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(54) **WIRELESS CLASSROOM RESPONSE SYSTEM**

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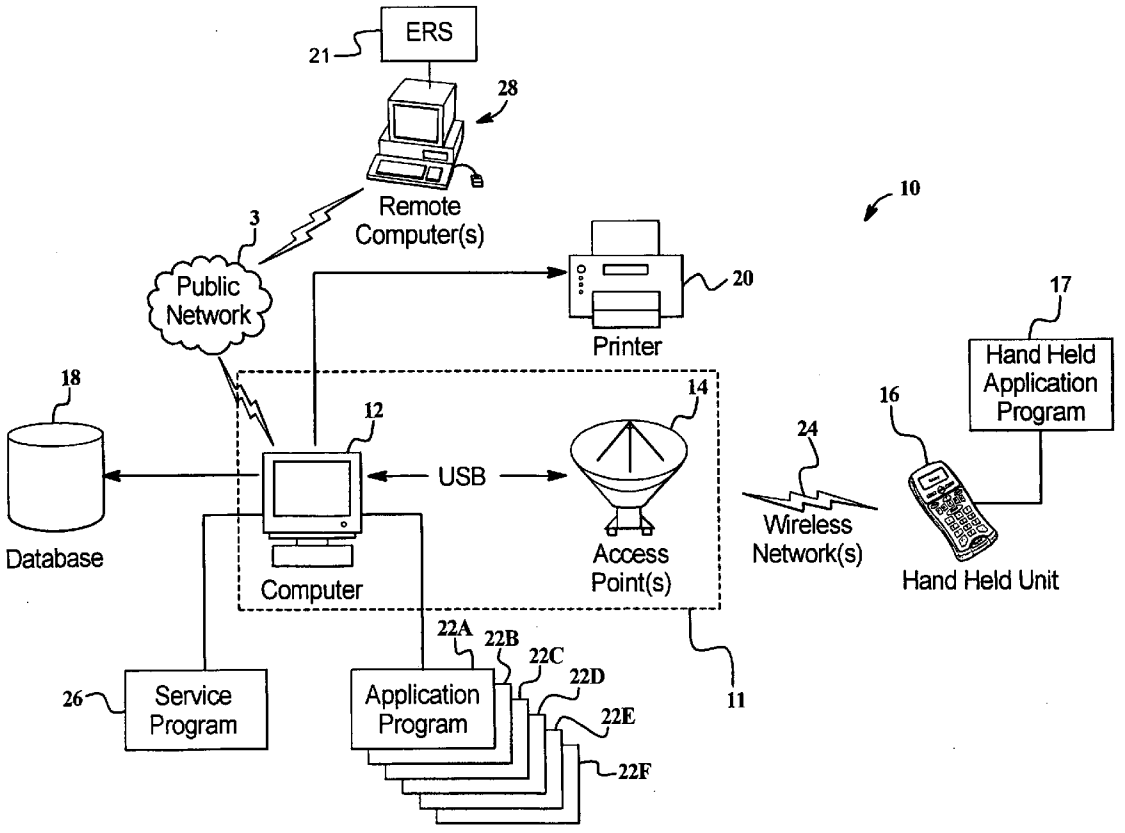
(57) **ABSTRACT**

A wireless classroom response system wireless network is located proximate to a classroom, a base station that coordinates the activities of the wireless network, and a plurality of handheld units. Each handheld unit is associated with an attendee of a class (either on a long-term or "owned basis, or on an ad-hoc or "shared" basis). Each handheld unit performs a discovery process that includes the steps of randomly choosing a wireless channel, attempting to discover the presence of the wireless network on the channel, and repeating these two steps if no wireless network is discovered.



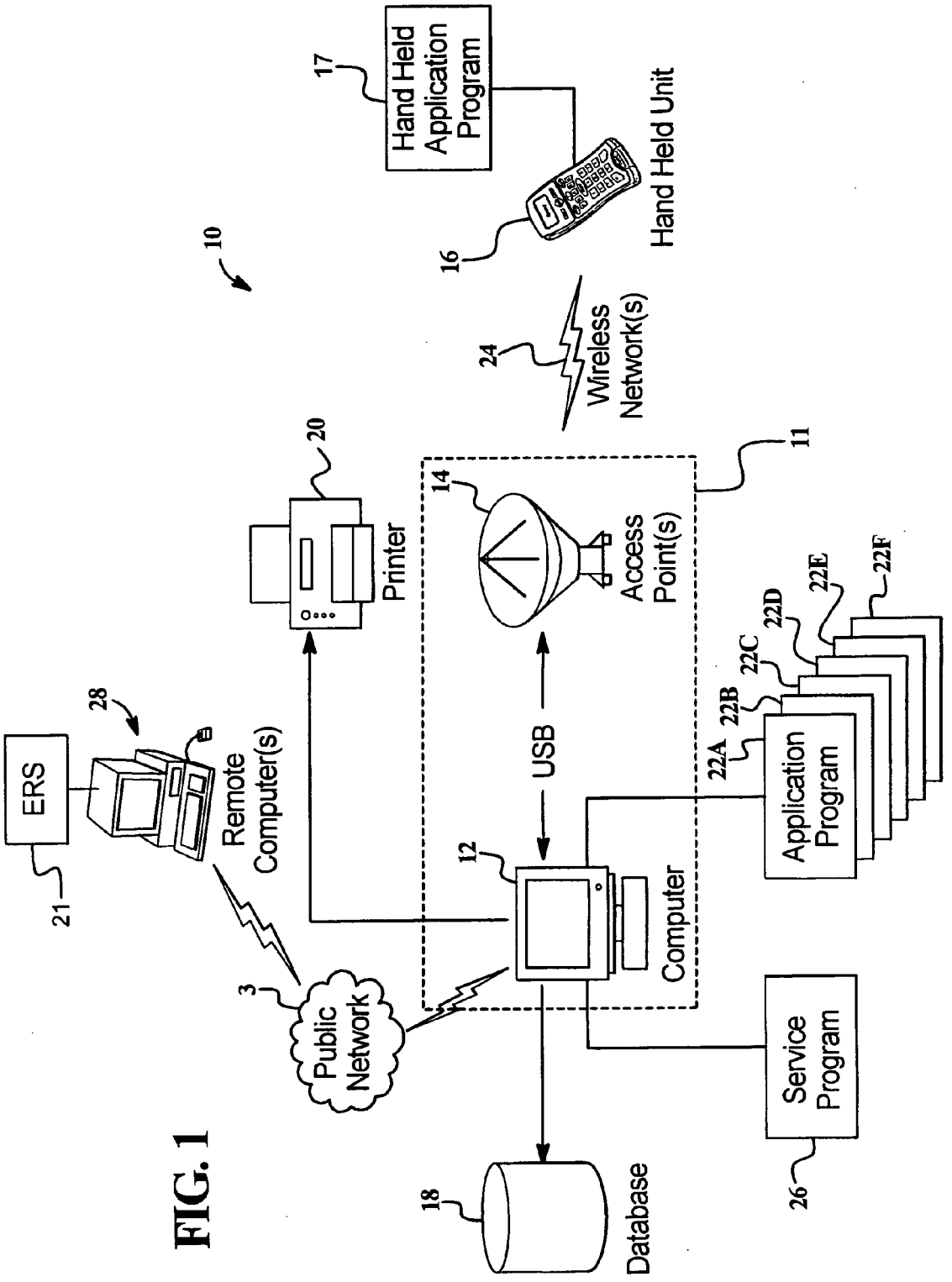

10
17
Hand Held Application Program
16
Hand Held Unit
24
Wireless Network(s)
11
20
Printer
14
Access Point(s)
22F
22E
22D
22C
22B
22A
Application Program
USB
28
ERS
Remote Computer(s)
21
12
Computer
3
Public Network
Service Program
26
18
Database

FIG. 1

FIG. 2

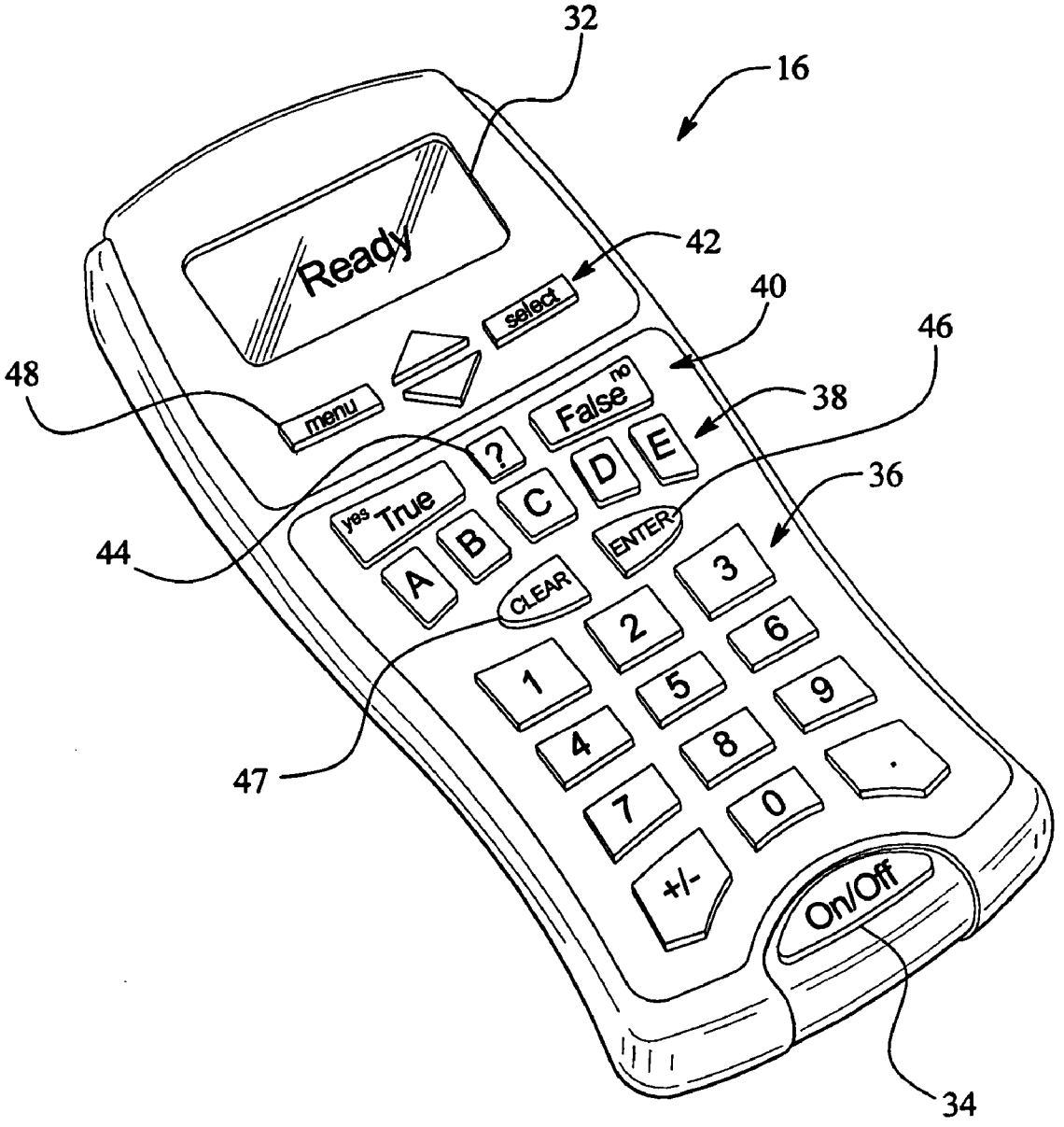

32
16
Ready
42
select
40
46
48
menu
no
False
38
?
D
E
36
yes
True
C
B
ENTER
44
A
CLEAR
3
2
6
1
5
9
4
8
.
47
7
0
+/-
On/Off
34

FIG. 3

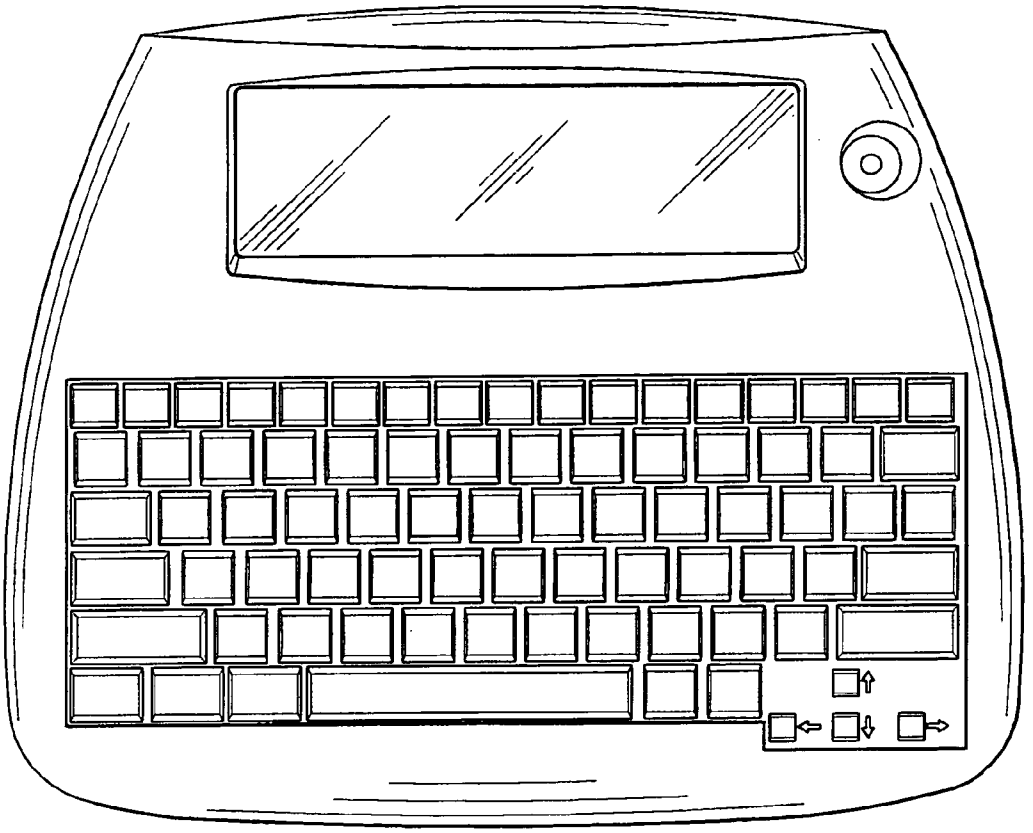
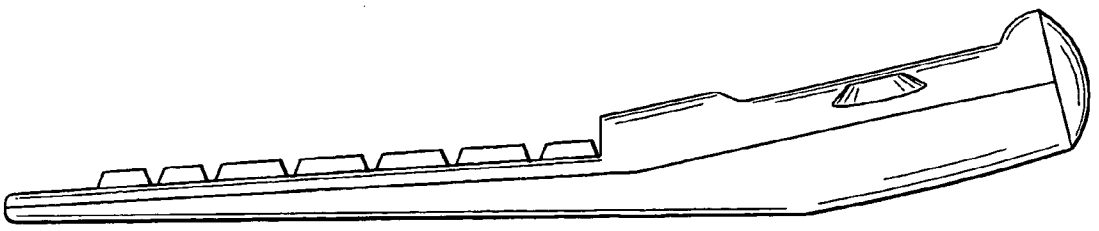


FIG. 4



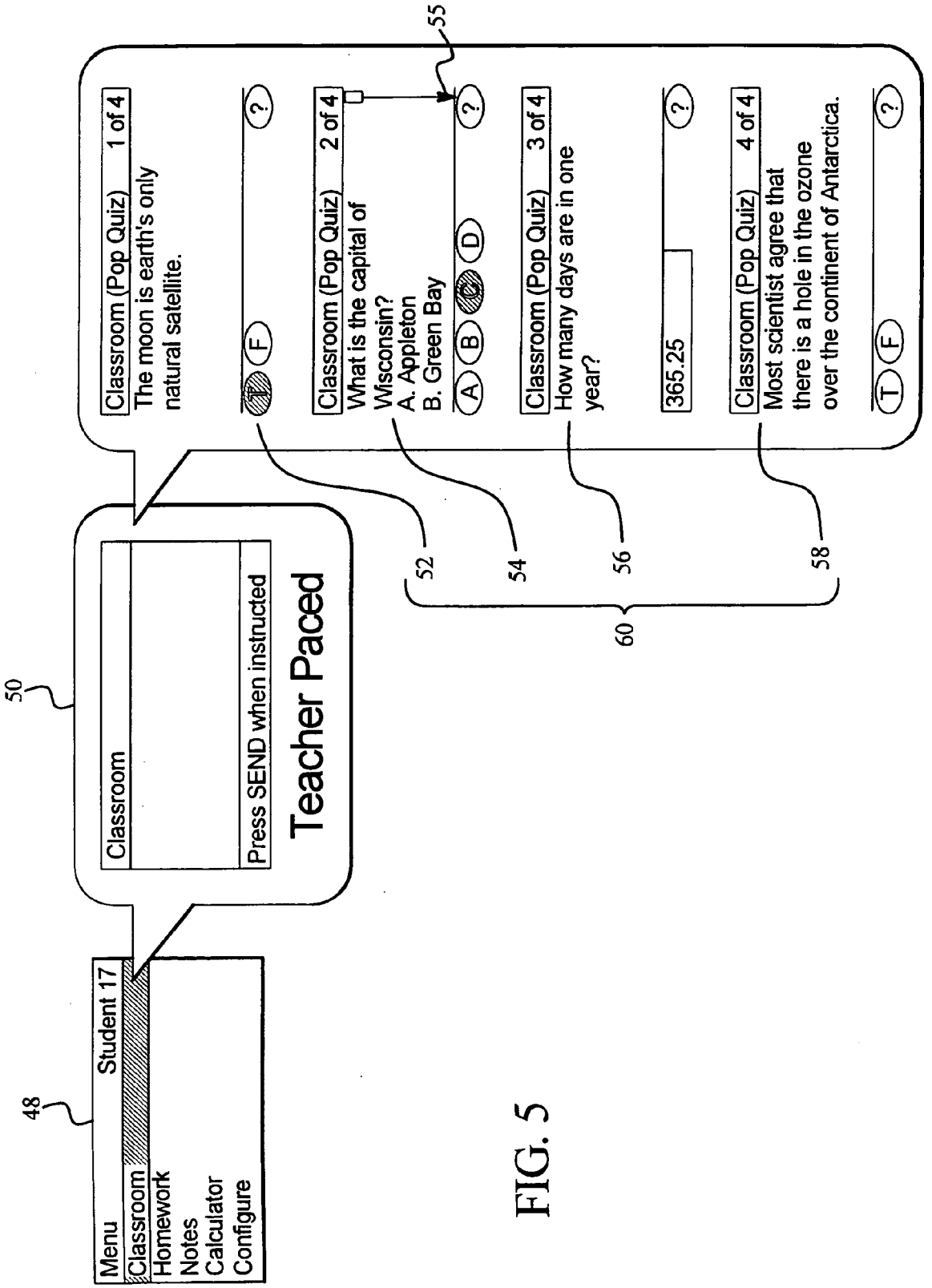

48
Menu
Student 17
Classroom
Homework
Notes
Calculator
Configure
50
Classroom
Press SEND when instructed
Teacher Paced
52
54
56
58
60
55
Classroom (Pop Quiz) 1 of 4
The moon is earth's only natural satellite.
T F ?
Classroom (Pop Quiz) 2 of 4
What is the capital of Wisconsin?
A. Appleton
B. Green Bay
A B C D ?
Classroom (Pop Quiz) 3 of 4
How many days are in one year?
365.25 ?
Classroom (Pop Quiz) 4 of 4
Most scientist agree that there is a hole in the ozone over the continent of Antarctica.
T F ?

FIG. 5

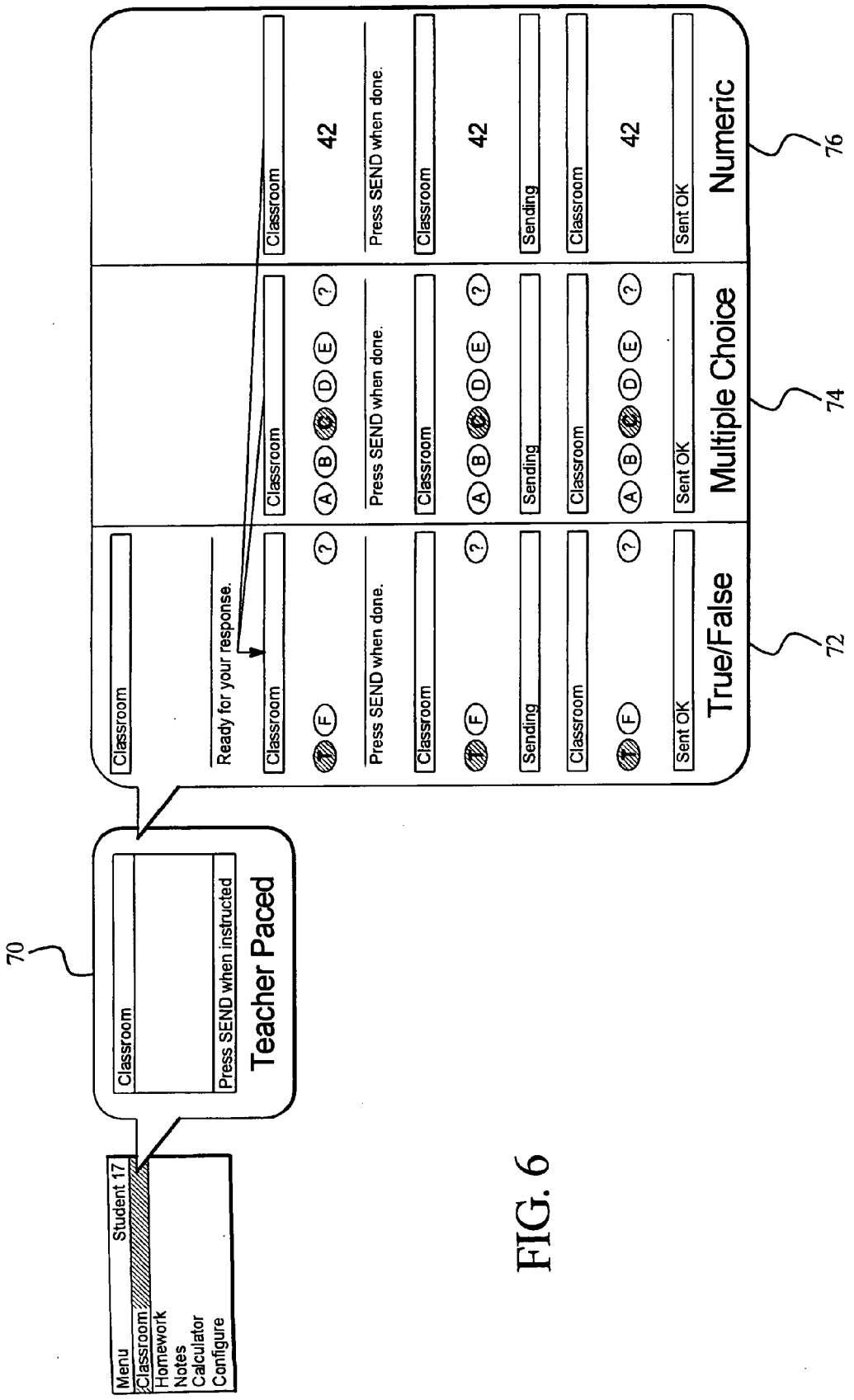

Menu
Student 17
Classroom
Homework
Notes
Calculator
Configure
Classroom
Press SEND when instructed
Teacher Paced
70
Classroom
Ready for your response.
Classroom
Press SEND when done.
Classroom
Sending
Classroom
Sent OK
True/False
72
Classroom
Classroom
42
Press SEND when done.
Classroom
42
Sending
Classroom
42
Sent OK
Multiple Choice
74
Classroom
Classroom
42
Press SEND when done.
Classroom
42
Sending
Classroom
42
Sent OK
Numeric
76

FIG. 6

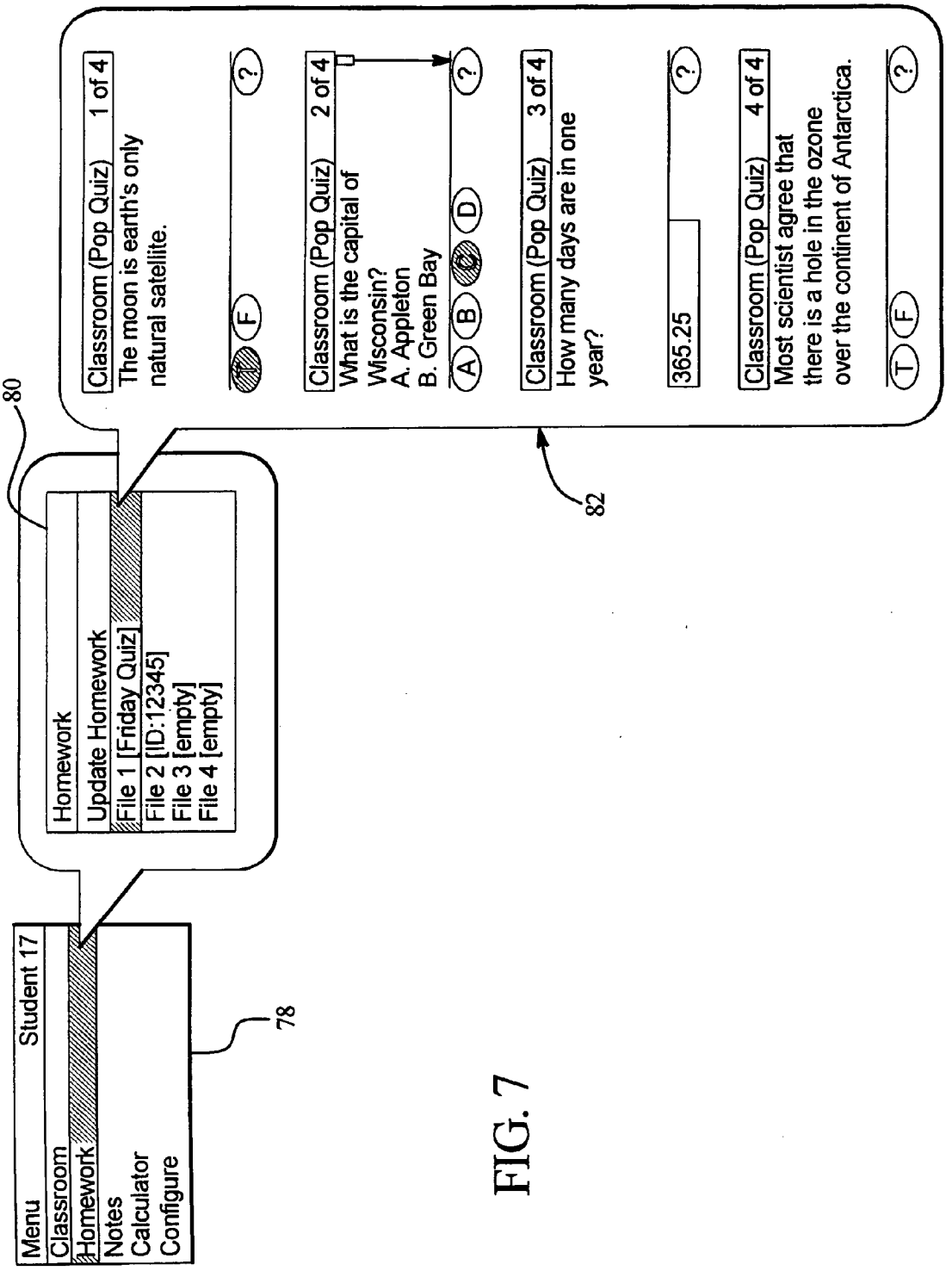

Menu
Student 17
Classroom
Homework
Notes
Calculator
Configure
78
Homework
Update Homework
File 1 [Friday Quiz]
File 2 [ID:12345]
File 3 [empty]
File 4 [empty]
80
Classroom (Pop Quiz) 1 of 4
The moon is earth's only natural satellite.
T F ?
Classroom (Pop Quiz) 2 of 4
What is the capital of Wisconsin?
A. Appleton
B. Green Bay
A B C D ?
Classroom (Pop Quiz) 3 of 4
How many days are in one year?
365.25 ?
Classroom (Pop Quiz) 4 of 4
Most scientist agree that there is a hole in the ozone over the continent of Antarctica.
T F ?
82

FIG. 7

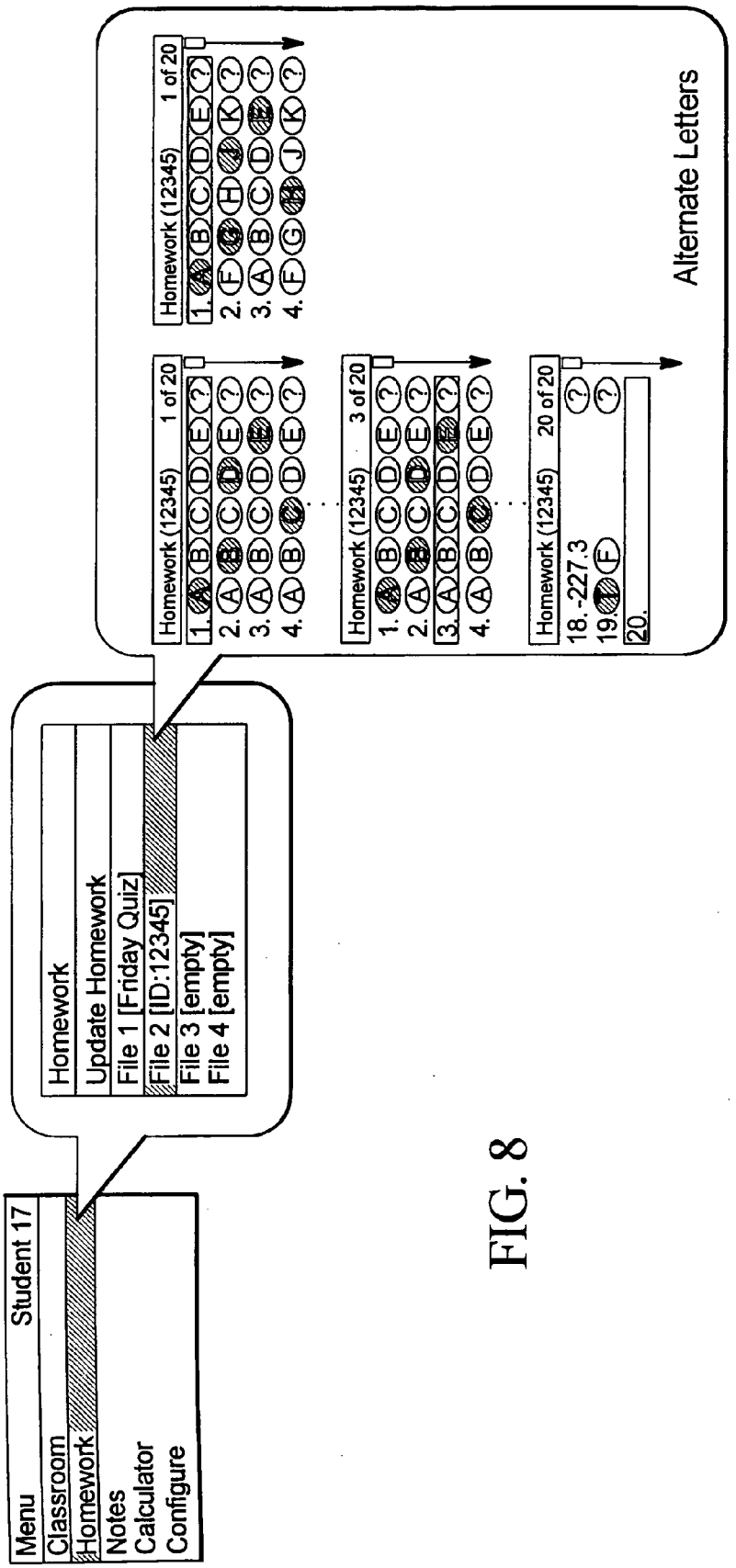

Menu
Student 17
Classroom
Homework
Notes
Calculator
Configure
Homework
Update Homework
File 1 [Friday Quiz]
File 2 [ID:12345]
File 3 [empty]
File 4 [empty]
Homework (12345) 1 of 20
Homework (12345) 3 of 20
Homework (12345) 20 of 20
Alternate Letters

FIG. 8

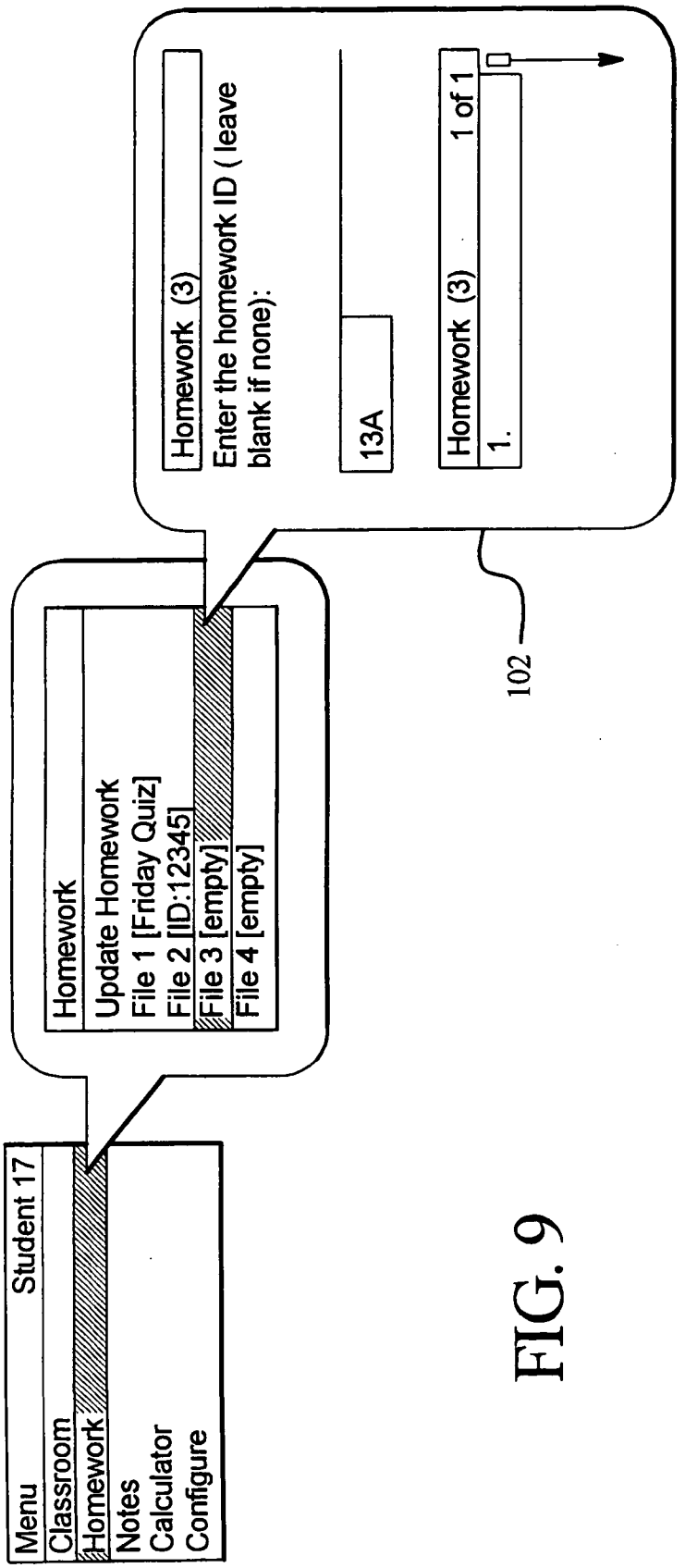

Menu
Student 17
Classroom
Homework
Notes
Calculator
Configure
Homework
Update Homework
File 1 [Friday Quiz]
File 2 [ID:12345]
File 3 [empty]
File 4 [empty]
Homework (3)
Enter the homework ID (leave blank if none):
13A
Homework (3)
1 of 1
1.
102

FIG. 9

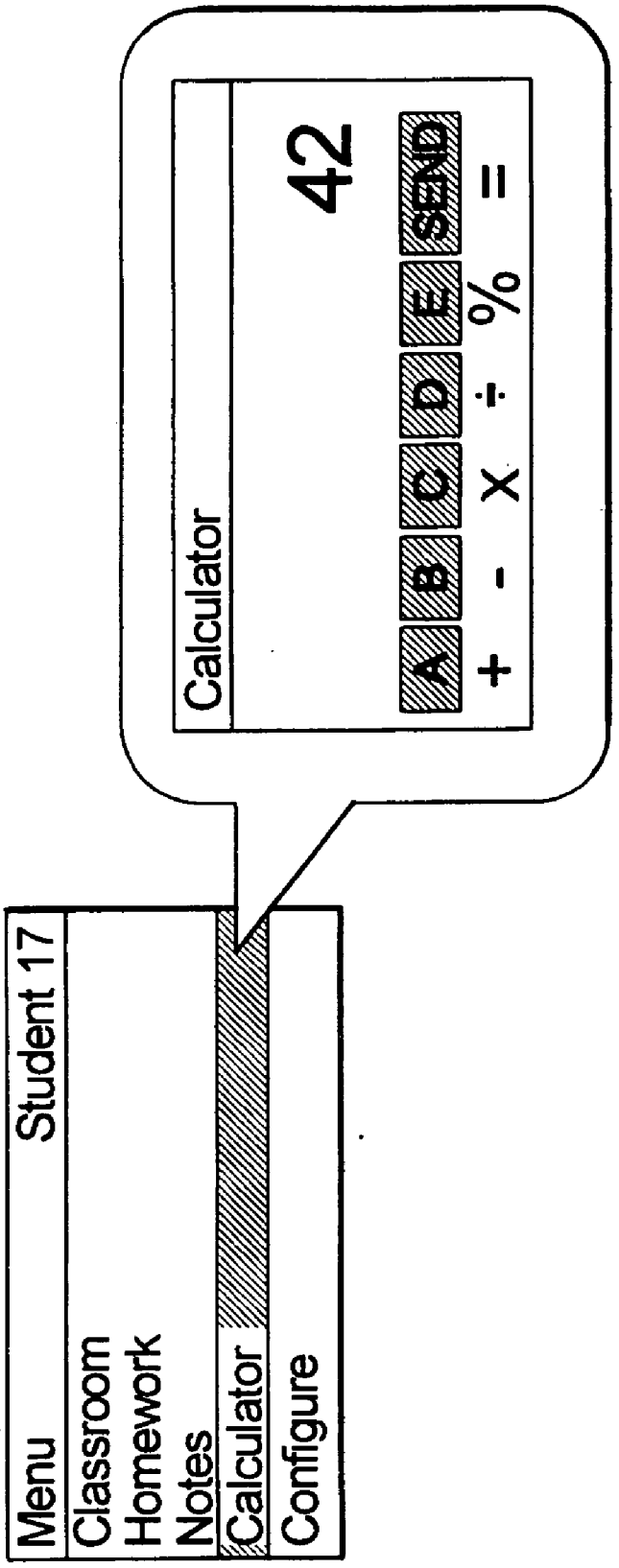

Menu
Student 17
Classroom
Homework
Notes
Calculator
Configure
Calculator
42
A
B
C
D
E
SEND
+
-
X
÷
%
=

FIG. 10

FIG. 11

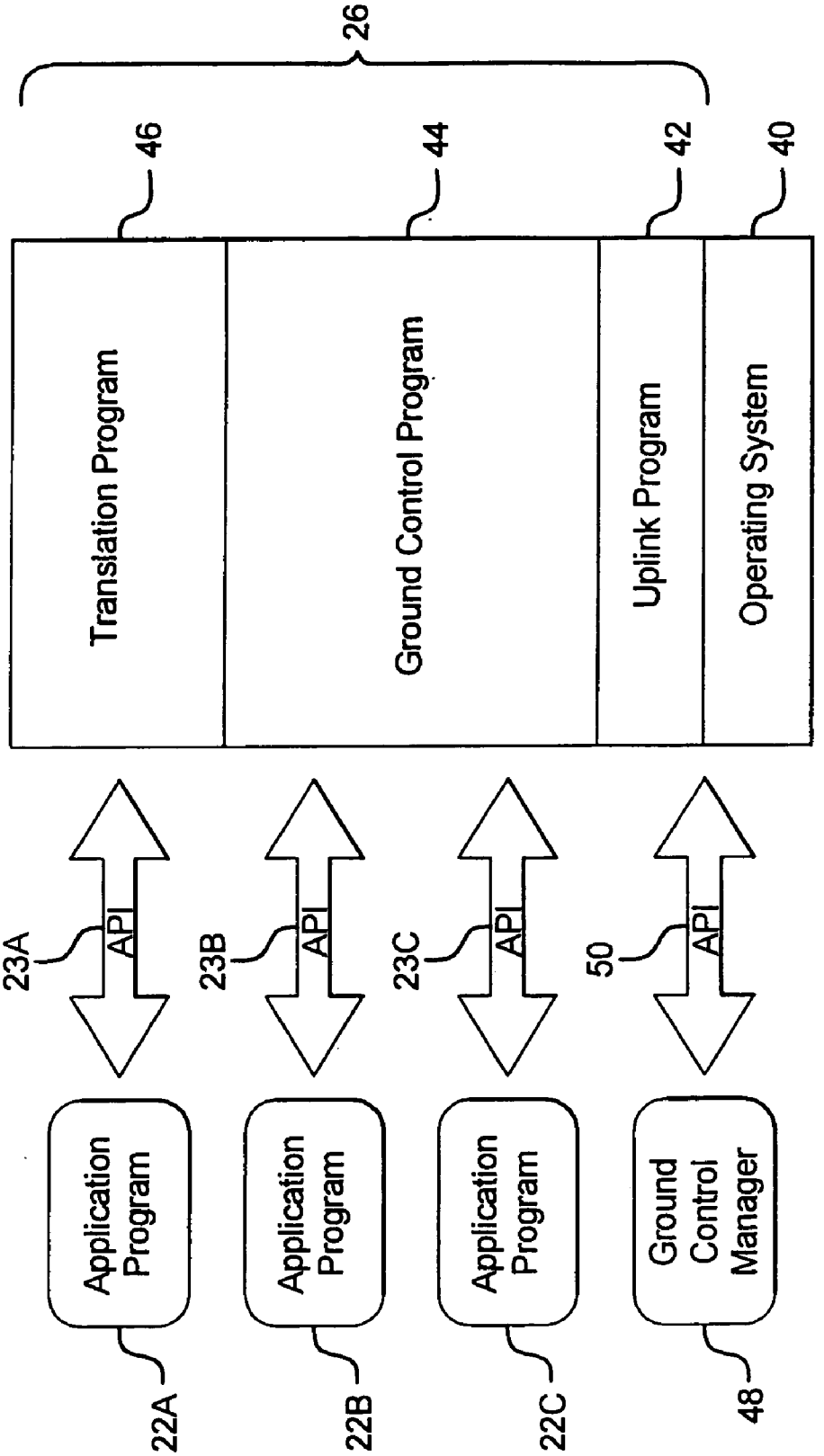

26
46
44
42
40
Translation Program
Ground Control Program
Uplink Program
Operating System
23A
23B
23C
50
API
API
API
API
Application Program
Application Program
Application Program
Ground Control Manager
22A
22B
22C
48

FIG. 12

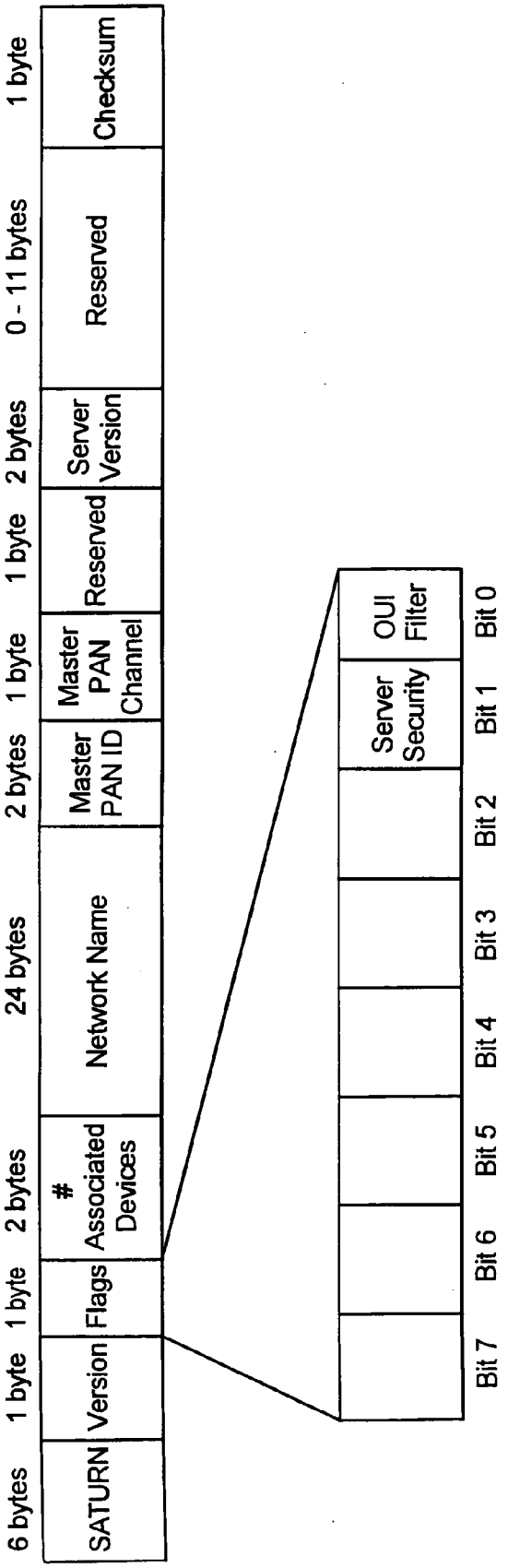

6 bytes
SATURN
1 byte
Version
1 byte
Flags
2 bytes
Associated Devices
24 bytes
Network Name
2 bytes
Master PAN ID
1 byte
Master PAN Channel
1 byte
Reserved
2 bytes
Server Version
0 - 11 bytes
Reserved
1 byte
Checksum
Bit 7
Bit 6
Bit 5
Bit 4
Bit 3
Bit 2
Server Security
Bit 1
OUI Filter
Bit 0

FIG. 13

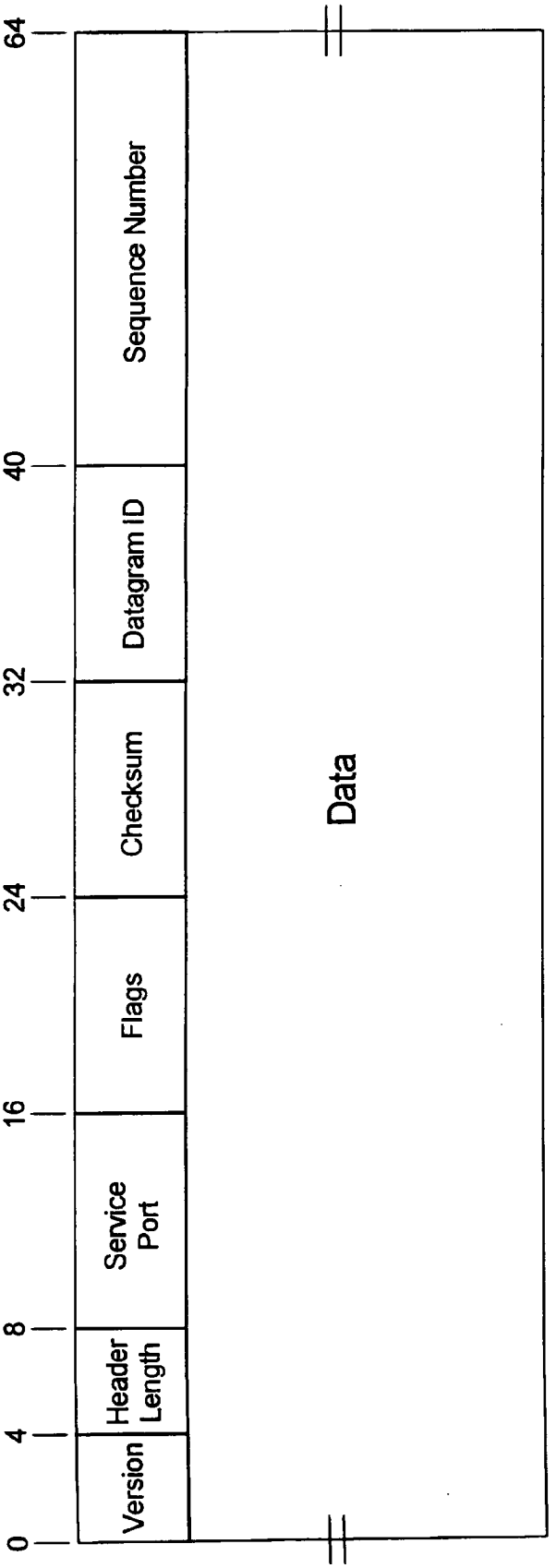

0
4
8
16
24
32
40
64
Version
Header Length
Service Port
Flags
Checksum
Datagram ID
Sequence Number
Data

FIG. 14

Segment #1 of Datagram 45

1	6	0x40	SYN	0xXX	45	0
Bytes 0 - 95						

Segment #2 of Datagram 45

1	6	0x40		0xXX	45	96
Bytes 96 - 191						

Segment #3 of Datagram 45

1	6	0x40	FIN	0xXX	45	192
Bytes 192 - 199						

WIRELESS CLASSROOM RESPONSE SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of the filing date of U.S. Provisional Application No. 60/694,414, filed Jun. 27, 2005 and U.S. Provisional Application No. 60/729,428, filed Oct. 21, 2005, each of which are incorporated herein by reference in their entirety.

FIELD OF THE INVENTION

[0002] The invention relates generally to wireless classroom response systems, and, more particularly, to wireless classroom response systems in which each student has a handheld unit that can wirelessly send messages to a computer.

BACKGROUND OF THE INVENTION

[0003] When a lesson is presented to a class of students it is often difficult to gauge whether the students are absorbing or even paying attention to the lesson. Wireless classroom response systems address this difficulty. Some currently-existing systems are deficient however, in that they do not permit the student to choose from multiple wireless networks. Others use proprietary communication schemes, thereby inhibiting the development of hardware and software by third-party vendors.

SUMMARY

[0004] In accordance with the foregoing, a wireless classroom response system is provided. In an embodiment of the invention, the system includes a wireless network that is located proximate to a classroom, a base station that coordinates the activities of the wireless network, and a plurality of handheld units. Each handheld unit is associated with an attendee of a class (either on a long-term or "owned basis, or on an ad-hoc or "shared" basis). Each handheld unit performs a discovery process that includes the steps of randomly choosing a wireless channel, attempting to discover the presence of the wireless network on the channel, and repeating these two steps if no wireless network is discovered. The wireless network may be one of many wireless networks, some of which may be located distant from the classroom in which the class that the attendee is actually attending. The discovery process can also include the handheld unit making multiple beacon requests, and the base station responding to at least one of those requests by transmitting a beacon frame that includes the identity of the network for which the base station is acting as the coordinator. In one implementation, the base station directs the handheld unit to a channel that has the least amount of traffic. This helps ensure that no single wireless channel on the network becomes overloaded with too many handheld units trying to communicate.

[0005] Other steps that the handheld unit may take in carrying out the discovery process include refraining from attempting discovery until the user (the attendee that is using the handheld unit) does something that actually requires connection to a wireless network. Once the user does do something requiring connection (such as joining a session that is currently taking place on one of the wireless networks), the handheld unit searches its memory to identify the wireless network to which it was previously connected. Once it identifies the "last good network," it displays the name of that network to the user, and asks the user whether the user wishes to reconnect to that network. If the user indicates that the answer is "yes," the handheld unit reconnects to that "last good network."

[0006] In an embodiment of the invention, the discovery process can be used to take either an inventory of the handheld units or to take attendance of the class. In other words, whenever a handheld unit connects to a wireless network, the base station can "count" the handheld unit as part of an inventory of the handheld units, or it can count the attendee that is presently using that handheld unit as "present" for the class.

[0007] In one embodiment of the invention, the base station includes a computer and a wireless access point communicatively linked to the computer, each of which perform "health checks" to ensure that connectivity between the two remains viable. Accordingly, the computer expects periodic check-ins from the access point. If a predetermined number of check-ins are missed, then the computer tries to restart the wireless access point. Similarly, the access point expects periodic check-ins from the computer, and if a predetermined number are missed, then the access point reboots itself.

[0008] In another embodiment of the invention, the base station provides software updates to the handheld units. If, during an update, a handheld unit loses contact with a wireless network, then the handheld unit goes into a "desperate mode," in which it connects to the first wireless network that it can find, and requests the latest available version of the software.

[0009] In yet another embodiment of the invention, the system has a wireless network, handheld units communicatively linked to the wireless network, and a base station that is also communicatively linked to the wireless network. In this embodiment, each handheld unit has a display screen and a navigation control (e.g., navigation buttons). The base station transmits questions to the handheld unit, which are displayed on the display screen of the handheld unit. The user (an attendee of a class) can use the navigation control to scroll through the text of each question. Additionally, the navigation control is overloaded, so that the attendee can put the navigation control into a second mode, in which it can be used to jump from one question to another.

[0010] In yet another embodiment of the invention, the handheld unit can be used as a calculator. The user (the attendee or student) enters a calculation, which is then transmitted over a wireless network to the base station. The base station (e.g., a computer that is part of the base station) performs the calculation and sends the result back to the handheld unit. The handheld unit then displays the result on its display screen.

[0011] In still another embodiment of the invention, at least one of the handheld units can be used (e.g., by a teacher or other presenter) to perform administrative tasks, such as controlling the pace at which the base station transmits the questions or retrieving an attendee's PIN.

[0012] Another embodiment of the invention is a wireless response system for use in a class that has multiple attendees. The system includes a wireless network, handheld units

communicatively linked to the wireless network, and a base station communicatively linked to the wireless network. The base station transmits multiple questions to the handheld units. Each of the handheld units has a display screen for displaying the questions, and a non-volatile memory. Each of the handheld units has an "owned" mode, in which information regarding one of the attendees (i.e., the attendee that "owns" the unit) is stored in the non-volatile memory. Furthermore, each of the handheld units has a "shared" mode, in which no person-specific information about any of the attendees is stored in the non-volatile memory.

[0013] In still another embodiment of the invention, each of the handheld units is capable of broadcasting an "alert" in response to a particular input made by the user. The alert is received by the base station, which then acknowledges the alert and contacts an emergency response system (e.g., via the internet or other public network). The base station can transmit information about the user to the emergency response system including location information. If GPS equipment is integrated with the base station or the handheld unit, the location information can be relatively precise. An operator at the emergency response system can transmit questions to the user, which show up on the handheld unit. These questions can include questions regarding the nature of the emergency. If the handheld unit is "owned," then the base station can automatically retrieve information about the user from a database, and provide that information to the emergency response system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] **FIG. 1** illustrates a wireless classroom response system according to an embodiment of the invention;

[0015] **FIGS. 2 & 3** illustrate a handheld unit that may be used in an embodiment of the invention;

[0016] **FIG. 4** illustrates another handheld unit that may be used in an embodiment of the invention.

[0017] **FIG. 5** illustrates a classroom activity that is conducted in a teacher-paced, prompted mode;

[0018] **FIG. 6**. illustrates a classroom activity that is conducted in a teacher-paced, unprompted mode;

[0019] **FIG. 7** illustrates a classroom activity that is conducted in a student-paced, prompted mode;

[0020] **FIGS. 8 & 9** illustrate classroom activities that are conducted in student-paced, unprompted mode;

[0021] **FIG. 10** illustrates how the handheld unit may function as a calculator in an embodiment of the invention;

[0022] **FIG. 11** illustrates a software architecture used in an embodiment of the invention;

[0023] **FIG. 12** illustrates the format of a network identification beacon payload according to an embodiment of the invention;

[0024] **FIG. 13** illustrates the format of a datagram according to an embodiment of the invention; and

[0025] **FIG. 14** illustrates the format of datagram segments according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

General Architecture

[0026] The architecture and operation of a wireless audience response system configured according to an embodiment of the invention will now be described. Referring to **FIG. 1**, the response system, generally labeled **10**, includes a base station **11**, a plurality of handheld units **16**, and one or more wireless networks **24**. The base station **11** includes a computer **12** and a one or more wireless access points (APs) **14**. The computer **12** is communicatively linked to the AP **14** via universal serial bus (USB), while each AP **14** is communicatively linked to the handheld units **16** via a wireless network **24**. The system **10** also includes a database **18** on which data representing questions and their corresponding answers are stored. The system **10** also includes a printer **20** communicatively linked to the computer **12**, which allows an instructor or other speaker to print out results of tests or surveys taken by users of the handheld units **16**, first through sixth application programs **22**A-**22**F (generically referred to as application programs **22**) executing on the computer **12**, which dictate how the computer **12** administers the questions transmitted to the handheld units **16** and processes the answers received in response thereto, and a service program **26**, which provides communication and routing services to the application programs **22** and the handheld units **16**. Finally, the system **10** may be communicatively linked with one or more remote computers **28** via a public network **3** (e.g., the Internet). At least one of the remote computers **28** hosts a web site from which questions may be downloaded. Also, student and class data may be stored on the remote computer **28**.

[0027] In this embodiment, each AP **14** is a Universal Serial Bus (USB) device that includes a microprocessor (e.g., an ARM processor) and an 802.15.4 chip set. The AP **14** carries out the functions of an 802.15.4 PAN Coordinator and also serves as the access point for devices to communicate with one of the wireless networks **24**. The handheld units **16** include 802.15.4 chip sets and execute a handheld application program **17** that enables them to communicate wirelessly with the service program **26** on the computer **12** via an AP **14**. By submitting requests via the service program **26**, the handheld units **16** use services of the application programs **22** hosted on the computer **12** to obtain such things as academic content, data synchronization, real time response activities, etc. Possible embodiments of the handheld units **16** are shown in **FIGS. 2, 3 & 4**. For ease of reference, the embodiment depicted in **FIG. 2** will be referred to as a Type I handheld unit while the embodiment depicted in **FIGS. 3 & 4** will be referred to as a Type II handheld unit. In many of the examples contained herein, the Type I handheld unit will be also referred to by the moniker "Responder."

[0028] Although any of a variety of communication protocols may be used in conjunction with the system **10**, according to various embodiments, each wireless network **24** of the system **10** communicates using an open network protocol, such as the IEEE 802.15.4 standard. When implemented using the IEEE 802.15.4 standard, each wireless network **24** operates as a personal area network (PAN). When deployed in a school environment, each classroom may have its own wireless network **24**, with its own PC **12** and one or more APs **14** communicatively linked thereto.

[0029] Referring again to **FIG. 1**, the computer **12** is connected to the APs **14** via a USB cable. The APs **14** act as wireless access points on the wireless networks **24**. The application program **22** interacts with an operating system and service program **26** (both executing on the computer **12**)

to send and receive data over a communications link which, in this embodiment, is a USB interface, through an AP **14**, and over a wireless network **24** which, in this embodiment, is an IEEE 802.15.4 compliant network. To communicate with the handheld units **16**, the application program **22** defines a service handler application programming interface (API) **23**. The application program **22** sends hypertext transport protocol (HTTP) messages via the port along with markup language documents to the handheld units **16**. The handheld units **16** respond as specified in the markup language documents, and those responses are received via the service handler API **23**.

The Handheld Unit

[**0030**] Referring to **FIG. 2**, an example of a Type I implementation of the handheld unit **16** will now be described. It is understood, however, that other configurations are possible. The handheld unit **16** is designed to be inexpensive, lightweight, rugged, and simple to use. It includes a microcontroller, flash memory, and a communications circuit. It executes software (in the form of firmware) that is depicted in **FIG. 1** as the handheld application program **17**. It has a graphical liquid crystal display **32** and twenty-five keys to support multiple response types. The keys include an ON/OFF key **34**, a group **36** of numeric keys, a group **38** of multiple choice keys, a group **40** of positive/negative keys, a group **42** of navigation keys (including up and down arrow keys, and a SELECT key), an ENTER key **46**, and a CLEAR key **47**. The ON/OFF key **34** is configured so as to reduce the chance of accidental pressing (having, for example, raised ribs on the enclosure or being aligned just below flush with the enclosure). As shown in **FIG. 2**, the keys are grouped into functional areas. For example, the group **38** of multiple choice keys A thru E is commonly used when responding to multiple choice questions. The group **36** of numeric keys, 0 thru 9, is used when responding to a question requiring a numeric reply. Each group of keys has elements that indicate to the user that the keys are, in fact, part of the same group. Possible ways to accomplish this include, but are not limited to key style (shape, color, label text font/size/color, etc.) and separators in enclosure (altitude, channels, borders, etc.)

[**0031**] The operation of the handheld unit **16** according to an embodiment of the invention will now be described. The general usage pattern is as follows: the user receives a question, which is either displayed on the LCD screen **32**, or provided some other way, such as verbally or written. The user presses one or more keys to formulate a response. In one embodiment, key action is invoked on key closure. The user then presses the ENTER key **46** to transmit the response wirelessly to the base station **11**. The handheld unit **16** has a response queue acts as a holding area for responses. The content of this queue changes when keys are pressed and is displayed prominently on the LCD **32**. However, the actual data stored in the queue and transmitted is not necessarily what the user sees on the LCD screen **32**. For example, when LCD **32** displays "True," a single data byte can be used to represent a positive response. This is done to minimize memory use and data packet size. The maximum response size is based on the size of the LCD screen **32**, the font size, and/or the amount of memory available in the microcontroller of the handheld unit **16**.

[**0032**] The functions of individual keys and groups of keys shown in **FIG. 2** according to an embodiment of the invention will now be described. Pressing the ON/OFF key **34** with no other keys down toggles the device state (on or off). Pressing the CLEAR key **47** causes a response queue to be cleared. The response queue is also cleared when the handheld unit **16** is powered on.

[**0033**] When the ENTER key **46** is pressed, the contents of the response queue are transmitted via the wireless communication circuit. During transmission, the text "Sending" is displayed on the LCD screen **32** until the next question is received from the base station **11** (**FIG. 1**).

[**0034**] The multiple choice keys group **38** is used to enter single key responses. When one of the keys of this group is pressed, the handheld unit **16** replaces the contents of the response queue. The group **40** of positive/negative keys is similarly used to enter single key responses. As with the multiple choice keys, pressing one of the positive/negative keys causes the handheld unit **16** to replace the contents of the response queue. In addition to indicating an answer of "true" or "false," the positive/negative keys are used for Yes/No responses. The handheld unit **16** also includes a "?" key **44**, may be used as a "help" key.

[**0035**] The group **36** of numeric keys is used to enter multi key responses. Positive, negative, whole, and decimal numbers may be entered. If the response queue contains a multiple choice or a positive/negative response when a numeric key is pressed, an implied CLEAR is executed first. When a key of the numeric key group **36** is pressed, the associated value is added to the rightmost position of the response queue, unless the queue is full, in which case it is ignored.

[**0036**] The group **42** of navigation keys permits the user to navigate through a user interface that is displayed on the screen **32**. For example, the user can use the navigation keys to scroll up or down and to highlight items that the user wishes to select (using the SELECT key). When the wireless response system is deployed in a classroom, the navigation keys allow the user to scroll through the text of the question that is currently being displayed on the screen **32**, or to navigate to an entirely different question. In one embodiment, the handheld unit overloads the arrow keys. In this embodiment, the default behavior of the arrow keys is to scroll through the text of the question currently being displayed. If the user presses the "?" key **44**, the function of the arrow keys changes, such that they permit the user to jump to the next or the previous question instead of scrolling text. Furthermore, if the user presses the SELECT key while the arrow keys are in this overloaded mode, a menu appears, prompting the user to enter the question number to which the user wishes to navigate. By responding to this prompt, the user can jump to any question. Pressing the "?" key **44** a second time causes the arrow keys to revert to their default behavior of scrolling text. Overloading the arrow keys in this manner allows for user-friendly navigation without increasing the number of keys on the handheld unit **16**.

[**0037**] In an embodiment of the invention, the handheld unit **16** manages power as follows. The microprocessor sleeps as much as possible (between keypresses) to maximize device runtime. Furthermore, the handheld unit **16** automatically powers off after 30 minutes of inactivity, regardless of key states. A continuously held-down key does not constitute activity. If one or more keys are held down accidentally by something sitting on the device or during

storage or transport, the handheld unit **16** powers itself off when the timeout interval expires, and does not power on again until all keys are released and only the ON/OFF key **34** is pressed.

Owned and Shared Device Modes

[**0038**] According to an embodiment of the invention, the wireless response system permits each handheld unit **16** (**FIG. 1**) to be designated either as "shared"—used by multiple people—or as "owned"—used by only one person. When a handheld unit **16** is in shared mode, no user information is stored on it. Once the unit is powered off by one user, another user can power it on and use it without any repercussions. In contrast, when a handheld unit **16** is in owned mode, it stores ownership information such as the user's name and the PIN selected by the user, in its memory. It also stores user data such as homework and notes. A handheld unit **16** that is in owned mode may also use a virtual "key chain" having one or more "keys." The virtual key chain (or simply "key chain") stores authentication information for a particular user. Each "key" may be used to authenticate the user (and the handheld unit **16**) to a wireless network **24** and/or to one of the application programs **22**. The virtual key chain is stored in a memory of the handheld unit **16**. The purpose of the virtual key chain is to simplify connection of the handheld unit **16** to the wireless networks **24** and/or to the application programs **22** by automatically supplying credentials without the need for user intervention.

Response Modes

[**0039**] According to an embodiment of the invention, there are two basic modes in which audience members can respond to a presenter using the handheld units **16**: prompted and unprompted. In a prompted response mode, a question is displayed on the handheld units **16**, and the audience members answer the displayed question. In an unprompted response mode, the question is not presented on the handheld units **16**, but by some other method, such as a presenter reading it aloud or an audience member reading it on a handout. In an unprompted mode, the audience member still answers the question using the handheld unit **16**.

Types of Activities

[**0040**] In an embodiment of the invention, individuals use the handheld units **16** (**FIG. 1**) in the context of what will be referred to herein as "activities." An "activity" is made up of one or more discrete tasks referred to as "actions." An activity can be a single action or a complex sequence of actions. For example, an activity can be something as simple as displaying a message to one of the handheld units **16**, or an activity can be something more sophisticated such as requesting a response to a multiple-choice question. An activity can have a static design, such as a quiz that includes 10 actions, each action being a question, each action being performed sequentially. Other activities may use dynamic, adaptive branching that relies on the logic of the application program **22** to inspect each response to a question and determine what the next action should be. Some activities are classified as "live." That is, they are intended to be conducted while the handheld units **16** are communicatively linked to the computer **12**.

[**0041**] The application programs **22** carry out some activities that are paced by the presenter and some activities that are paced by the audience members. Since many of the examples described herein are set in the context of a classroom environment, these two types of activities will be referred to herein as "teacher-paced" and "student-paced." It is understood, of course, that the invention is not limited to classroom use. A teacher-paced activity is one in which the class participates as a whole, and where each student responds to questions generated by an application program **22**. In a teacher-paced activity, the teacher controls the pace at which questions are transmitted to the handheld units **16**. For example, the students may be shown only one question at a time on their handheld units **16**, and the question is shown only when specified by the teacher. Students then answer only when the teacher allows the responses to be collected. If a student fails to keep pace with the class, then the application program **22** can speed the student ahead to the current action in the activity, the next time the fallen-behind student responds in any way using his handheld unit **16**. A student-paced activity is one in which each student views questions and responds at his own speed. Students can be given individual student-paced activities, or the entire class may be given the same student-paced activity. The student-paced activity may be configured so that overloading of the navigation keys (discussed above) is enabled, thereby giving students the ability to navigate back and forward through questions.

Teacher-Paced, Prompted Activity

[**0042**] An example of a teacher-paced, prompted activity will now be described with reference to **FIGS. 1 and 5**. First, the application program **22** transmits a mark-up language document to the plurality of handheld units **16**. The mark-up language document includes instructions for presenting a sequence **60** of questions on the handheld units **16** (for a pop quiz). Each handheld unit **16** then interprets the instructions contained in the mark-up language document and, accordingly, displays the first question **52** in the sequence. Each student has the opportunity to respond to the first question **52** by making the appropriate input to the student's handheld unit **16**. When the teacher makes the appropriate input to the computer **12**, the application program **22** transmits a message to the handheld units **16**, that causes the handheld units to permit the students to advance to the second question **54** in the sequence **60**. Note that the display containing the second question **54** includes a scroll bar **55**. This process continues, with the third and fourth questions **56** and **58** being enabled in succession until the teacher ends the quiz by making the appropriate input to the computer **12**.

[**0043**] Alternatively, one of the handheld units **16** may be placed into a "remote control" mode to allow the teacher to use that handheld unit **16** initiate a session and control the pacing of the questions via the keypad of the handheld unit **16** and one of the wireless networks **24**. This remote control mode allows the teacher to leave her desk and visit with the students. In the context of a presentation, the presenter can put a handheld unit **16** into remote control mode and move about the audience while controlling a live activity. The presenter can pace the session, view the questions that the participants are asking, chose a question template to transmit to the audience handheld units for ad hoc Q&A sessions, etc.

Teacher-Paced, Unprompted Activity

[0044] **FIG. 6** illustrates the sequence of displays shown on each handheld unit **16** for a quiz that is given in a teacher-paced, unprompted mode. The sequence of actions is similar to that described in conjunction with **FIG. 6**, except that the mark-up language document transmitted by the application program **22** to the handheld units **16** (**FIG. 1**) does not include questions but rather includes one or more answer templates, such as a True/False template **72**, multiple choice template **74** and a numeric template **76**. The handheld units **16** display the answer templates on their respective LCD screens **32**. Furthermore, instead of the questions being presented on the LCD screen **32** of each of the handheld units **16**, the teacher reads the questions aloud to the students.

Student-Paced, Prompted Activity

[0045] According to an embodiment of the invention, the response system **10** (**FIG. 1**) can also be used to allow the teacher to distribute homework assignments, and to allow the students to complete and turn in the homework assignments. In such an embodiment, the application program **22** transmits one or more mark-up language documents representing a homework assignment to the handheld units **16**. Outside of class, the students individually complete the homework assignment by making the appropriate inputs into their respective handheld units. **FIG. 7** illustrates the sequence of displays shown on a handheld unit for an example homework assignment in a student-paced, prompted mode. The student selects "homework" from a first menu **78**, then selects "Friday Quiz" from a second menu **80**. In response, the handheld unit **16** displays a sequence **82** of questions (i.e., in a "prompted" mode) that the student must answer. During the next classroom session, the student makes the appropriate inputs to the handheld unit **16** to cause it to transmit her answers to the application program **22**, thereby "turning in" the completed homework assignment.

Student-Paced, Unprompted Activity

[0046] The sequence of displays for another example homework assignment is shown in **FIG. 8**. In this example, the teacher gives handouts containing the questions to the students, and the mark-up language document that the handheld units **16** receive from the application program **22** only contains answer templates. Otherwise, the procedure for completing and turning in the homework assignment is the same as described in conjunction with **FIG. 7**.

[0047] Yet another sequence of displays for a homework assignment is shown in **FIG. 9**. In this example, however, the teacher gives handouts containing the questions to the students. Furthermore, the application program **22** does not transmit a mark-up language document to the handheld units **16** for answering the questions, but the students instead use a generic answer form **102** that is pre-stored in the handheld units **16**. Otherwise, the procedure for answering the questions and turning in the answers is the same as described in conjunction with **FIGS. 7 and 8**.

Calculator Function

[0048] According to an embodiment of the invention, the handheld unit **16** is also able to function as a calculator. **FIG. 10** illustrates how this functionality appears on the LCD screen **32**. Many of the calculations themselves are not performed by the handheld unit **16**, however. Instead they are performed by the computer **12**. Thus, when a user enters an expression using the keypad of the handheld unit **16**, the expression is transmitted via one of the wireless networks **24** to the computer **12**. Complex operations such as floating-point math are performed by a computation engine executing as part of the service program **26**. The computer **12** then transmits the results of the operation back to the handheld unit **16** for display to the user. This off-loading feature enables the handheld unit **16** to be low-cost in terms of the memory it requires and in terms of how powerful of a microprocessor is required. The teacher may, by making the appropriate input to the computer **12** (**FIG. 1**), cause the application program **22** to send commands to the handheld units **16** that will disable the calculator function.

The Service Program

[0049] Referring to **FIG. 11**, with appropriate reference to **FIG. 1**, a more specific embodiment of the software that executes on the computer **12** will now be described. The software includes an operating system **40** and the service program **26**. The service program **26** includes an uplink program **42**, a ground control program **44**, and a translation program **46**. The computer **12** also hosts first, second, and third application programs **22**A, **22**B, and **22**C. Each of the application programs calls or can be called by the translation program **46** or the ground control program **44** via an application programming interface (API). A first API **23**A facilitates interaction between the translation program **46** and the first application program **22**A, a second API **23**B facilitates interaction between the ground control program **44** and the second application program **22**B, and a third API **23**C facilitates communication between the ground control program **44** and the third application program **22**C. The application programs **22**A-**22**C send and receive data to and from the handheld units **16** via the ground control program **44**. In one embodiment, the first application program **22**A provides services to Type I handheld devices. The Type I handheld devices communicate using a compact markup language referred to herein the Saturn Datagram Markup Language (SDML), which the translation program **46** translates into Extensible Markup Language (XML) to provide to the first application program **22**A. Similarly, XML documents that the first application program **22**A sends to the Type I handheld units are passed to the translation program **46**, which converts them into SDML documents, which are then transmitted to the handheld units **16**. The second application program **22**B provides services to Type II handheld units, which communicate in XML. Thus, communication between the second application program **22**B and the Type II handheld units does not need to be processed by the translation program **46**.

[0050] Referring still to **FIG. 11**, the uplink program **42** is responsible for handling the initial USB connection and low-level communication to the AP **14**. The ground control program **44** provides a communications gateway between the handheld units **16** and the application programs. The ground control program **44** also provides a USB interface to the AP **14**, upper layer management services for the 801.15.4 media access control (MAC), datagram fragmentation and assembly services, and device management services. In providing device management services, the ground control

program **44** executes utilities to configure and manage the handheld units **16** via a user interface (such as a Windows® or Macintosh® user interface).

The Ground Control Manager

[**0051**] Referring still to **FIG. 11**, the computer **12** executes a ground control manager program **48** that is separate from the ground control program **44**. The ground control manager program **48** is a utility that is used to configure the AP **14**, assign device ownership, inspect connected devices, and perform other management tasks. The application programs **22**, working with the ground control program **44** via the appropriate API can also implement many of the management tasks normally performed by the ground control manager program **48**.

Firmware Update

[**0052**] One function that the ground control manager program **48** performs is wireless updates to the firmware executing on the handheld units **16**. Each handheld unit **16** can be updated independently. A system administrator may, for example, order a firmware update on CD-ROM or download it from the internet, and install the update on the computer **12**. The ground control manager program **48** reports the available update or updates to the handheld units **16** via a wireless network **24** (**FIG. 1**). The handheld application program **17** on each handheld unit **16** prompts the user to select which updates should be installed. To prevent inadvertent updates, the handheld unit **16** may also require administrator authentication proceed with the update. The handheld unit **16** that is being updated loads a small, self-contained program, referred to as the "bootloader," and makes it permanently resident in memory. The bootloader manages the process of requesting and receiving the new firmware and storing it in the flash memory of the handheld unit **16**. The bootloader is preferably as small as possible, in order to preserve limited memory in the handheld unit **16**. Thus, the bootloader contains a minimal user interface and does not have a full communications stack. Information regarding the network connection and the selected firmware update is passed from the handheld application program **17** to the bootloader via a shared non-volatile memory space. If the handheld unit **16** looses power or looses communication with a wireless network **24** during an update, it puts itself into what will be referred to as "desparate mode," in which it scans for and automatically connects to the first wireless network **24** that it finds. The ground control manager program **48** responds by transmitting, to the handheld unit **16**, the latest version of the handheld application program **17** that it has, thereby allowing the handheld unit **16** to return to its normal operating state.

Floating Administration

[**0053**] In addition to updating the firmware of the handheld units **16**, the ground control manager program **48** can perform the functions of recovering a lost PIN for a handheld unit **16** and resetting its ownership to shared mode. In one embodiment, any administrator or authorized person (not just the one that issued the handheld unit **16** to the user) can initiate these functions from the handheld unit **16**. For example, if a user forgets his PIN, he does not need to worry about going back to the administrator that assigned the handheld to him, but may seek out any authorized person responsible for the administration of any wireless network **24** for support. The authorized person requests, via the ground control manager program **48**, the recovery of the user's PIN. The administrator enters an administrative PIN (which may be a PIN that is known to all of the wireless networks **24**) via the keypad to complete the recovery.

Network Discovery

[**0054**] In an embodiment of the invention, the handheld units **16** (**FIG. 1**) connect to the wireless networks **24** (which are personal area networks in this embodiment) using the IEEE 802.15.4 Low-Rate Wireless Personal Area Network standard. The application programs **22** running on the computer **12** connect to one or more of the wireless networks **24** via TCP/IP sockets. The ground control program **44** (**FIG. 11**), the USB, and the AP **14** bridge the communications between application programs **12** and the handheld units **16**. As part of the network discovery process, the handheld units **16** locate the wireless networks using an 802.15.4 active scan. An active scan locates 802.15.4 PAN coordinators by stepping through logical channels in the 802.15.4 airspace (starting from the lowest channel and working up to the highest channel), and issuing a beacon request. In some embodiments, the handheld unit **16** issues multiple beacon requests. This helps to compensate for losses of beacon responses due to collisions that may occur in high-traffic situations (particularly on non-beacon networks). Each PAN coordinator (e.g., each AP **14**) in the wireless networks **24** that receives the request (or requests), responds to the request with a 802.15.4 beacon frame. Within this frame is the beacon payload carrying the Network Identifier Block, which will be discussed below in further detail.

[**0055**] In one embodiment of the invention, each of the handheld units **16** performs its active scan by randomly choosing the channel on which to begin the scan (instead of starting with the lowest channel). Furthermore, instead of stepping through the channels in sequence, each handheld unit **16** scans the channels in random order. This scheme reduces the chances of any particular channel being overloaded during the discovery process.

[**0056**] Once a handheld unit **16** is connected to one of the wireless networks **24**, the application programs **22** can interact with it. Furthermore, the very act of connecting to the wireless network **24** enables the service program to include the handheld unit **16** as part of an inventory of the handheld units **16**. The service program **26** can also use the fact of the handheld units **16** connecting to a wireless network **24** as representing the attendance of the user of the device. Thus, for example, if John Smith is the "owner" of a handheld unit **16**, and his handheld unit **16** connects to a wireless network **24**, then the service program **26** lists John Smith as being present. This list is displayed to an administrator on a user interface on the computer **12**.

Network Identifier Block

[**0057**] The Network Identifier Block that each PAN coordinator transmits to the handheld units **16** in response to a beacon request contains information about the PAN to which the PAN coordinator belongs. The format of the Network Identifier Block in an embodiment of the invention is show in Table 1 below.

TABLE 1

Field	Size	Description
SATURN	6 bytes	Fixed field header identifying the beacon originated from one of the wireless networks. Value is an unterminated ASCII string equal to the value "SATURN".
Version	1 byte	Version: Identifies the version of the Network Identifier block. Version is two 4 bit BCDs of the form Major.Minor Current version is 0x01
Flags	1 byte	MAC OUI Filtering Enable: Bit 0. If set, the AP 14 will only accept device associations for those whose MAC OUI is equal to its own. Server Security Use: Bit 1. If set, the sever is using security. Note that Frame Control Field Security bits may not be set even though this bit is set. This situation occurs when simple atgencrypt security is used by the server. In this situation, only data requests have security and will have their Frame Control Security bits set.
Associated Devices	2 bytes	Associated Devices Count: The number of active devices associated to the AP 14.
Network Name	24 bytes	Network Name: Name assigned to the wireless network. Format is a null terminated ASCII string if length is less than 24 bytes. If name is 24 bytes, no termination is used.
Master PAN ID	2 bytes	Master PAN ID: The ID of the PAN master for each individual PAN that is hosted by the computer 12. Multiple PANs exist for computers that have more than one AP 14 connected to its USB port.
Master PAN Channel	1 byte	Master PAN Channel: The channel number of the PAN master. This value along with the Master PAN ID are used to match PANs belonging to a server.
	1 byte	Reserved
Server Version	2 bytes	Server Version: The major.minor version of the service program 26 in BCD. Example: 01.12 = 0x0112
Checksum	1 byte	Checksum: A checksum computed over the block to provide a second level of identification of wireless networks. An 8-bit checksum. It is calculated by adding the block bytes together. On receipt of the beacon payload, the handheld unit 16 performs the same checksum calculation and on a mismatch, deems the beacon (e.g., the AP 14) as not belonging to a valid wireless network.

[0058] The Network Name field is intended for use by each handheld unit **16** to help determine whether or not to associate to the wireless network **24**. This name is set by the owner/administrator of that wireless network. When the system **10** is deployed in a classroom environment, the administrator/owner may be the instructor. The string can be displayed to the user along with other wireless networks that were found in the active scan, thereby allowing the user to make the choice of which wireless network **24** to join. The handheld application program **17** connects to the wireless network via the ground control program **44** (hosted on the computer **12**). The ground control program **44** provides a TCP/IP port for connection. The identifier for the AP **14** is simply the localhost or IP address of the computer **12** along with the TCP port number. In one embodiment, the AP **14** port number will be selected at random from the Internet Assigned Numbers Authority (IANA) dynamic and private port range of 49152 to 65535.

Reconnecting to a Previously Available Network

[0059] Each time a handheld unit **16** (**FIG. 1**) establishes a connection to a wireless network **24** (in an embodiment of the invention), the handheld unit **16** stores the information about that network (which will be referred to as the "last good network") in its non-volatile memory, including the name of the network (obtained from the Network Identifier Block of the beacon response). When the handheld unit **16** is powered on, it does not attempt to connect to a wireless network **24** until the user does something that actually requires a network connection. When the user does do something that requires a connection (such as joining a classroom session), the handheld unit **16** retrieves the last good network information from its non-volatile memory and checks for the presence of that network. If that network is present, the handheld application program **17** (**FIG. 1**) displays a visual prompt that asks the user whether the user would like to stay connected to that network. The prompt includes the name of the network. If the last good network is not detected as present, or if the user chooses "no," then the handheld unit **16** performs a full network scan. This "lazy" reconnection scheme reduces the number of times that the handheld unit **16** performs active scans and thus helps to extend the life of the handheld unit's batteries. Furthermore, by displaying the network name to the user when prompting for a reconnect, the handheld unit **16** helps to prevent connection to the wrong wireless network **24**.

Load Balancing Among Access Points

[0060] When a handheld unit **16** (**FIG. 1**) connects to one of the wireless networks **24**, it broadcasts a beacon request, and receives responses, in the form of beacon frames, from one or more APs **14**. In an embodiment of the invention, the handheld unit **16** uses the contents of the "Associated Devices" field of the Network Identifier Block in each of the beacon frames to identify which of the access points has the fewest number of handheld units **16** already associated with it. The handheld unit **16** then connects to that access point (AP **14**). This ensures proper load balancing among the access points of each network. Another way in which the system **10** performs load balancing is as follows. Each time a handheld unit **16** requests data from the computer **12** (or from one of the application programs **22** executing thereon), the ground control manager program **48** determines whether there are any other available APs **14** that have fewer devices associated with them than the AP **14** to which the handheld unit **16** is currently associated. If there are, then the ground control manager program **48** directs the handheld unit **16** to reconnect to the AP **14** that has the fewest number of devices associated with it.

Health Check and Network Recovery

[0061] According to an embodiment of the invention, the system **10** (**FIG. 1**) provides for two-way health monitoring between the computer **12** and each of the APs **14**. Specifically, the service program **26** (**FIG. 1**) periodically performs a "health check" on each of the APs **14**. The service program **26** does this by checking in with each of the APs **14** at predetermined intervals. Likewise, each of the APs **14** periodically checks in with the service program **26** at

predetermined intervals. If an AP **14** fails to check in with the service program **26** after a maximum-acceptable number of intervals, the service program **26** attempts to restart that AP **14** (and, hence, the wireless network **24** that is being coordinated by that AP **14**). If the AP **14** still fails to check in after the service program **26** makes a maximum-acceptable number of restart attempts, then the service program **26** designates the AP **14** as stalled, and gives the system administrator feedback on the computer **12** via a server log and a server utility user interface. From the point of view of the AP **14**, a similar flow of logic occurs. If the AP **14** does not receive a check-in from the service program **26** after a maximum-acceptable number of intervals, the AP **14** reboots itself into a standby mode. In the standby mode, the wireless network **24** for which the AP **14** is the PAN coordinator is stopped, and no requests from the handheld units **16** on that network are processed. The frequency of health checks made by both the service program **26** and the AP **14**, as well as the maximum-acceptable number of missed health checks and restart attempts are system-configurable.

[**0062**] The previously-described health check mechanism is sufficiently flexible to detect major problems, while still being able to recover from temporary losses of connectivity with the APs **14**. For example, if a USB cable connecting the AP **14** and the computer **12** comes loose or is inadvertently disconnected for a short period of time, only a few health checks will be missed (by the service program **26** and the AP **14**). If the cable is reconnected before the maximum-acceptable number of health checks are missed, then the service program **26** restarts the AP **14** using its previous network settings, and traffic between the AP **14** and the handheld units **16** resumes without any need for the users to manually reconnect or to perform any other initial setup.

Structure of the Saturn Protocol Datagram

[**0063**] In an embodiment of the invention, data transmitted between the handheld units **16** and the base station **11** is carried in 802.15.4 data frames using a delivery construct that will be referred to herein as Saturn Protocol (SP) datagrams. SP datagrams use a segment format similar to the TCP/IP segment format and have the structure depicted in **FIG. 13**. The content of the various fields of an SP datagram is described below in Table 2.

TABLE 2

Field	Size	Description
Version	4 bits	Version: Identifies the version of the Saturn Protocol used to generate the datagram.
HL	4 bits	Header Length: Length of the header in bytes. Value for version 0x1 header is 0x8.
Service Port	1 byte	Service Port: Identifies the service port for the message. Services are provided on the host via handlers. Values 0x00–0x3f are reserved. 1 (0x01) = Ground Control 2 (0x02) = Ground Control Manager 3 (0x03) = Firmware Manager 4 (0x04) = Server Manager 5 (0x05) = Owner Assignment Manager Application service assignments: 64 (0x40) = Responder 65 (0x41) = Type II device 66 (0x42) = Print Server
Flags	1 byte	Segment Flags: FIN (0x01) no more data. Indicates the final closure signal for the datagram transfer of bytes. SYN (0x02) synchronize sequence number. Indicates the initial synchronizing message. ACKR (0x04) acknowledgment requested. Indicates the sender is requesting acknowledgement. ACK (0x10) acknowledgment. Indicates acknowledgement of the number of bytes specified in the sequence number. NASS (0x20) not associated. If set by the PAN coordinator, the sending device is not associated and thus the datagram is rejected.
Checksum	1 byte	Checksum: Checksum of the header bytes.
Datagram ID	1 byte	Datagram Identifier: Identifies the datagram the segment belongs to.
Sequence Number	24 bits	Sequence Number: Specifies the current byte sequence being sent. For a SYN segment, this number provides the starting point for sequencing the bytes to be delivered. For transfers larger than 2^24 bytes, the sequence number is wrapped back around as needed.
Data	Variable	Data: The datagram data.

[**0064**] The Datagram ID field is used to identify datagram segments during a transaction using 802.15.4 data request and data indication communication protocols. Datagram IDs are simple 8 bit IDs that are incremented each time a new transaction is started by the sender.

[**0065**] The Sequence Number field is used to determine the portion of the data payload the segment carries. The arrival of the datagram segment with the FIN bit equal to 1 indicates that the final segment. Reception of the FIN segment does not mean the datagram assembly is complete as it is possible previous segments may have been lost and are in the process of being resent. Determining that a datagram is completed is based on examining the sequence for missing segments.

[**0066**] The ground control program **44** automatically assembles data into segments for application programs (such as the first, second, and third application programs **22**A, **22**B, and **22**C) that use its services. The handheld devices **16**, however, provide their own services for segmentation of data.

[**0067**] In an embodiment of the invention, SP datagram segments are limited in size by the Maximum Transmission Units (MTU) of the 802.15.4 MAC data frame. Depending on the security suite in use for the 802.15.4 network, this MTU can be reduced due to overhead of encryption and freshness implementations. In an unsecured network, the MTU is 102 bytes. To construct a segment, a template header with the Version, Header Length, Service Port, and Datagram ID fields is created and then used to send each segment of the data in an 802.15.4 data frame. The SYN flag is set for the first segment. The FIN flag is set for the last segment. The Sequence Number for the first segment should start at 0. Remaining segments have their Sequence Number set based on the byte sequence they carry.

[**0068**] Referring to **FIG. 14**, an example of an SP datagram is shown. In this example, it is assumed that 200 bytes

of data are being sent, and that the datagram is number **45** in sequence. This package requires a total of three 802.15.4 MAC data frames (102 byte MTU) to send the entire message. When segments arrive at the computer **12**, they are matched up according to the sender's 802.15.4 address from the MAC data frame, and the Service Port and Datagram ID field values in the SP datagram header.

High Level Communication Between the Base State and Handheld Units

[**0069**] In accordance with an embodiment of the invention, the handheld units **16** (**FIG. 1**) communicate with the computer **12** of the base station **11** using a compact protocol. One implementation of the compact protocol will be referred to herein as Saturn Device Transport Protocol (SDTP). The handheld units **16** and the computer **12** also communicate using a compact mark-up language format. One implementation of the compact protocol will be referred to herein as the Saturn Device Mark-up Language (SDML). Messages sent between the handheld units **16** and the computer **12** are in the form of requests for services (from the handheld unit **16** to the computer **12**) and responses (from the computer **12** to the handheld unit **16**). Referring to **FIG. 11**, it is the ground control program **44** that processes such requests from handheld units.

Obtaining Services from the Application Programs

[**0070**] Referring again to **FIG. 11**, each application program **22** may "register" with the ground control program **44** to provide one or more services. Such registered application programs are also referred to herein as "service handlers." For an application program to act as a service handler, it expresses an API for receiving data from the handheld units **16**, and an API for receiving data from handheld units **16**. Both APIs are represented by the APIs **23** in **FIGS. 1 and 11**. Each SP datagram includes a "Service" field that is used to determine the application program (service handler) that will handle processing the data payload. Example entries for this field are "Responder" to identify the application program that processes requests from Type I handheld units, "Type II" to identify the application program that processes requests from Type II handheld units and "Print Server" to identify the application that processes print request.

[**0071**] When SP datagrams from a handheld unit **16** are constructed and sent over the one of the wireless networks (**FIG. 1**), datagram segments arrive at the ground control program **44** (**FIG. 11**), which assembles them. After assembly of the datagram segments, the ground control program **44** extracts the payload along with the source address of the handheld unit **16** that sent the datagram. This address and the data payload are then "routed" (via the appropriate socket) to the application program **22** that has previously registered (via a service port provided by the ground control program **44**) with the ground control program **44** to handle that particular type of request. The application program **22** then processes the request. In most cases, the processing results in the execution of business logic and the return of a response to the handheld unit **16** that initiated the communication. If no application program **22** has registered with the ground control program **44** for a particular service, the datagrams requesting that service are ignored. Depending on the service, an error response may be returned to the handheld unit **16**. If an application program **22** does respond, the response is put into a datagram payload by the ground control program **44** and fragmented as needed before being routed to the handheld unit **16** for which it is intended.

[**0072**] As shown in **FIGS. 1 and 11**, there can be several application programs **22** running at any time. For example, the application program **22**A could register with ground control program **44** to handle requests for Type I handheld units, and the application program **22**B could register to handle requests for Type II handheld units. Future services can also be accommodated in the ground control program **44** by simply requesting a service assignment ID from one of the remote computers **28** (**FIG. 1**).

[**0073**] To request services from one or more application programs according to an embodiment of the invention, a handheld unit **16** forms and transmits a "service request" to the computer **12**. A service request is formed using Hypertext Transport Protocol (HTTP) POST message. When the computer **12** receives a datagram from a handheld unit **16**, the ground control program **44** identifies which application program has registered to handle the datagram, and then calls a "ReceiveData" service of that application program. If an application program wishes to send data to a handheld unit **16**, the application program calls a "SendData" service of the ground control program **44**.

[**0074**] In an embodiment of the invention, the ground control program **44** itself offers certain services to the application programs **22**. These services are available through a service port defined by the ground control program **44**, and allow the application programs to get and set information for the handheld units **16**, configure the APs **14**, and connect/disconnect to the handheld units **16**.

Student Alert System

[**0075**] As discussed previously, when the system **10** (**FIG. 1**) is deployed in a classroom environment, the handheld units **16** are operated by attendees of the class, such as students. In one embodiment of the invention, the service program **26** and the handheld application program **17** include software for implementing a student alert system, in which a student or other attendee can, in an emergency, use his or her handheld unit **16** to broadcast an alert. To trigger the alert, the student presses and holds down a particular key on the handheld unit **16** (the selection of the key and the amount of time required for the keypress to trigger the alert are configurable). Upon detecting the alert input by the student, the handheld application program **17** causes the handheld unit **16** to broadcast an 802.15.4 orphan notification command along with a reserved extended address. For example, if the handheld unit **16** normally has a 16 bit address, its orphan notification command includes the 16 bit address plus an addition 4 bit extension. Upon receiving the orphan notification with the extended address (the "alert") from the handheld unit **16**, the service program **26** assumes that the handheld unit **16** is in alert mode. The service program **26** then ignores all data traffic that it receives from all other handheld units **16** or application programs **22**, so as to devote all of the resources of the computer **12** to servicing the alert. The service program **26** responds to the handheld unit **16** (using the extended address as the destination address) to confirm that the alert has been received. The response of the service program **26** is identified as such in the "service port" field of the SP datagram header (see, e.g.,

FIG. 13). The response may include anything from a simple message that help is on the way to a series of questions relating to the nature of the student's emergency. Upon receiving the alert, the service program **26** also issues an alert message to an Emergency Response System (ERS) **21** via the public network **3** and one of the remote computers **28**. The communication between the computer **12** and the remote computer **28** in this context occurs through a web services connection, which exposes a web services application programming interface (API). Accordingly, any ERS operator having software that can access the web services API can respond to the student (via the public network **3**, the base station **11**, one of the wireless networks **24** and the handheld unit **16**). The operator can then inquire about the student's location, the nature of the alert, etc. Communication between the ERS operator and the student may occur using the same format described above for classroom quizzes—by exchanging mark-up language documents and by using HTTP GET and POST commands. For example, upon receiving an alert, the ERS operator could post a question, and the user could respond with yes, no, a, b, c, d, e, or by using numeric keys.

[0076] According to one embodiment, the service program **26** also determines whether the handheld unit **16** that is broadcasting the alert is "owned," such as by referring to the ownership information in the database **18**. If the handheld unit **16** is owned, the service program **26** obtains ownership information from the database **18** and transmits information about the owner, such as his or her name, to the ERS operator. Furthermore, the service program **26** may also transmit information regarding the location of the base station **11** to the ERS operator. Such information is configurable by the system administrator of the computer **12**, and is stored in the database **18**. For example, the information may include the room in which the base station **11** is located, such as "Science Lab, Room **102**,""3rd Floor Room **310**," or "Fitness Room." In some embodiments, the base station **11** includes Global Positioning System (GPS) equipment. In such a case, the service program **26** can use data from the GPS equipment to transmit precise location data to the ERS operator. In other embodiments, the handheld unit **16** includes GPS equipment, in which case it can use the GPS data to transmit its location to the service program **26**, which then relays that location information to the ERS operator.

CONCLUSION

[0077] It can be seen from the foregoing that a new and useful wireless classroom response system has been described. It should be noted that the use of the terms "a" and "an" and "the" and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. It should also be noted that recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein.

[0078] All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., "such as") provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention. Preferred embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. It should be understood that the illustrated embodiments are exemplary only, and should not be taken as limiting the scope of the invention.

What is claimed is:

1. A wireless response system for use in a class, the system comprising:

a wireless network located proximate to a room in which the class is being conducted;

a base station that coordinates the activities of the wireless network;

a plurality of handheld units, each of the plurality of handheld units being associated with an attendee of the class, a handheld unit of the plurality of handheld units performing steps comprising:

randomly choosing a wireless channel;

attempting to discover the presence of the wireless network on the randomly chosen wireless channel; and

repeating the choosing and attempting steps if the attempting step fails.

2. The system of claim 1, wherein the handheld unit of the plurality attempts to discover the presence of the wireless network by performing steps comprising making a plurality of requests for a beacon frame from the wireless network.

3. The system of claim 2, wherein the base station performs steps comprising receiving at least one of the requests and, in response to the received request, transmitting a beacon frame that includes the identity of the wireless network.

4. The system of claim 1, the wireless network being one of a plurality of wireless networks, wherein another of the plurality of handheld units performs steps comprising:

powering on;

remaining unconnected to the wireless network;

detecting that its associated class attendee has performed an action that requires the it to connect to a wireless network of the plurality;

retrieving the identity of the last wireless network of the plurality of wireless networks to which the it was previously connected;

asking its associated attendee whether the attendee wishes to reconnect to the identified last wireless network;

receiving an affirmative response from its associated attendee; and

based on the receiving step, connecting to the identified last wireless network.

5. The system of claim 1, wherein the base station performs steps comprising identifying which wireless channel has the least amount of wireless network traffic and

directing the handheld unit to connect to the wireless network using the identified wireless channel

6. The system of claim 1, wherein the base station comprises a computer and a wireless access point communicatively linked to the computer, the computer performing steps comprising:

determining whether health check messages have been received from the wireless access point;

if, based on the determining step, a predetermined number of health check messages have not been received, restarting the wireless access point; and

and wherein the wireless access point performs steps comprising:

determining whether health check messages have been received from the computer;

if, based on the determining step, a predetermined number of health check messages have not been received, rebooting itself.

7. The system of claim 1, wherein the wireless network is one of a plurality of wireless networks, wherein the handheld unit of the plurality of handheld units performs further steps comprising:

requesting a software update from the wireless network;

during the requested update, being interrupted, such that the update does not get completed;

connecting to the first available network of the plurality of wireless networks; and

requesting the software update from the first available wireless network.

8. The system of claim 1, the base station performing steps comprising:

identifying which of the plurality of handheld units has successfully discovered the wireless network; and

displaying a list of the identified handheld units to a system administrator.

9. The system of claim 1, wherein the base station performs steps comprising:

identifying which of the plurality of handheld units has successfully discovered the wireless network;

determining which attendee is associated with the identified handheld units; and

displaying a list of the attendees associated with the identified handheld units to a system administrator.

10. A wireless response system for use in a class, the system comprising:

a wireless network;

a plurality of handheld units communicatively linked to the wireless network;

a base station communicatively linked to the wireless network, the base station performing steps comprising transmitting a plurality of questions to the plurality of handheld units;

each of the plurality of handheld units comprising:

a display screen for displaying the plurality of questions, and

a navigation control, the navigation control having a first mode, in which it permits an attendee of the class to scroll through the text of a question of the plurality, and a second mode, in which it permits an attendee of the class to jump from one of the plurality of questions to another of the plurality of questions.

11. The system of claim 10, the navigation control comprising a button.

12. The system of claim 10, wherein a handheld unit of the plurality performs steps comprising:

receiving the entry of a numerical operation that is to be performed;

transmitting data relating to the numerical operation to the base station;

receiving the result of the operation from the base station;

and wherein the base station performs steps comprising:

receiving the numerical operation data;

computing the result of the numerical operation, and

transmitting the result to the handheld unit.

13. The system of claim 10, wherein a handheld unit of the plurality performs steps comprising:

controlling the pace at which the base station transmits the plurality of questions.

14. The system of claim 10, wherein a handheld unit of the plurality performs steps comprising:

receiving, from the base station, data representing the answers to the plurality of questions that the base station that were received from the rest of the plurality of handheld units.

15. The system of claim 10, wherein a handheld unit of the plurality performs steps comprising:

receiving an input from a system administrator representing a request to recover a personal identification number of the handheld unit;

transmitting a message representing the request to the base station; and

receiving the recovered personal identification number.

16. A wireless response system for use in a class, the class having a plurality of attendees, the system comprising:

a wireless network;

a plurality of handheld units communicatively linked to the wireless network;

a base station communicatively linked to the wireless network, the base station performing steps comprising transmitting a plurality of questions to the plurality of handheld units;

each of the plurality of handheld units comprising a display screen for displaying the plurality of questions, and a non-volatile memory,

each of the plurality of handheld units having

an owned mode, in which the handheld unit is assigned to a particular one of the plurality of attendees and has information regarding the attendee to which it is assigned stored in its non-volatile memory, and

a shared mode, in which the handheld unit is not assigned to any particular attendee.

17. The system of claim 16, wherein a handheld unit of the plurality performs steps comprising:

receiving an input from an attendee indicating that there is an emergency;

broadcasting an alert to the wireless network; and

receiving, in response from the wireless network, an acknowledgement of the alert.

18. The system of claim 16, wherein a handheld unit of the plurality performs steps comprising:

receiving an input from an attendee indicating that there is an emergency;

broadcasting an alert to the wireless network; and

receiving, in response from the wireless network, a question regarding the emergency; and

displaying the question to the attendee.

19. The system of claim 18, wherein the base station performs steps comprising:

receiving an answer to the question; and

transmitting the answer to an emergency response system via a public network.

20. The system of claim 16, wherein the base station performs further steps comprising:

receiving an alert from a handheld unit of the plurality of wireless handheld units;

transmitting information regarding the alert to an emergency response system, the information comprising global positioning system data.

21. The system of claim 20, wherein the global positioning system data includes data regarding the location of the base station.

22. The system of claim 20, wherein the global positioning system data includes data regarding the location of the handheld unit from which the alert came.

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