any location
Location Interpreter
any location
any location
Start
Sensor
any location
User Location
position, any location
Context Pack Database
location any
location any
Appointment Location
any location
Location DB Synchronizer
getPosition(any location)
Geocoding Service

FIG. 54

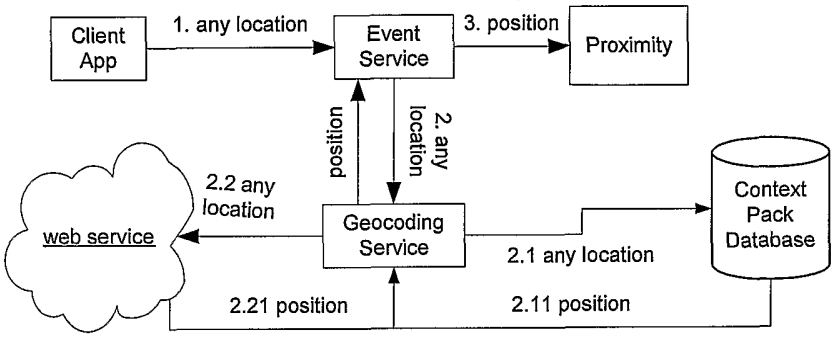

Client App
1. any location
Event Service
3. position
Proximity
position
2. any location
2.2 any location
web service
Geocoding Service
Context Pack Database
2.1 any location
2.21 position
2.11 position

FIG. 55

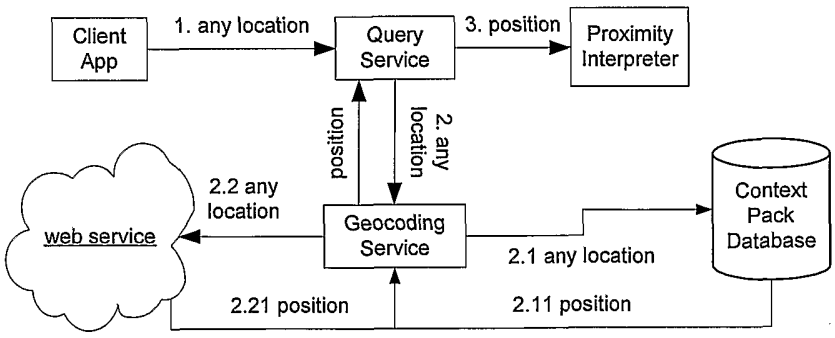

Client App
1. any location
Query Service
3. position
Proximity Interpreter
position
2. any location
2.2 any location
web service
Geocoding Service
Context Pack Database
2.1 any location
2.21 position
2.11 position

FIG. 56

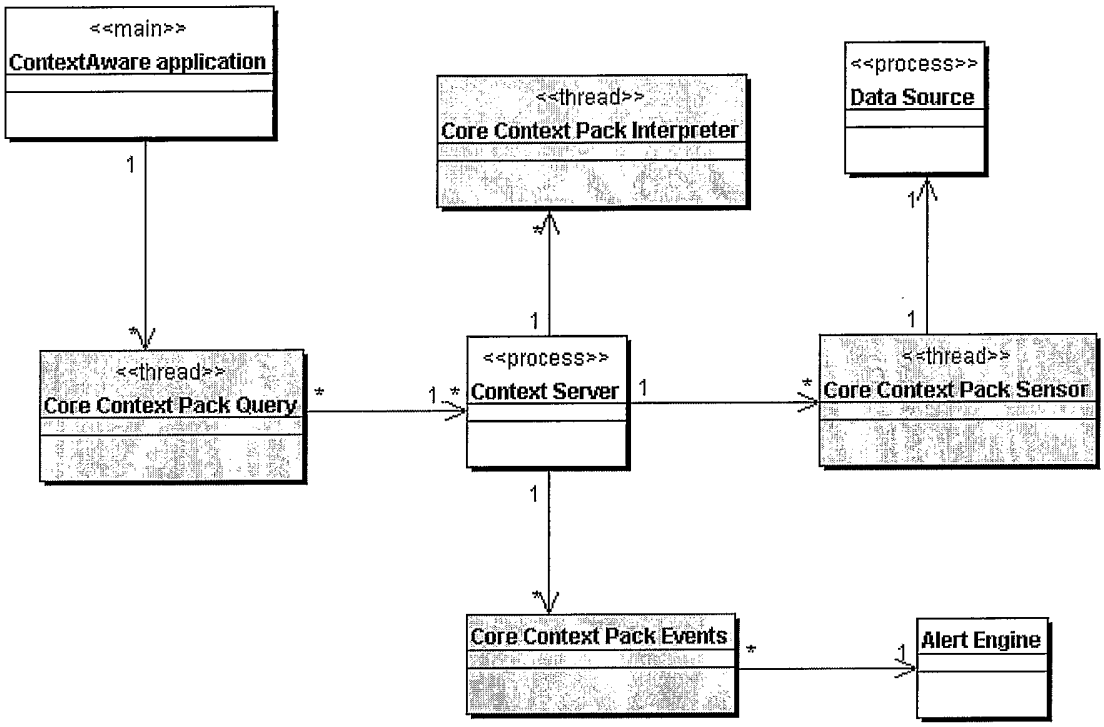
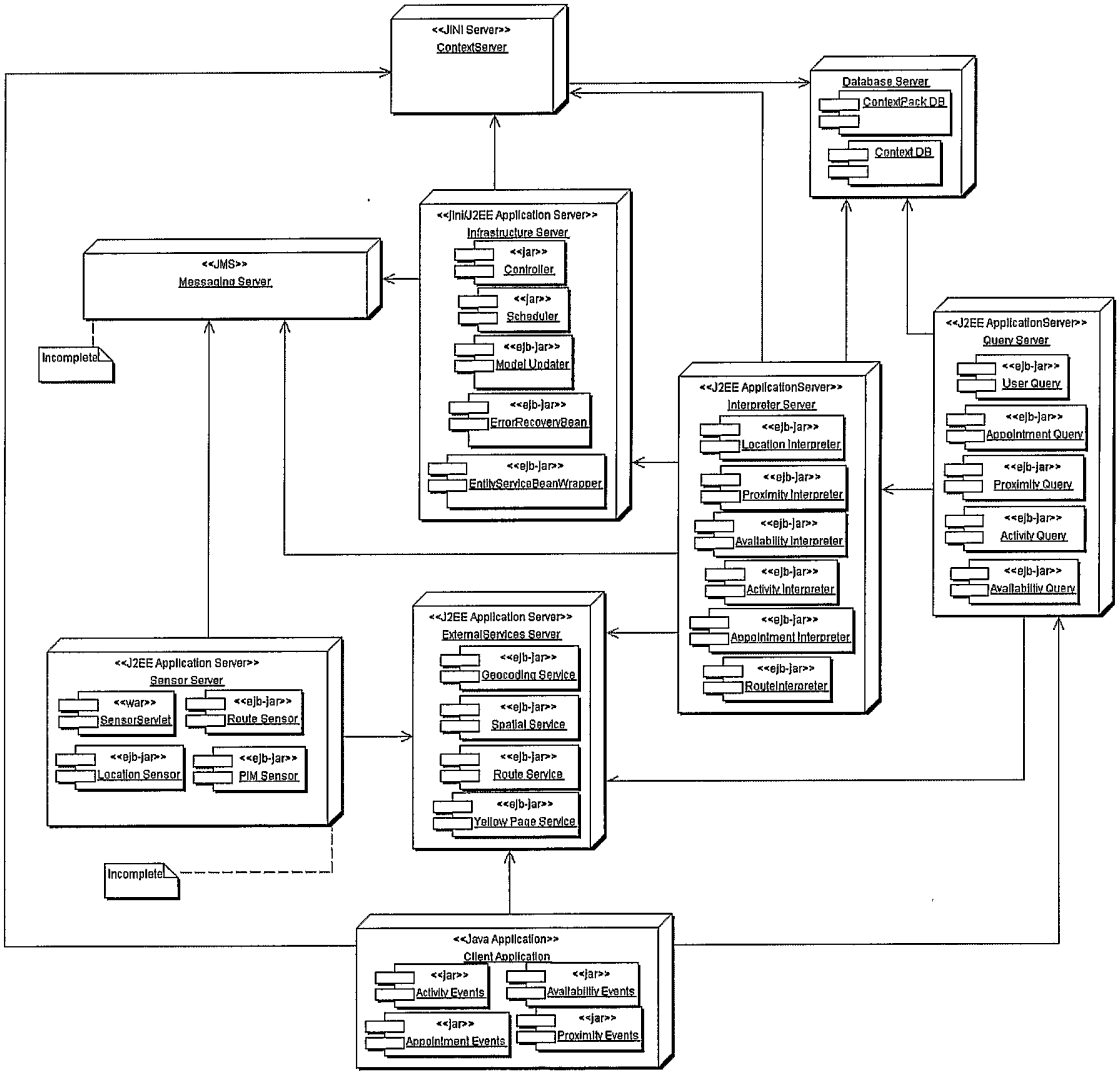

<<main>>
ContextAware application
<<thread>>
Core Context Pack Interpreter
<<process>>
Data Source
<<thread>>
Core Context Pack Query
<<process>>
Context Server
<<thread>>
Core Context Pack Sensor
Core Context Pack Events
Alert Engine
1
*

FIG. 57


<<JINI Server>>
ContextServer
Database Server
ContextPack DB
Context DB
<<JINI/J2EE Application Server>>
Infrastructure Server
<<jar>>
Controller
<<jar>>
Scheduler
<<ejb-jar>>
Model Updater
<<ejb-jar>>
ErrorRecoveryBean
<<ejb-jar>>
EntityServiceBeanWrapper
<<JMS>>
Messaging Server
Incomplete!
<<J2EE ApplicationServer>>
Interpreter Server
<<ejb-jar>>
Location Interpreter
<<ejb-jar>>
Proximity Interpreter
<<ejb-jar>>
Availability Interpreter
<<ejb-jar>>
Activity Interpreter
<<ejb-jar>>
Appointment Interpreter
<<ejb-jar>>
RouteInterpreter
<<J2EE ApplicationServer>>
Query Server
<<ejb-jar>>
User Query
<<ejb-jar>>
Appointment Query
<<ejb-jar>>
Proximity Query
<<ejb-jar>>
Activity Query
<<ejb-jar>>
Availability Query
<<J2EE Application Server>>
ExternalServices Server
<<ejb-jar>>
Geocoding Service
<<ejb-jar>>
Spatial Service
<<ejb-jar>>
Route Service
<<ejb-jar>>
Yellow Page Service
<<J2EE Application Server>>
Sensor Server
<<war>>
SensorServlet
<<ejb-jar>>
Route Sensor
<<ejb-jar>>
Location Sensor
<<ejb-jar>>
PIM Sensor
Incomplete!
<<Java Application>>
Client Application
<<jar>>
Activity Events
<<jar>>
Availability Events
<<jar>>
Appointment Events
<<jar>>
Proximity Events

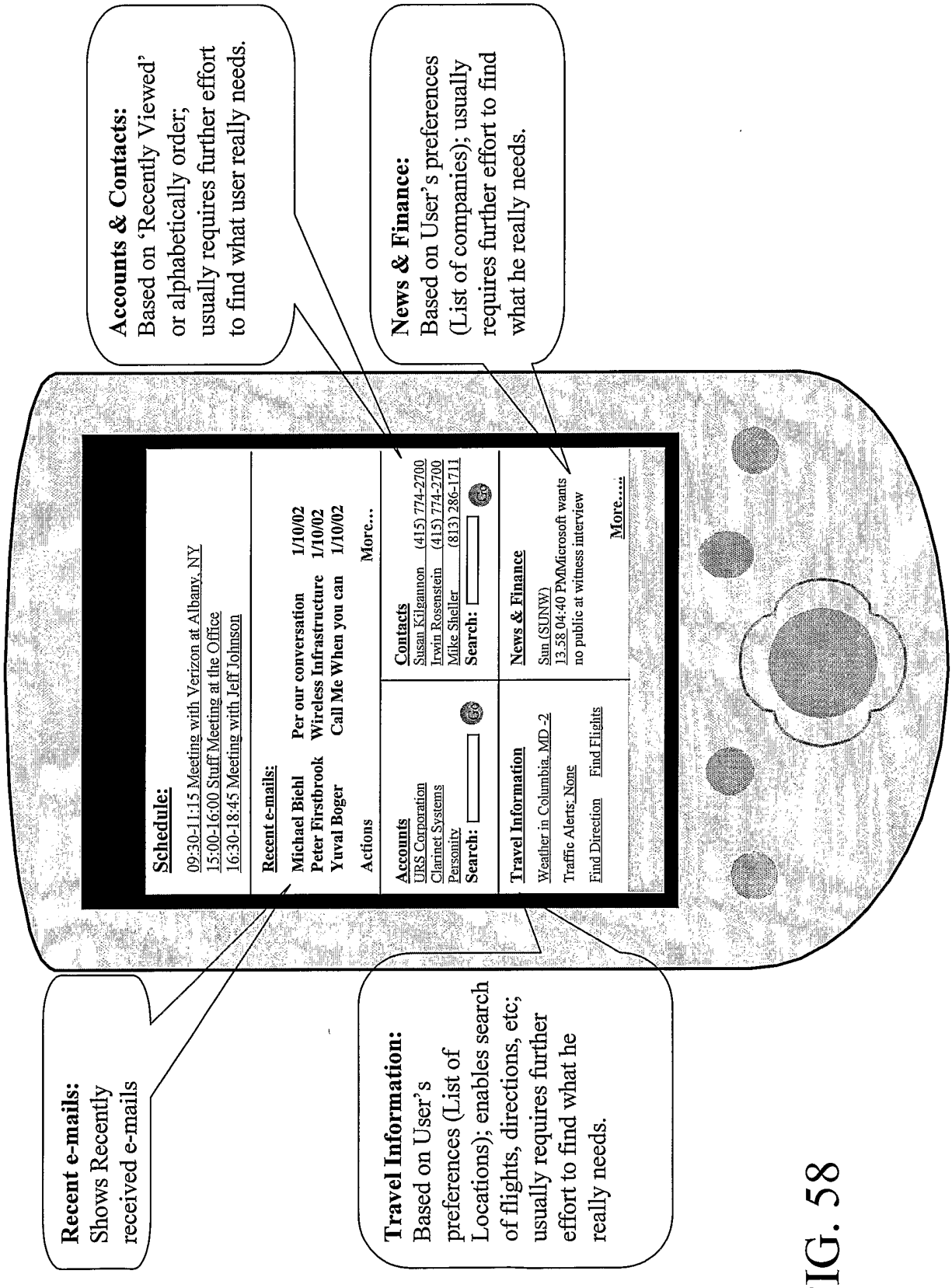
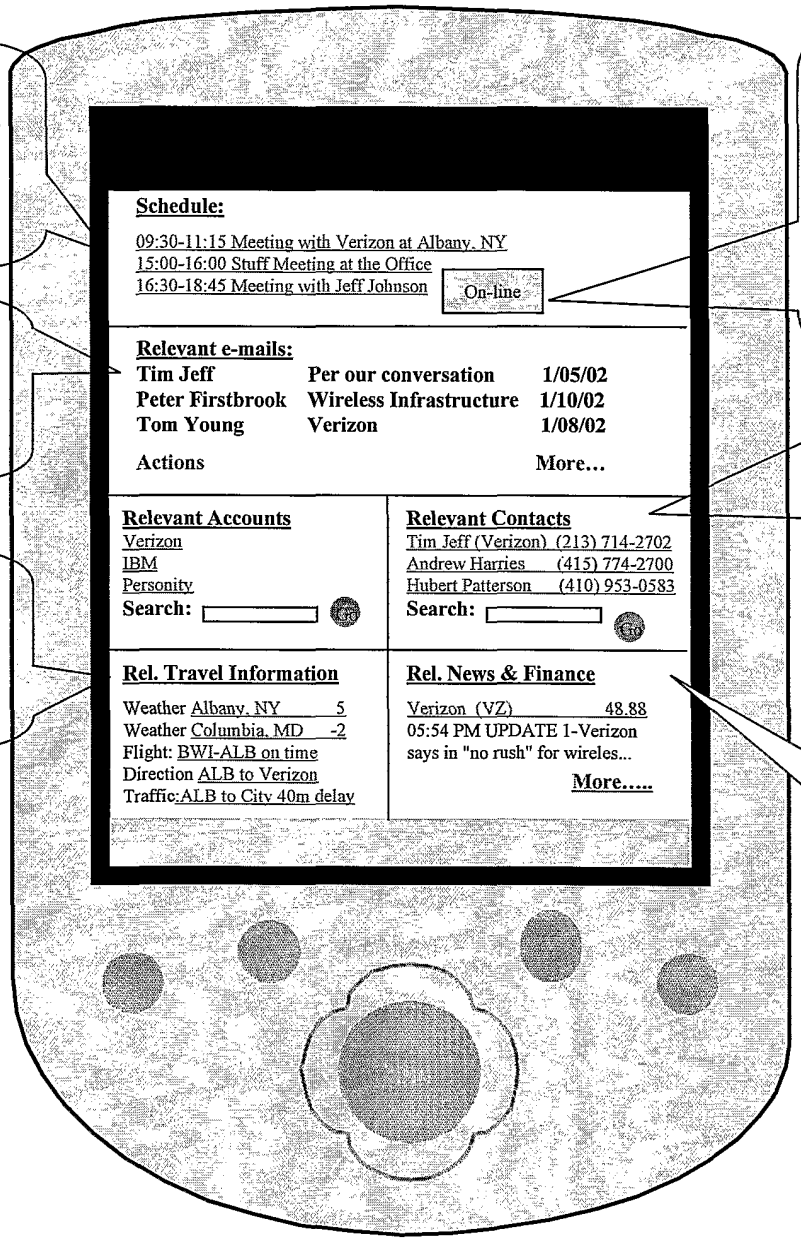

Schedule:
09:30-11:15 Meeting with Verizon at Albany, NY
15:00-16:00 Stuff Meeting at the Office
16:30-18:45 Meeting with Jeff Johnson
Recent e-mails:
Michael Biehl Per our conversation 1/10/02
Peter Firstbrook Wireless Infrastructure 1/10/02
Yuval Boger Call Me When you can 1/10/02
Actions More...
Accounts
URS Corporation
Clarinet Systems
Personity
Search:
Contacts
Susan Kilgannon (415) 774-2700
Irwin Rosenstein (415) 774-2700
Mike Sheller (813) 286-1711
Search:
Travel Information
Weather in Columbia, MD -2
Traffic Alerts: None
Find Direction Find Flights
News & Finance
Sun (SUNW)
13.58 04:40 PMMicrosoft wants
no public at witness interview
More.....
Accounts & Contacts: Based on 'Recently Viewed' or alphabetically order; usually requires further effort to find what user really needs.
News & Finance: Based on User's preferences (List of companies); usually requires further effort to find what he really needs.
Recent e-mails: Shows Recently received e-mails
Travel Information: Based on User's preferences (List of Locations); enables search of flights, directions, etc; usually requires further effort to find what he really needs.

FIG. 58

Schedule:
Inferring that the user is in a meeting w/ a customer; clicking the meeting will provide relevant actions

Relevant e-mails:
Based on User's Context: Schedule, Important Leads, Location, etc.

Travel Information:
Based on User's Context (Location, Future Location, etc.);



Schedule:
Since Jeff is a peer, the System presents his Availability and enables the user to contact Jeff immediately through the Preferred Way of Communication

Accounts & Contacts:
Inferring the relevant Account and Contacts, based on the user's Context (Schedule, Location, SFA, Task List, etc.)

News & Finance:
Based on User's Context (Location, Schedule, etc)

FIG. 59