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(54) **INTELLIGENT WIRELESS COMMUNICATIONS FOR CONTINUOUS ANALYTE MONITORING**

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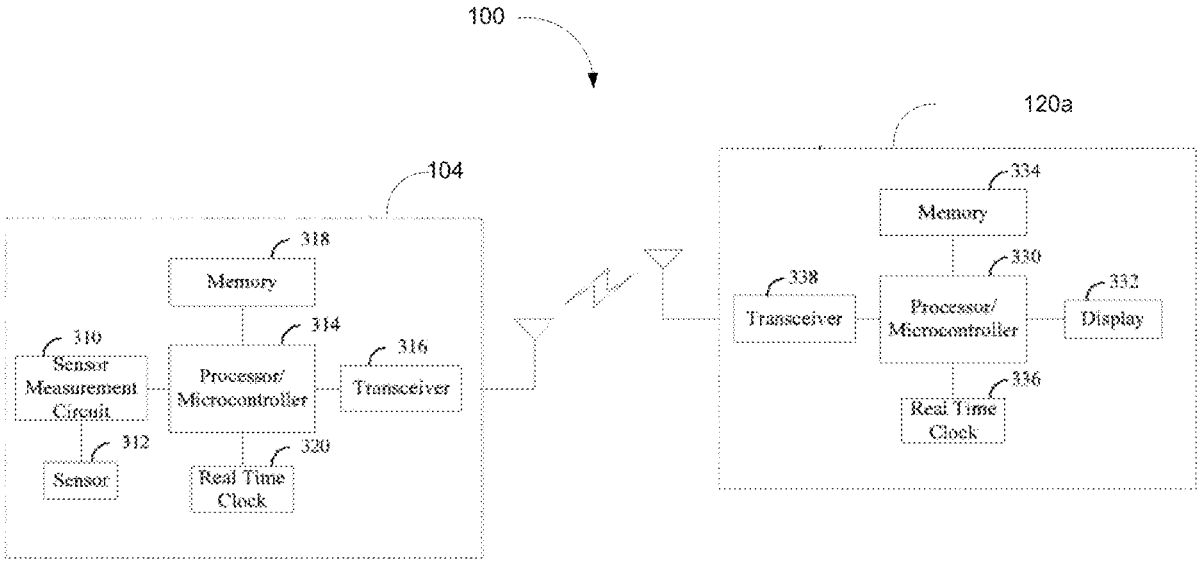
(57) **ABSTRACT**

Various embodiments relate generally to continuous monitoring of analyte values received from an analyte sensor system. In some example embodiments, there is provided a method that includes receiving sensor information, calculating and storing estimated analyte measurement values based upon the received sensor information. The method also includes determining one or more communication conditions, and instructing a transceiver to advertise to a first display device in accordance with one or more communication variables based upon the one or more communication conditions. The method then transmits the estimated analyte measurement values to the at least first display device. Related systems, methods, and articles of manufacture are also described.



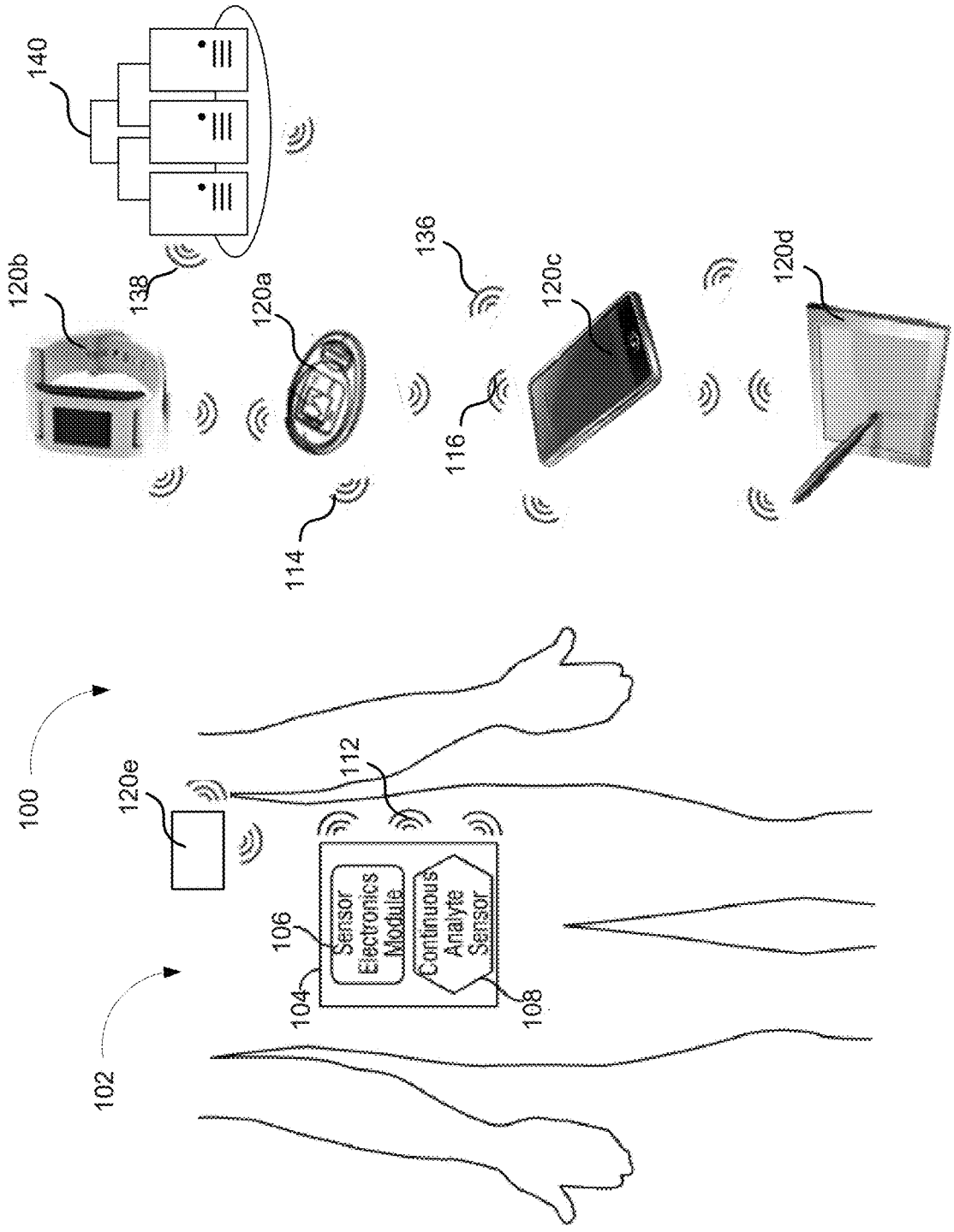

140
138
120b
120a
136
120c
120d
116
114
100
120e
112
Sensor Electronics Module
Continuous Analyte Sensor
106
104
108
102

FIG. 1

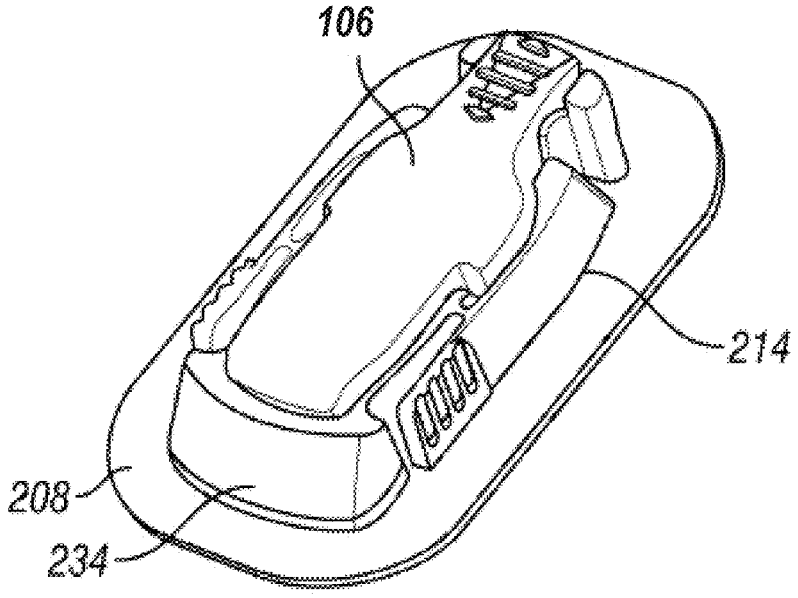


FIG. 2A

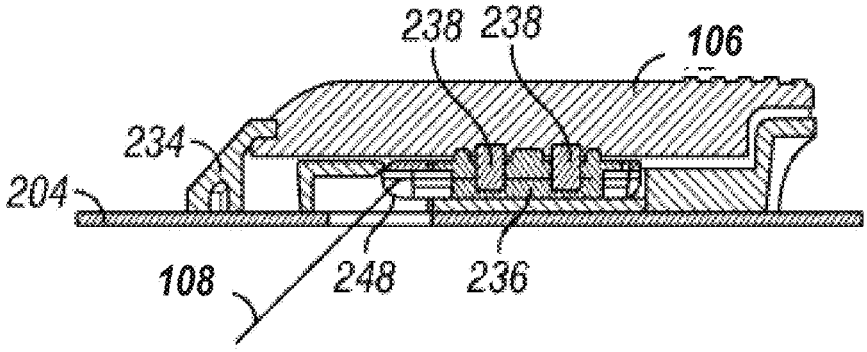


FIG. 2B

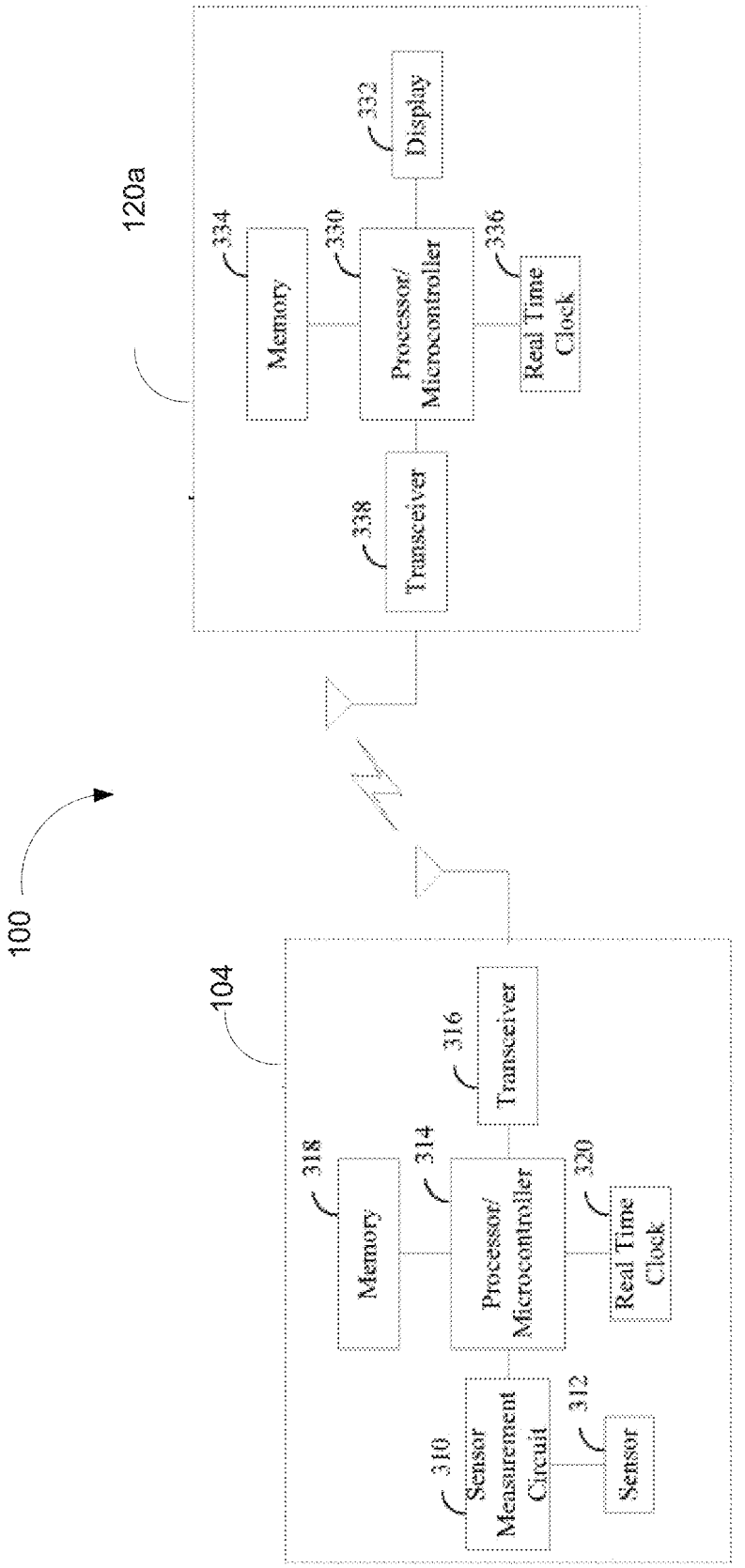

100
104
316
Transceiver
318
Memory
314
Processor/
Microcontroller
320
Real Time
Clock
310
Sensor
Measurement
Circuit
312
Sensor
120a
334
Memory
330
Processor/
Microcontroller
332
Display
336
Real Time
Clock
338
Transceiver

FIG. 3

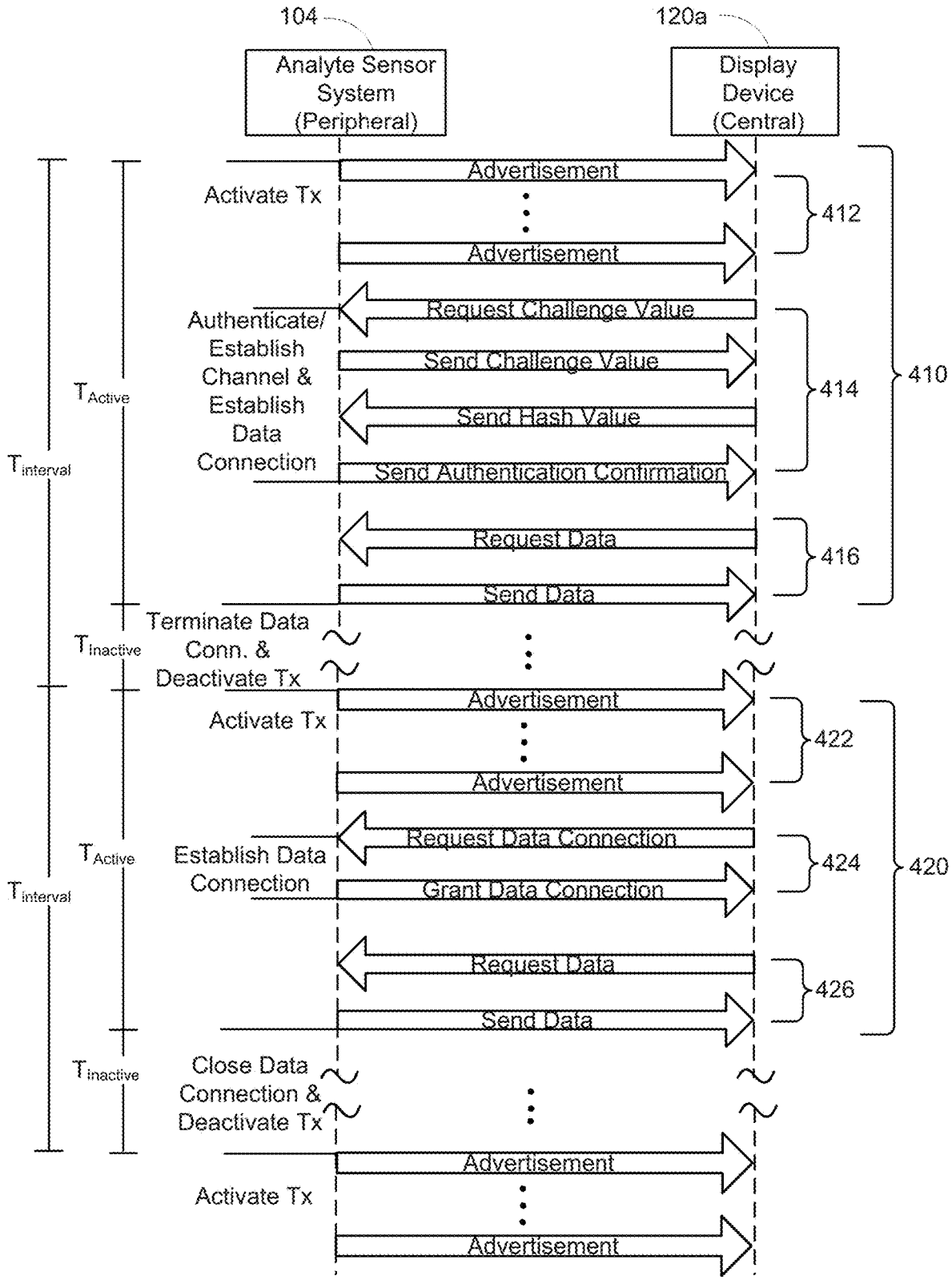

104
120a
Analyte Sensor System (Peripheral)
Display Device (Central)
Advertisement
Activate Tx
Advertisement
412
Request Challenge Value
Authenticate/ Establish Channel & Establish Data Connection
Send Challenge Value
Send Hash Value
Send Authentication Confirmation
414
410
Request Data
Send Data
416
T Active
T interval
Terminate Data Conn. & Deactivate Tx
T inactive
Advertisement
Activate Tx
Advertisement
422
Request Data Connection
Establish Data Connection
Grant Data Connection
424
420
Request Data
Send Data
426
T Active
T interval
T inactive
Close Data Connection & Deactivate Tx
Advertisement
Activate Tx
Advertisement

FIG. 4

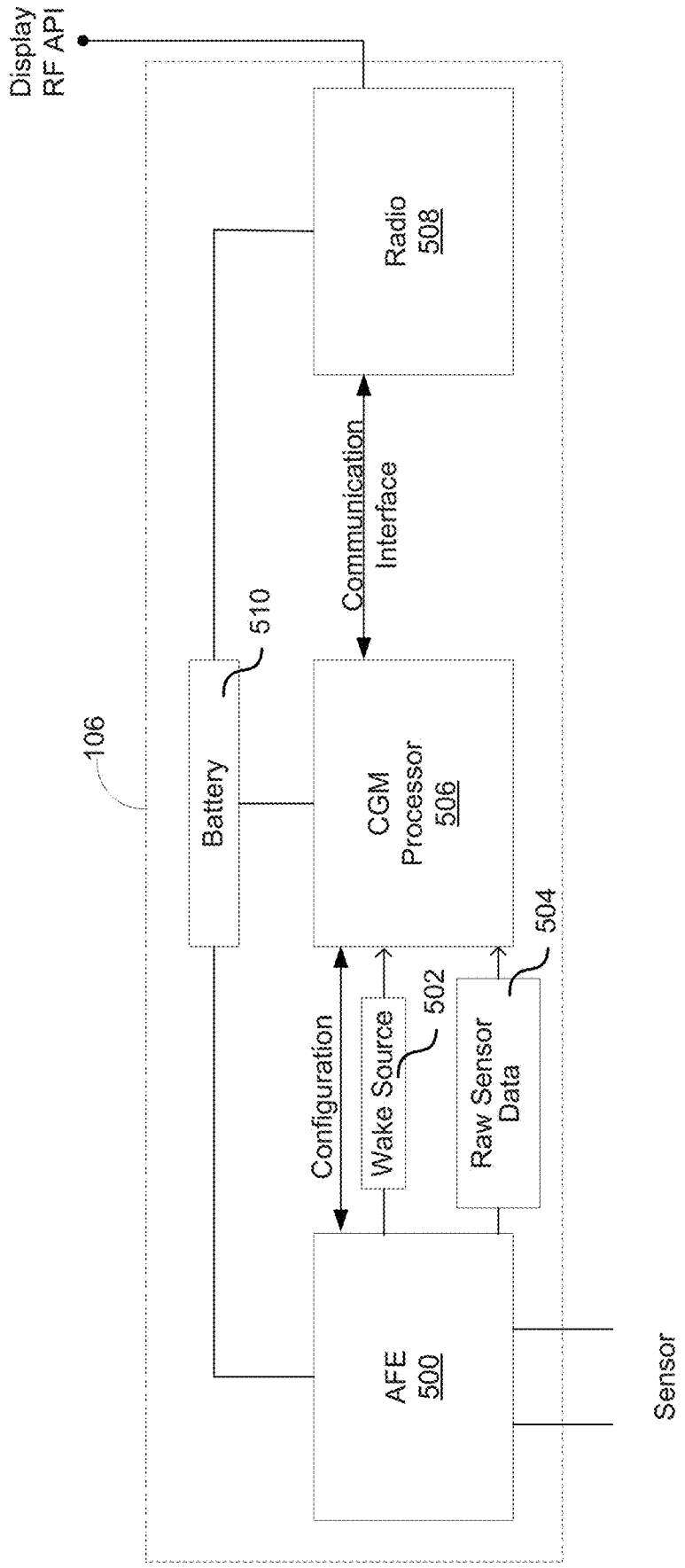

Display
RF API
Radio
508
Communication
Interface
510
106
Battery
CGM
Processor
506
504
502
Configuration
Wake Source
Raw Sensor
Data
AFE
500
Sensor

FIG. 5

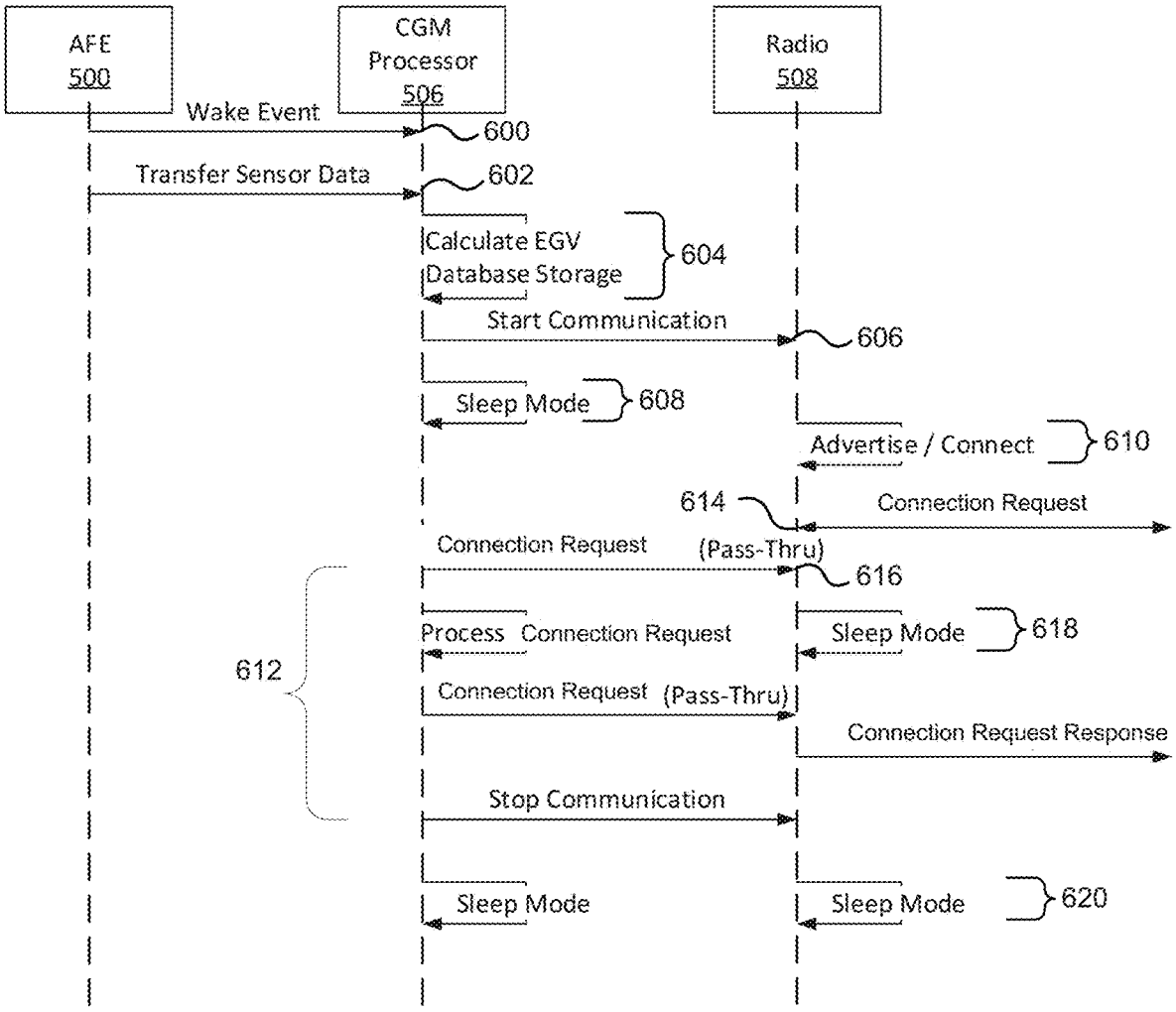

AFE
500
CGM
Processor
506
Radio
508
Wake Event
600
Transfer Sensor Data
602
Calculate EGV
Database Storage
604
Start Communication
606
Sleep Mode
608
Advertise / Connect
610
614
Connection Request
Connection Request
(Pass-Thru)
616
612
Process Connection Request
Sleep Mode
618
Connection Request
(Pass-Thru)
Connection Request Response
Stop Communication
Sleep Mode
Sleep Mode
620

FIG.6

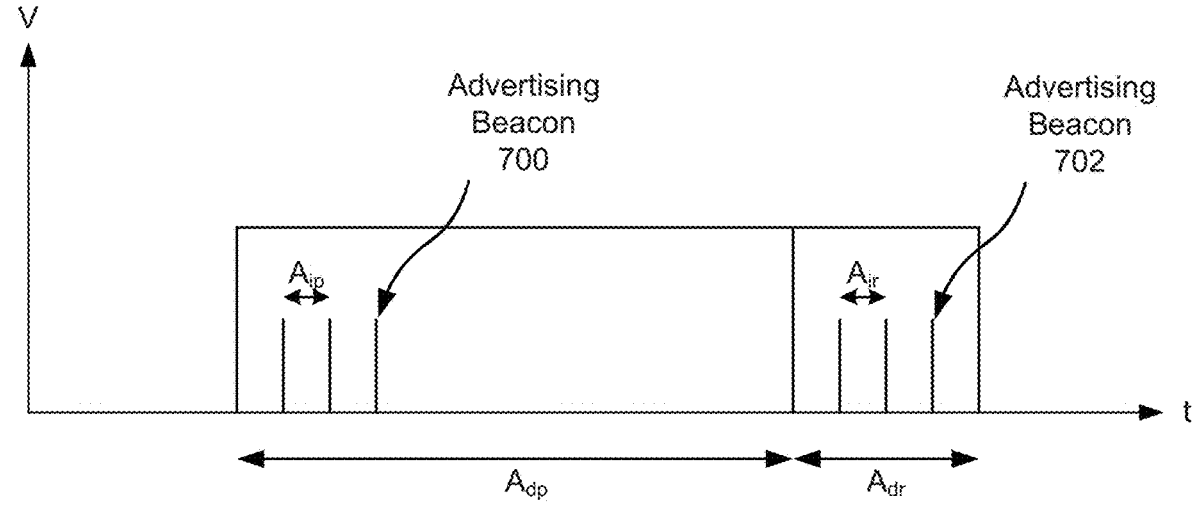


FIG. 7A

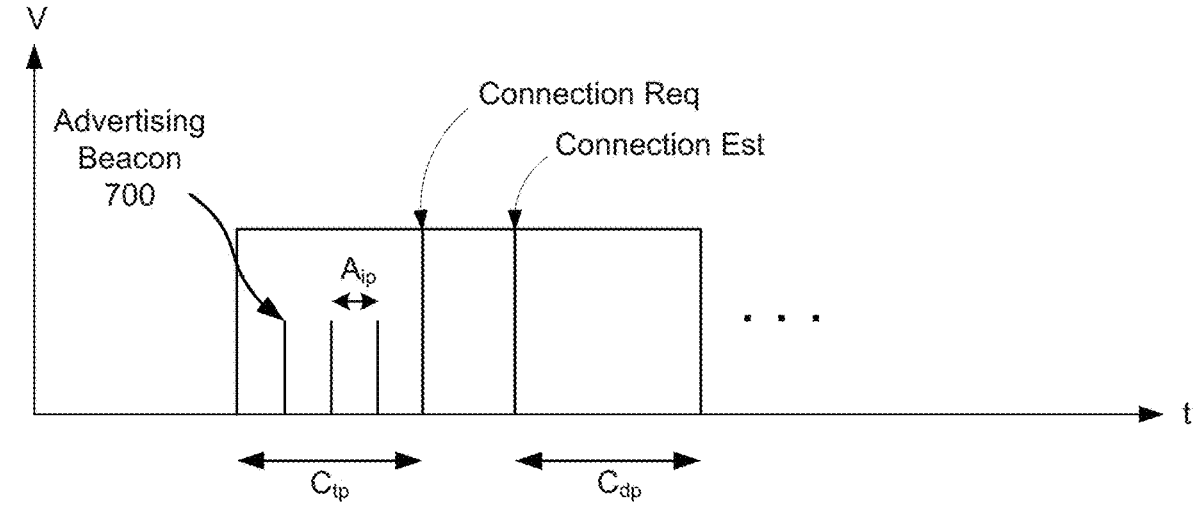


FIG. 7B

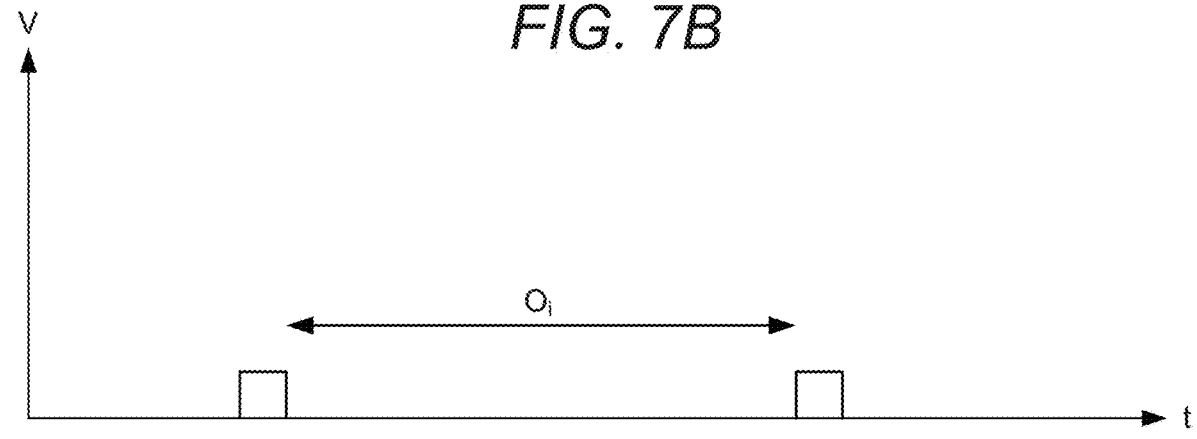


FIG. 7C

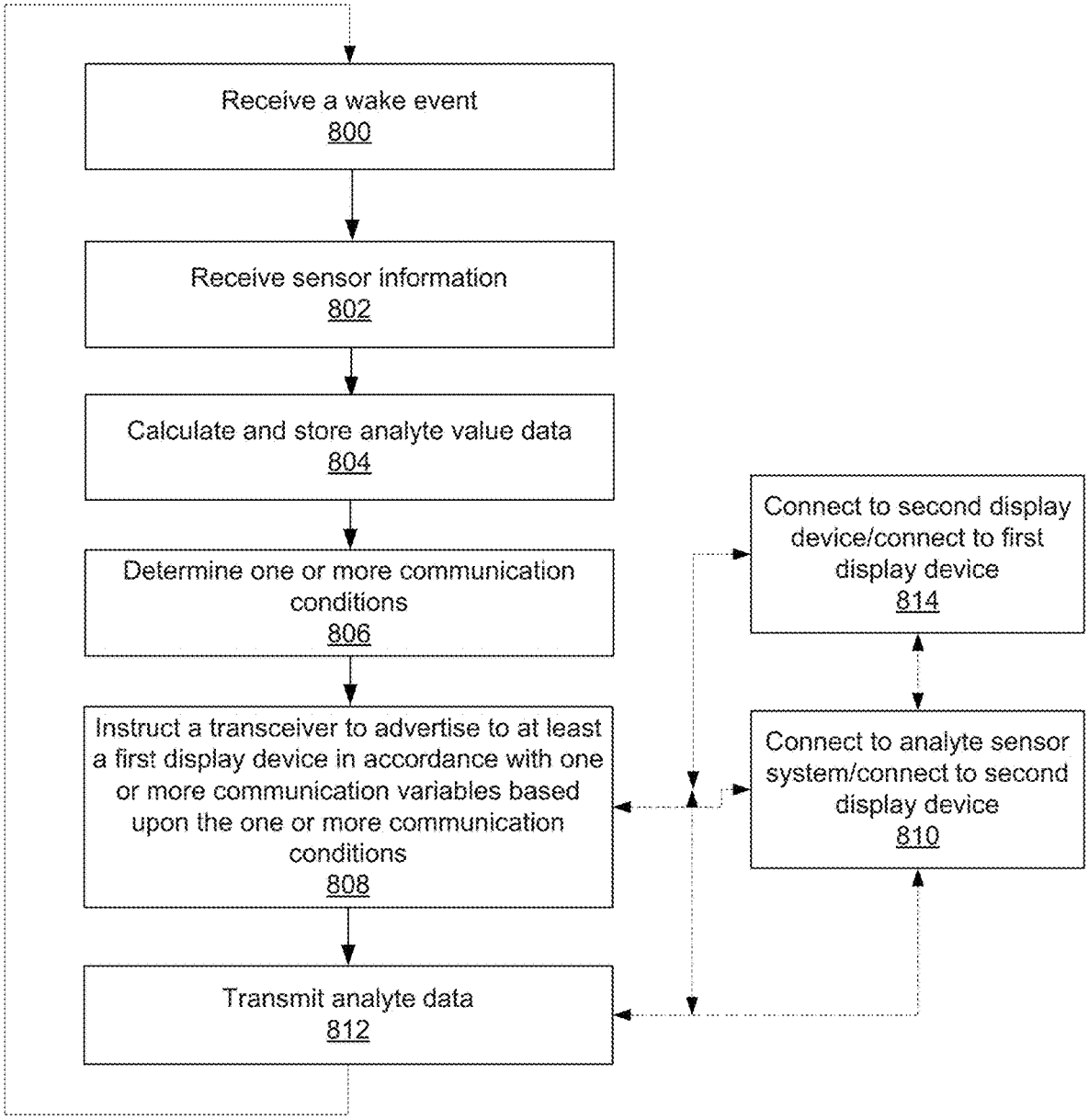

Receive a wake event
800
Receive sensor information
802
Calculate and store analyte value data
804
Determine one or more communication conditions
806
Instruct a transceiver to advertise to at least a first display device in accordance with one or more communication variables based upon the one or more communication conditions
808
Transmit analyte data
812
Connect to second display device/connect to first display device
814
Connect to analyte sensor system/connect to second display device
810

FIG. 8A

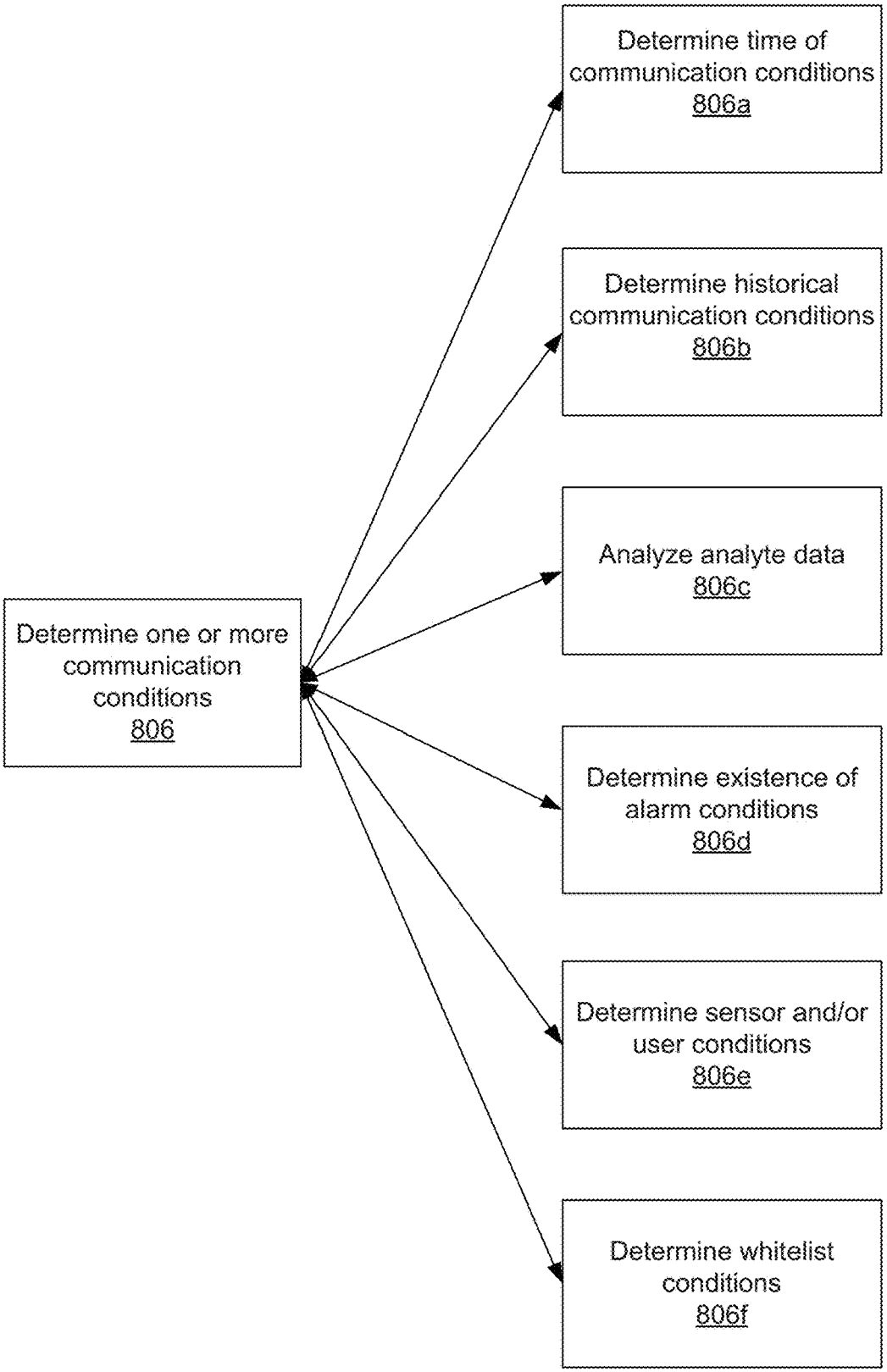

Determine one or more communication conditions 806
Determine time of communication conditions 806a
Determine historical communication conditions 806b
Analyze analyte data 806c
Determine existence of alarm conditions 806d
Determine sensor and/or user conditions 806e
Determine whitelist conditions 806f

FIG. 8B

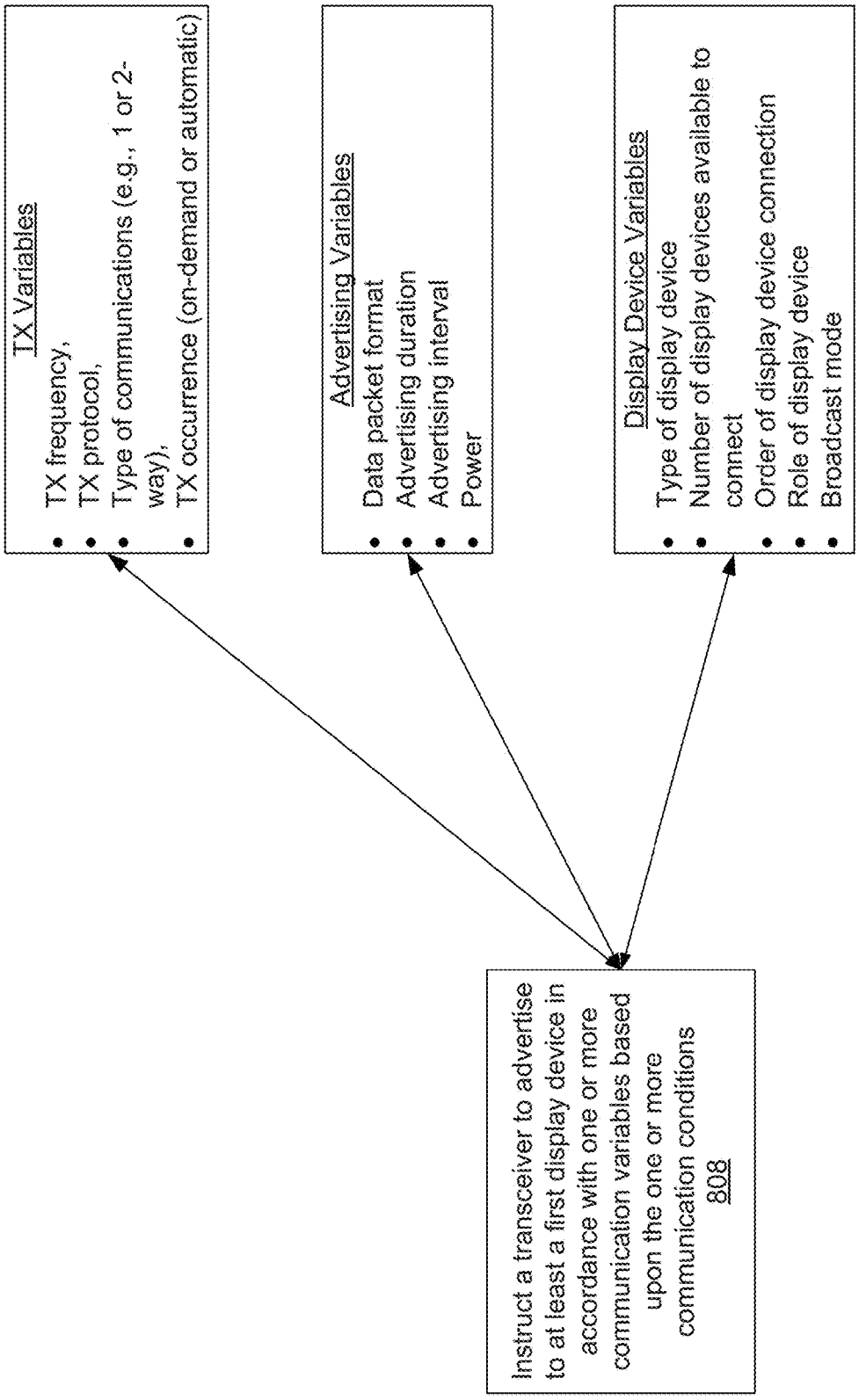

TX Variables
TX frequency,
TX protocol,
Type of communications (e.g., 1 or 2-way),
TX occurrence (on-demand or automatic)
Advertising Variables
Data packet format
Advertising duration
Advertising interval
Power
Display Device Variables
Type of display device
Number of display devices available to connect
Order of display device connection
Role of display device
Broadcast mode
Instruct a transceiver to advertise to at least a first display device in accordance with one or more communication variables based upon the one or more communication conditions
808

FIG. 8C

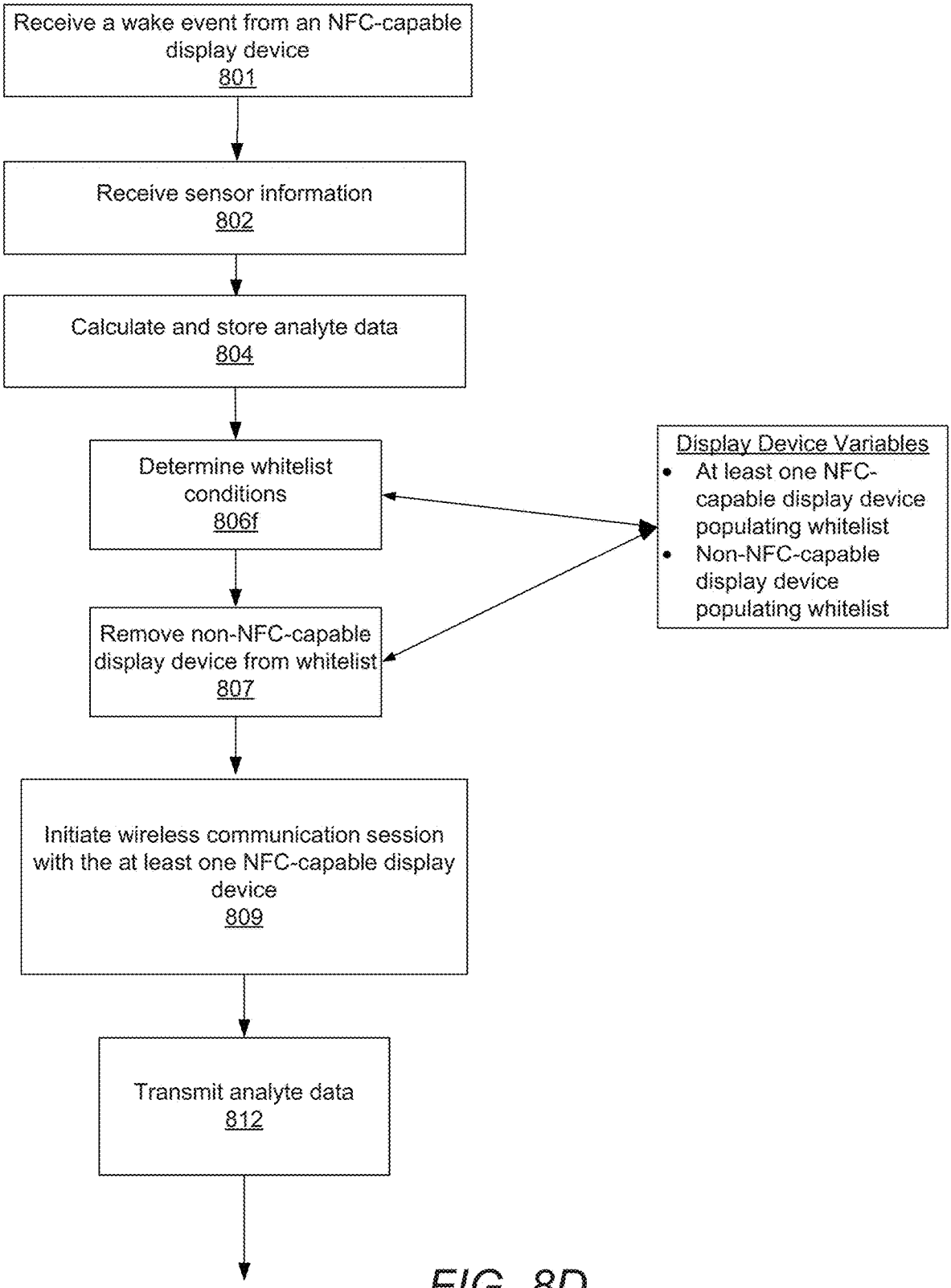

Receive a wake event from an NFC-capable display device
801
Receive sensor information
802
Calculate and store analyte data
804
Determine whitelist conditions
806f
Display Device Variables
At least one NFC-capable display device populating whitelist
Non-NFC-capable display device populating whitelist
Remove non-NFC-capable display device from whitelist
807
Initiate wireless communication session with the at least one NFC-capable display device
809
Transmit analyte data
812

FIG. 8D

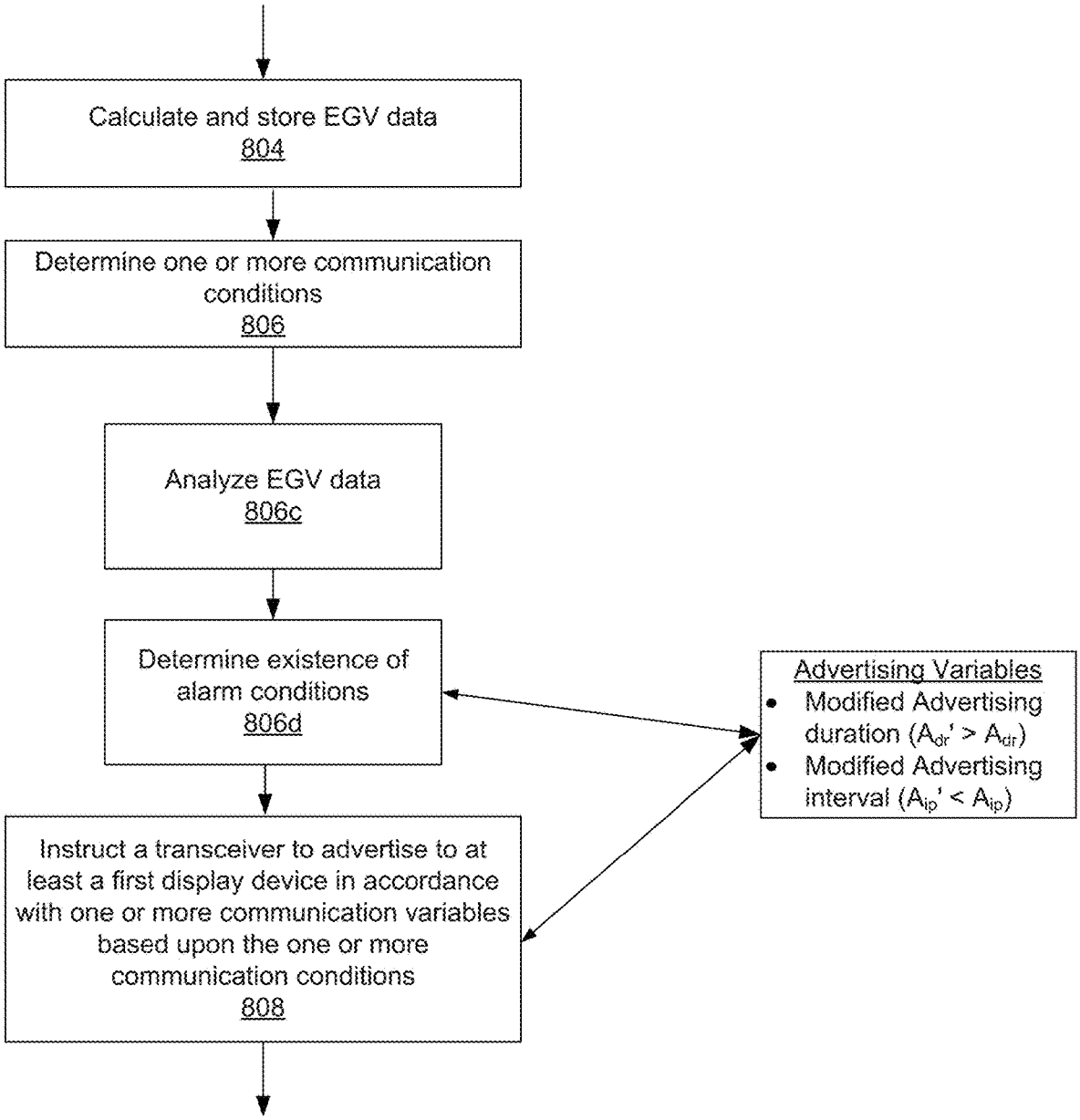

Calculate and store EGV data
804
Determine one or more communication conditions
806
Analyze EGV data
806c
Determine existence of alarm conditions
806d
Instruct a transceiver to advertise to at least a first display device in accordance with one or more communication variables based upon the one or more communication conditions
808
Advertising Variables
Modified Advertising duration ($A_{dr}' > A_{dr}$)
Modified Advertising interval ($A_{ip}' < A_{ip}$)

FIG. 8E

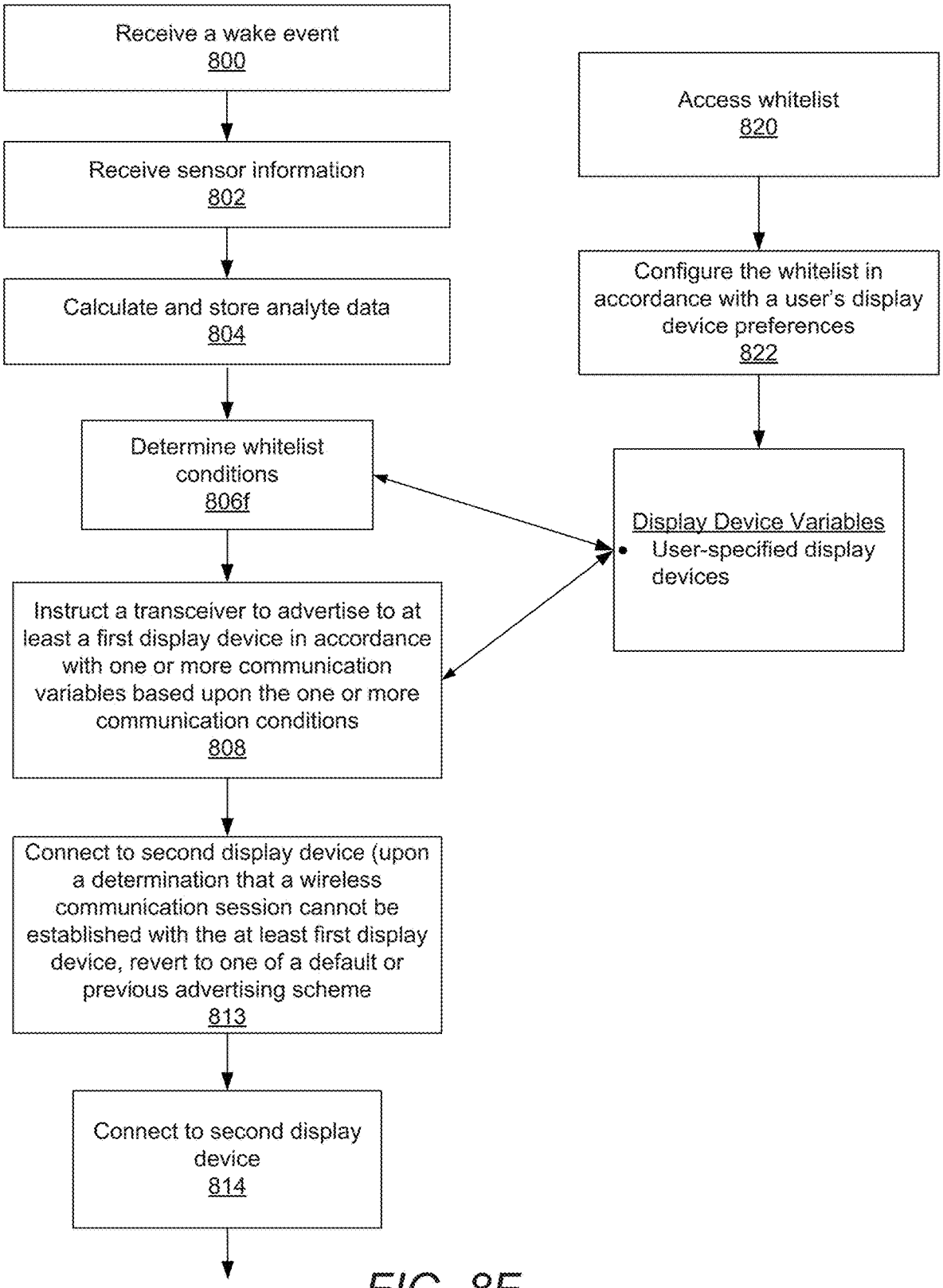

Receive a wake event
800
Receive sensor information
802
Calculate and store analyte data
804
Determine whitelist conditions
806f
Instruct a transceiver to advertise to at least a first display device in accordance with one or more communication variables based upon the one or more communication conditions
808
Connect to second display device (upon a determination that a wireless communication session cannot be established with the at least first display device, revert to one of a default or previous advertising scheme
813
Connect to second display device
814
Access whitelist
820
Configure the whitelist in accordance with a user's display device preferences
822
Display Device Variables
User-specified display devices

FIG. 8F

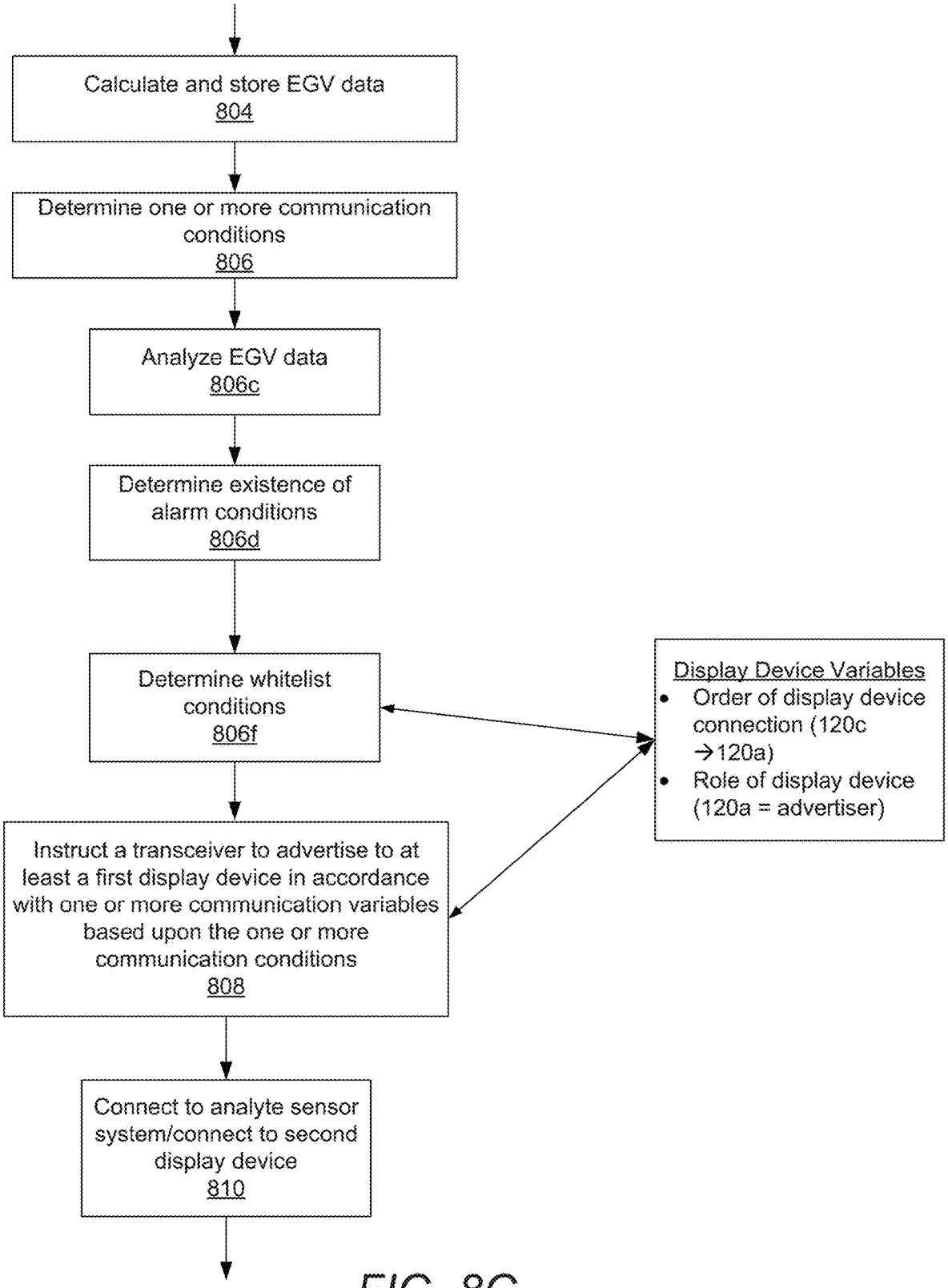

Calculate and store EGV data
804
Determine one or more communication conditions
806
Analyze EGV data
806c
Determine existence of alarm conditions
806d
Determine whitelist conditions
806f
Display Device Variables
Order of display device connection (120c →120a)
Role of display device (120a = advertiser)
Instruct a transceiver to advertise to at least a first display device in accordance with one or more communication variables based upon the one or more communication conditions
808
Connect to analyte sensor system/connect to second display device
810

FIG. 8G

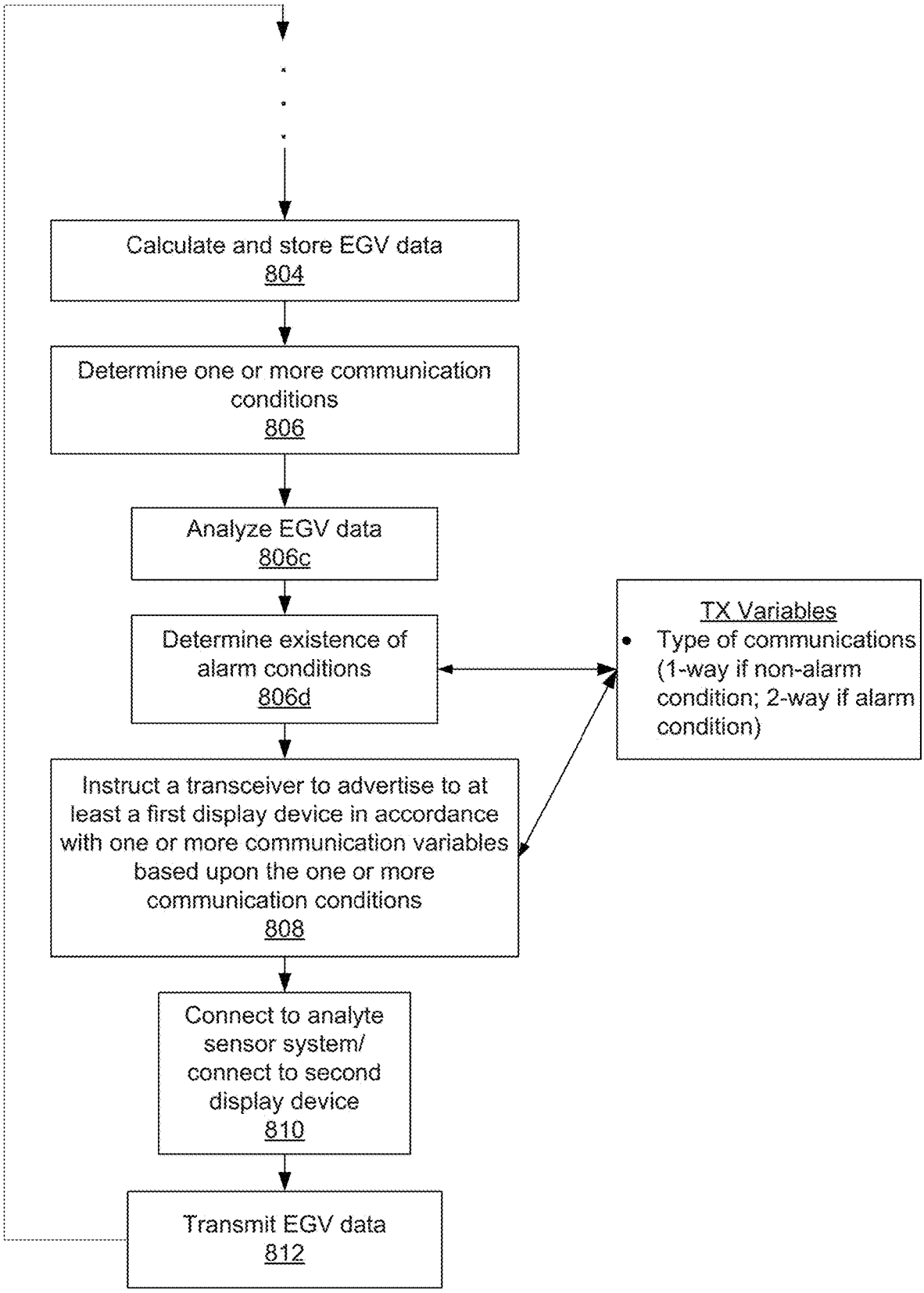

Calculate and store EGV data
804
Determine one or more communication conditions
806
Analyze EGV data
806c
Determine existence of alarm conditions
806d
TX Variables
Type of communications (1-way if non-alarm condition; 2-way if alarm condition)
Instruct a transceiver to advertise to at least a first display device in accordance with one or more communication variables based upon the one or more communication conditions
808
Connect to analyte sensor system/ connect to second display device
810
Transmit EGV data
812

FIG. 8H

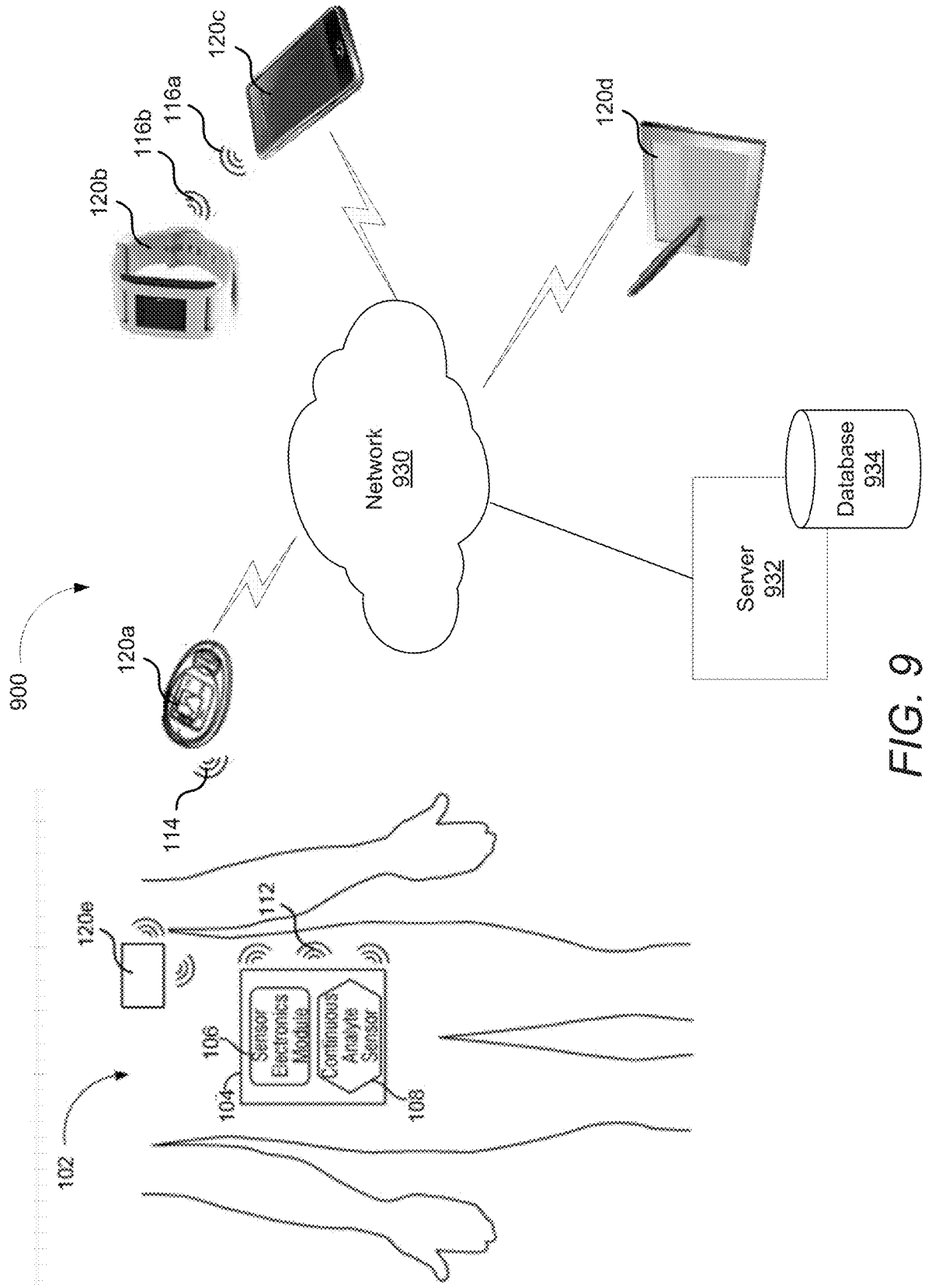

900
102
104
106
108
112
114
116a
116b
120a
120b
120c
120d
120e
Sensor Electronics Module
Common Analyte Sensor
Network 930
Server 932
Database 934

FIG. 9

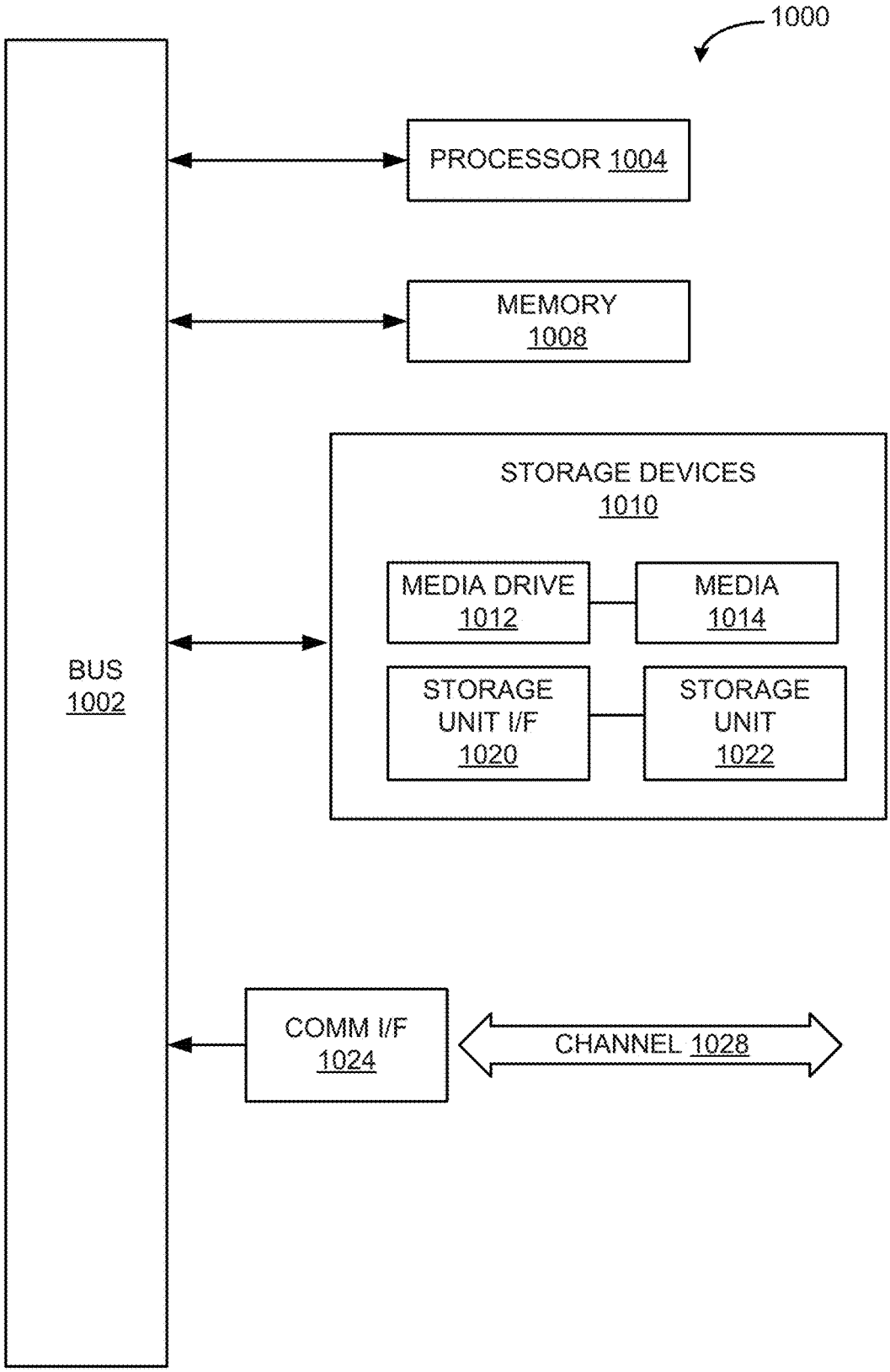

1000
PROCESSOR 1004
MEMORY 1008
STORAGE DEVICES 1010
MEDIA DRIVE 1012
MEDIA 1014
STORAGE UNIT I/F 1020
STORAGE UNIT 1022
BUS 1002
COMM I/F 1024
CHANNEL 1028

FIG. 10

INTELLIGENT WIRELESS COMMUNICATIONS FOR CONTINUOUS ANALYTE MONITORING

INCORPORATION BY REFERENCE TO RELATED APPLICATION

[0001] Any and all priority claims identified in the Application Data Sheet, or any correction thereto, are hereby incorporated by reference under 37 CFR 1.57. This application is a continuation of U.S. application Ser. No. 15/384,944, filed on Dec. 20, 2016, which claims the benefit of U.S. Provisional Appl. No. 62/271,880, filed on Dec. 28, 2015. The aforementioned applications are incorporated by reference herein in their entirety, and are hereby expressly made a part of this specification.

FIELD

[0002] Various embodiments relate generally to continuous monitoring of analyte values received from an analyte sensor system.

BACKGROUND

[0003] Diabetes mellitus is a disorder in which the pancreas cannot create sufficient insulin (Type I or insulin dependent) and/or in which insulin is not effective (Type 2 or non-insulin dependent). In the diabetic state, the victim suffers from high blood sugar, which causes an array of physiological derangements (kidney failure, skin ulcers, or bleeding into the vitreous of the eye) associated with the deterioration of small blood vessels. A hypoglycemic reaction (low blood sugar) may be induced by an inadvertent overdose of insulin, or after a normal dose of insulin or glucose-lowering agent accompanied by extraordinary exercise or insufficient food intake.

[0004] Conventionally, a diabetic person carries a self-monitoring blood glucose (SMBG) monitor, which typically requires uncomfortable finger pricking methods. Due to the lack of comfort and convenience, a diabetic person will normally only measure his or her glucose level two to four times per day. Unfortunately, these time intervals are spread so far apart that the diabetic person will likely find out too late, sometimes incurring dangerous side effects, of a hyperglycemic or hypoglycemic condition. In fact, it is not only unlikely that a diabetic person will take a timely SMBG value, but it is also unlikely that the diabetic will know if his or her blood glucose value is going up (higher) or down (lower) utilizing conventional monitoring systems and methods.

[0005] Consequently, a variety of non-invasive, transdermal (e.g., transcutaneous) and/or implantable electrochemical sensors are being developed for continuously detecting and/or quantifying blood glucose values. These devices generally transmit raw or minimally processed data for subsequent analysis at a remote device, which can include a display.

SUMMARY

[0006] Details of one or more implementations of the subject matter described in this specification are set forth in the accompanying drawings and the description below. Other features, aspects, and advantages will become apparent from the description, the drawings, and the claims. Note that the relative dimensions of the following figures may not be drawn to scale. In some aspects of the disclosed technology, a computer-implemented method includes receiving sensor information; calculating and storing estimated analyte measurement values based upon the received sensor information; determining one or more communication conditions; instructing a transceiver to advertise to at least a first display device in accordance with one or more communication variables based upon the one or more communication conditions; and transmitting the estimated analyte measurement values to the at least first display device. In some implementations, the computer-implemented method further includes determining the one or more communication conditions comprises determining at least one of the following: a time associated with the communication conditions; historical communication conditions; an existence of an alarm condition; a condition of the continuous glucose monitoring sensor; a condition of a user of the continuous glucose monitoring sensor; and whitelist conditions. In some implementations, the one or more communication variables includes at least one of an advertising duration parameter and an advertising interval parameter according to which advertising beacons are transmitted to the first display device, and wherein the at least one of the advertising duration and advertising interval parameters are adjusted to the first display device. In some implementations, the first display device includes one of a last-connected display device populating the whitelist, a preferred display device populating the whitelist, and a display device configured to advertise to at least a second display device. In some implementations, the alarm condition comprises a determination that the condition of the user is approaching or experiencing a medically critical state. In some implementations, the one or more communication variables are optimized for establishing a wireless communication session with the first display device. In some implementations, the optimization of the one or more communication variables includes at least one of increasing a default advertising duration parameter and decreasing a default advertising interval parameter. In some examples, the one or more communication variables are optimized for establishing a wireless communication session with the first display device upon a determination that the estimated analyte measurement values are indicative of a trend towards a medically critical state. In some implementations, the one or more communication variables are adjusted for delaying establishment of a wireless communication session with the first display device upon a determination that the estimated analyte measurement values are indicative of a trend towards a medically non-critical state.

[0007] In some aspects of the disclosed technology, an apparatus includes signal conditioning circuitry communicatively connected to a continuous analyte sensor for receiving sensor information from the continuous analyte sensor indicative of analyte levels of a host to which the continuous analyte sensor is operatively attached; a processor, wherein upon receiving the sensor information from the signal conditioning circuitry, instructs a radio to perform the following: transmit a plurality of advertising beacons to a first display device in accordance with one or more communication variables based upon one or more communication conditions determined by the apparatus; and upon the first display device responding to one of the plurality of advertising beacons, establish a wireless communication session with the first display device and transmit the sensor infor-

mation or analyte values derived from the sensor information to the at least first display device. In some implementations, the one or more communication variables includes at least one of: a transmission frequency variable indicating a frequency with which the sensor information or the analyte values are transmitted to the first display device; a transmission protocol indicating a wireless communication protocol to be utilized in the transmission of the sensor information or the analyte values to the first display device; a communications type variable indicating a one-way communication or a two-way communication with the first display during the transmission of the sensor information or the analyte values to the first display device; and a transmission occurrence variable indicating whether the transmission of the sensor information or the analyte values to the first display device are to occur in an on-demand or automatic manner. In some implementations, the one or more communication variables further includes: a data packet format type variable to be utilized for the transmission of the plurality of advertising beacons; an advertising duration variable indicative of a duration for which the first display device is to be advertised to; an advertising interval variable indicative of an amount of time between the transmission of each of the plurality of advertising beacons; and a power variable indicative of power to be used by the radio for the transmission of the advertising beacons. In some implementations, the one or more communication variables further includes a display device type variable indicating a type of at least one of the first display device and additional display devices to which the sensor information or analyte values are to be sent; a display device number indicating a number of display devices available to receive the sensor information or analyte values; an order variable indicating a connection order of display devices previously having established a wireless communication session with the radio; a role variable indicating whether at least one of the first display device and the additional display devices are at least one of a primary display device, a secondary display device, a preferred display device, a scan-only display device, an advertising display device, and a sensor information or analyte values forwarding display device; and a broadcast mode variable indicating one-way or two-way broadcasting to be used in conjunction with at least one of the first display device and the additional display devices if the at least one of the first display device and the additional display devices comprise an advertising display device or a sensor information or analyte values forwarding display device.

[0008] In some aspects of the disclosed technology, a computer-implemented method, includes calculating and storing estimated glucose value data based upon glucose measurements obtained by a continuous glucose monitoring sensor; determining one or more communication conditions; and advertising to one or more display devices in a manner based on the one or more communication conditions. In some implementations, the determination of the one or more communication conditions includes analyzing historical estimated glucose value data. In some implementations, the analysis of the historical estimated glucose value data results in an observed trend. In some implementations, the determination of the one or more communication conditions further includes determining whether an alarm condition exists based on the observed trend. In some implementations, the advertising to the one or more displays includes incorporating the estimated glucose value data in advertising beacons upon a determination that no alarm condition exists. In some implementations, the estimated glucose value data is incorporated in the advertising beacons in an encrypted format. In some implementations, the advertising to the one or more displays includes transmitting advertising beacons to the one or more display devices upon a determination that an alarm condition exists. In some examples, the computer-implemented method further includes establishing wireless communication sessions during which the estimated glucose value data is transmitted to the one or more display devices upon the one or more display devices responding to their respective advertising beacons.

[0009] In some aspects of the disclosed technology, an apparatus includes: a continuous analyte sensor adapted to obtain raw analyte data; a processor and a memory unit having computer code configured to cause the processor to: calculate and store analyte value data derived from the raw analyte data; determine one or more communication conditions; and a radio adapted to advertise to one or more display devices in a manner based on the one or more communication conditions.

[0010] In some aspects of the disclosed technology, an apparatus includes a memory; and a processor, the memory having computer code configured to cause the processor to: receive estimated glucose value data; and based upon observed communication conditions and communication variables adapted based on the observed communication conditions, transmit the estimated glucose value data to one or more display devices.

[0011] Any of the features of aspects specified herein are applicable to all other aspects and embodiments identified herein. Moreover, any of the features of an aspect is independently combinable, partly or wholly with other aspects described herein in any way, e.g., one, two, or three or more aspects may be combinable in whole or in part. Further, any of the features of an aspect may be made optional to other aspects. Any aspect of a method can be performed by a system or apparatus of another aspect, and any aspect or of a system can be configured to perform a method of another aspect.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Various embodiments are described in detail with reference to the accompanying figures. The drawings are provided for purposes of illustration only and merely depict typical or example embodiments. These drawings are provided to facilitate the reader's understanding of the systems and methods described herein, and shall not be considered limiting of the breadth, scope, or applicability of the various embodiments.

[0013] FIG. **1** is a diagram illustrating certain embodiments of an example continuous analyte sensor system communicating with at least one display device in accordance with various technologies described in the present disclosure.

[0014] FIG. **2**A is a perspective view of an example sensor electronics module of the example continuous analyte sensor system of FIG. **1**.

[0015] FIG. **2**B is a side view of the example sensor electronics module of FIG. **2**A.

[0016] FIG. **3** is a block diagram illustrating elements of an example continuous analyte monitoring system and display devices in accordance with various embodiments described in the present disclosure.

[0017] FIG. **4** is an example advertising/connection sequence in accordance various embodiments described in the present disclosure.

[0018] FIG. **5** is a block diagram illustrating various elements involved in the transmission of data from an example continuous analyte monitoring system in accordance with various embodiments described in the present disclosure.

[0019] FIG. **6** is an example transmitter processing/command sequence in accordance with various embodiments described in the present disclosure.

[0020] FIG. **7**A is an example advertising profile in accordance with various embodiments described in the present disclosure.

[0021] FIG. **7**B is an example connection profile in accordance with various embodiments described in the present disclosure.

[0022] FIG. **7**C is an illustration of an example operating interval in accordance with various embodiments described in the present disclosure.

[0023] FIGS. **8**A-**8**H are flow charts illustrating example processes performed for adapting communications in accordance with communication conditions and communication variables in accordance with various embodiments of the present disclosure.

[0024] FIG. **9** is a diagram illustrating certain alternative examples of a continuous analyte sensor system communicating with at least one display device in accordance with various technologies described in the present disclosure.

[0025] FIG. **10** is a block diagram of an example computing module that may be used to implement various features of embodiments described in the present disclosure.

DETAILED DESCRIPTION

[0026] The following description illustrates some example embodiments of the disclosed technology or technologies in detail. Those of skill in the art will recognize that there are numerous variations and modifications of the disclosed embodiments encompassed by its scope. Accordingly, the description of a certain example embodiments should not be deemed to limit the scope of the present disclosure.

Overview

[0027] As alluded to previously, continuous monitoring of blood glucose values, one example of an analyte (discussed in greater detail below) can improve upon conventional monitoring systems and methods by improving comfort and convenience, as well as lessening the chance that a person's deteriorating or medically critical condition goes unnoticed. Thus, various embodiments described herein are directed to systems and methods of continuous analyte monitoring and the optimization of communications/initiating communications for the transmittal and receipt of continually monitored analyte data.

[0028] In some embodiments, a system is provided for continuous measurement of an analyte in a host that can include: a continuous analyte sensor configured to continuously measure a concentration of the analyte in the host; and a sensor electronics module physically connected to the continuous analyte sensor to receive the analyte concentration measurements and communicate them to display devices. In particular, the sensor electronics module includes electronics configured to process a data stream associated with an analyte concentration measured by the continuous analyte sensor in order to generate sensor information that includes raw sensor data, transformed sensor data, and/or any other sensor data or data derived therefrom, e.g., predictive or trend data. The sensor electronics module may further be configured to generate sensor information that is customized for respective display devices, such that different display devices may receive different sensor information for presentation to the host, a host care taker, etc.

[0029] Communications between the sensor electronics module and one or more display devices can be controlled via an advertising and connection protocol indicating, for example, how often and/or how long the sensor electronics module advertises to a display device, the order in which the sensor electronics module advertised to a display device, etc. The sensor electronics module may comprise a communications unit operative in accordance with the advertising and connection protocol, such as a radio transceiver, that effectuates such communications between the sensor electronics module and the one or more display devices. The control effectuated by the advertising and connection protocol can be achieved by varying or adjusting variables or parameters that can impact communications in accordance with one or more communication conditions that can be accounted for.

[0030] As can be appreciated, the nature of continual analyte measurement, as well as a desired form factor for the sensor electronics module would be well-served by a power efficient design. Thus, the initiation of communication between the sensor electronics module and display devices, as well as communications themselves are optimized in accordance with various embodiments so as to maximize battery life in the sensor electronics module. In addition to power savings, this optimization can improve connection reliability between the sensor electronics module and display devices, as well as reduce connection delays and/or delays associated with presenting sensor information to the host.

[0031] The term "analyte" as used herein is a broad term and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and furthermore refers without limitation to a substance or chemical constituent in a biological fluid (for example, blood, interstitial fluid, cerebral spinal fluid, lymph fluid or urine) that can be analyzed. Analytes can include naturally occurring substances, artificial substances, metabolites, and/or reaction products. In some embodiments, the analyte for measurement by the sensor heads, devices, and methods is analyte. However, other analytes are contemplated as well, including but not limited to acarboxyprothrombin; acylcarnitine; adenine phosphoribosyl transferase; adenosine deaminase; albumin; alpha-fetoprotein; amino acid profiles (arginine (Krebs cycle), histidine/urocanic acid, homocysteine, phenylalanine/tyrosine, tryptophan); andrenostenedione; antipyrine; arabinitol enantiomers; arginase; benzoylecgonine (cocaine); biotinidase; biopterin; c-reactive protein; carnitine; carnosinase; CD4; ceruloplasmin; chenodeoxycholic acid; chloroquine; cholesterol; cholinesterase; conjugated 1-ß hydroxy-cholic acid; cortisol; creatine kinase; creatine kinase MM isoenzyme; cyclosporin A; d-penicillamine; de-ethylchloroquine; dehydroepiandrosterone sulfate; DNA (acetylator polymorphism, alcohol dehydrogenase, alpha 1-antitrypsin, cystic fibrosis, Duchenne/Becker muscular dystrophy, analyte-6-phosphate dehydrogenase, hemoglobin

A, hemoglobin S, hemoglobin C, hemoglobin D, hemoglobin E, hemoglobin F, D-Punjab, beta-thalassemia, hepatitis B virus, HCMV, HIV-1, HTLV-1, Leber hereditary optic neuropathy, MCAD, RNA, PKU, *Plasmodium vivax*, sexual differentiation, 21-deoxycortisol); desbutylhalofantrine; dihydropteridine reductase; diptheria/tetanus antitoxin; erythrocyte arginase; erythrocyte protoporphyrin; esterase D; fatty acids/acylglycines; free ß-human chorionic gonadotropin; free erythrocyte porphyrin; free thyroxine (FT4); free tri-iodothyronine (FT3); fumarylacetoacetase; galactose/gal-1-phosphate; galactose-1-phosphate uridyltransferase; gentamicin; analyte-6-phosphate dehydrogenase; glutathione; glutathione perioxidase; glycocholic acid; glycosylated hemoglobin; halofantrine; hemoglobin variants; hexosaminidase A; human erythrocyte carbonic anhydrase I; 17-alpha-hydroxyprogesterone; hypoxanthine phosphoribosyl transferase; immunoreactive trypsin; lactate; lead; lipoproteins ((a), B/A-1, ß); lysozyme; mefloquine; netilmicin; phenobarbitone; phenytoin; phytanic/pristanic acid; progesterone; prolactin; prolidase; purine nucleoside phosphorylase; quinine; reverse tri-iodothyronine (rT3); selenium; serum pancreatic lipase; sissomicin; somatomedin C; specific antibodies (adenovirus, anti-nuclear antibody, anti-zeta antibody, arbovirus, Aujeszky's disease virus, dengue virus, *Dracunculus medinensis, Echinococcus granulosus, Entamoeba histolytica*, enterovirus, *Giardia duodenalisa, Helicobacter pylori*, hepatitis B virus, herpes virus, HIV-1, IgE (atopic disease), influenza virus, *Leishmania donovani*, leptospira, measles/mumps/rubella, *Mycobacterium leprae, Mycoplasma pneumoniae*, Myoglobin, *Onchocerca volvulus*, parainfluenza virus, *Plasmodium falciparum*, poliovirus, *Pseudomonas aeruginosa*, respiratory syncytial virus, *rickettsia* (scrub typhus), *Schistosoma mansoni, Toxoplasma gondii, Trepenoma pallidium, Trypanosoma cruzi*/rangeli, vesicular *stomatis* virus, *Wuchereria bancrofti*, yellow fever virus); specific antigens (hepatitis B virus, HIV-1); succinylacetone; sulfadoxine; theophylline; thyrotropin (TSH); thyroxine (T4); thyroxine-binding globulin; trace elements; transferring; UDP-galactose-4-epimerase; urea; uroporphyrinogen I synthase; vitamin A; white blood cells; and zinc protoporphyrin. Salts, sugar, protein, fat, vitamins, and hormones naturally occurring in blood or interstitial fluids can also constitute analytes in certain embodiments. The analyte can be naturally present in the biological fluid, for example, a metabolic product, a hormone, an antigen, an antibody, and the like. Alternatively, the analyte can be introduced into the body, for example, a contrast agent for imaging, a radioisotope, a chemical agent, a fluorocarbon-based synthetic blood, or a drug or pharmaceutical composition, including but not limited to insulin; ethanol; *cannabis* (marijuana, tetrahydrocannabinol, hashish); inhalants (nitrous oxide, amyl nitrite, butyl nitrite, chlorohydrocarbons, hydrocarbons); cocaine (crack cocaine); stimulants (amphetamines, methamphetamines, Ritalin, Cylert, Preludin, Didrex, PreState, Voranil, Sandrex, Plegine); depressants (barbiturates, methaqualone, tranquilizers such as Valium, Librium, Miltown, Serax, Equanil, Tranxene); hallucinogens (phencyclidine, lysergic acid, mescaline, peyote, psilocybin); narcotics (heroin, codeine, morphine, opium, meperidine, Percocet, Percodan, Tussionex, Fentanyl, Darvon, Talwin, Lomotil); designer drugs (analogs of fentanyl, meperidine, amphetamines, methamphetamines, and phencyclidine, for example, Ecstasy); anabolic steroids; and nicotine. The metabolic products of drugs and pharmaceutical compositions are also contemplated analytes. Analytes such as neurochemicals and other chemicals generated within the body can also be analyzed, such as, for example, ascorbic acid, uric acid, dopamine, noradrenaline, 3-methoxytyramine (3MT), 3,4-Dihydroxyphenylacetic acid (DOPAC), Homovanillic acid (HVA), 5-Hydroxytryptamine (5HT), and 5-Hydroxyindoleacetic acid (FHIAA).

[0032] Display Devices

[0033] In some embodiments, the sensor electronics module may be configured to search for and/or attempt to wirelessly communicate with a display device, such as one from a list of display devices (also referred to as a whitelist). This list of display devices reflects those display devices that have successfully been paired or bonded with the sensor electronics module. For example, a display device may respond to an advertising signal transmitted by the sensor electronics module. Upon receiving this response, the list may be updated with an identifier indicative of the display device. In some embodiments, a display device may be removed from the list after some predetermined time of inactivity, e.g., no communications between the sensor electronics module and the display device. In some embodiments, another list (referred to as a bonding list) may be utilized to maintain a listing of display devices that were previously paired to or bonded with the sensor electronics module. Re-pairing a display device to the sensor electronics module can be avoided when utilizing a bonding list. For example, if a display device is removed from the whitelist, e.g., due to some predetermined amount of inactivity, the identifier of that display device may be stored in the bonding list. In other embodiments, upon pairing or bonding/inclusion in the whitelist, the display device identifier may also be stored in the bonding list. In this way, the bonding list can be accessed upon the sensor electronics module receiving a response to an advertising signal from a display device to check whether or not the display device was previously bonded to the sensor electronics module. If so, a data connection can be established without engaging in authentication (discussed below with respect to FIG. **4**).

[0034] In some embodiments, the search for and/or attempted wireless communication can occur in a predetermined and/or programmable order (e.g., grading and/or escalating). For example, if an attempt at communicating with and/or alarming a first display device fails, this failure triggers an attempt to communicate with and/or alarm a second display device, and so on. It should be noted that the sensor electronics module is not necessarily tied to a single display device. Rather the sensor electronics module is configured to communicate with a plurality of different display devices directly, systematically, simultaneously (e.g., via broadcasting), regularly, periodically, randomly, on-demand, in response to a query, based on alerts or alarms, and/or the like.

[0035] The sensor information may comprise transformed sensor information that does not require processing by the display device prior to display of the sensor information. However, some display devices may comprise software including display instructions (software programming comprising instructions configured to display the sensor information and optionally query the sensor electronics module to obtain the sensor information) configured to enable display of the sensor information thereon. In some embodiments, the display device is programmed with the display instructions at the manufacturer and can include security

and/or authentication to avoid plagiarism of the display device. In some embodiments, a display device is configured to display the sensor information via a downloadable program (for example, a downloadable Java Script via the internet), such that any display device that supports downloading of a program (for example, any display device that supports Java applets) can be configured to display displayable sensor information (e.g., mobile phones, tablets, PDAs, PCs and the like).

[0036] In some embodiments, certain display devices may be in direct wireless communication with the sensor electronics module, although intermediate network hardware, firmware, and/or software can be included within the direct wireless communication. In some embodiments, a repeater (e.g., a Bluetooth repeater) can be used to re-transmit the transmitted sensor information to a location farther away than the immediate range of the telemetry module of the sensor electronics module. In some embodiments, a receiver (e.g., Bluetooth receiver) can be used to re-transmit the transmitted sensor information to a display device, e.g., a TV screen, possibly in a different format, such as in a text message. In certain embodiments, the sensor electronics module transmits sensor information to one or more display devices, where the sensor information transmitted from the sensor electronics module is received by the display device without intermediate processing of the sensor information.

[0037] In some embodiments, one or more display devices are configured to query the sensor electronics module for sensor information, where the display device requests sensor information from the sensor electronics module in an "on-demand" fashion, for example, in response to a query. In some embodiments, the sensor electronics module is configured for periodic, systematic, regular, irregular or aperiodic transmission of sensor information to one or more display devices (for example, every 1, 2, 5, or 10 minutes or more). In some embodiments, the sensor electronics module is configured to transmit data packages associated with a triggered alert (e.g., triggered by one or more alert conditions). However, any combination of the above-described statuses of data transmission can be implemented with any combination of a paired sensor electronics module and display device(s). For example, one or more display devices can be configured for querying a sensor electronics module database and for receiving alarm information triggered by one or more alarm conditions being met. Additionally, the sensor electronics module can be configured to transmit sensor information to one or more display devices (the same or different display devices as described in the previous example), where the display devices function differently with regard to how they obtain sensor information.

[0038] In some embodiments, as described in more detail below, a display device is configured to query data storage memory in the sensor electronics module for certain types of data content, including direct queries into a database in the sensor electronics module's memory and/or requests for configured or configurable packages of data content therefrom; namely, the data stored in the sensor electronics module is configurable, queryable, predetermined, and/or pre-packaged, based on the display device with which the sensor electronics module is communicating. In some additional or alternative embodiments, the sensor electronics module generates the sensor information based on its knowledge of which display device is to receive a particular transmission. Additionally, some display devices are capable of obtaining calibration information and wirelessly transmitting the calibration information to the sensor electronics module, such as through manual entry of the calibration information, automatic delivery of the calibration information, and/or an integral reference analyte monitor incorporated into the display device. U.S. Patent Publication Nos. 2006/0222566, 2007/0203966, 2007/0208245, and 2005/0154271, all of which are incorporated herein by reference in their entirety, describe systems and methods for providing an integral reference analyte monitor incorporated into a display device and/or other calibration methods that can be implemented with embodiments disclosed herein.

[0039] In general, a plurality of display devices (e.g., a custom analyte monitoring device, a mobile phone, a tablet, a smart watch, a reference analyte monitor, a medicament delivery device, a medical device and a personal computer) may be configured to wirelessly communicate with the sensor electronics module. The one or more display devices can be configured to display at least some of the sensor information wirelessly communicated by the sensor electronics module. The sensor information may include, for example, sensor data, such as raw data and/or transformed sensor data, such as analyte concentration values, rate of change information, trend information, alert information, sensor diagnostic information, calibration information, non-visual information such as temperature readings, sound, etc.

Example Configurations

[0040] FIG. **1** is a diagram depicting an example continuous analyte monitoring system **100** including an analyte sensor system **104** operatively connected to a host **102** and a plurality of display devices **120** according to certain aspects of the present disclosure. For ease of reference, reference number **120** may be used to refer to the plurality of display devices together as a group, whereas respective alphanumeric reference numbers **120***a*, **120***b*, **120***c*, **120***d*, and/or **120***e* may be used to refer to specific display devices. It should be noted that display device **120***e* alternatively or in addition to being a display device, may be a medicament delivery device that can act cooperatively with the analyte sensor system **104** to deliver medicaments to host **102**. The analyte sensor system **104** may include a sensor electronics module **106** and a continuous analyte sensor **108** associated with the sensor electronics module **106**. The sensor electronics module **106** may be in direct wireless communication with one or more of the plurality of the display devices **120** via wireless communications signals. As will be discussed in greater detail below, display devices **120** may also communicate amongst each other and/or through each other to analyte sensor system **104**. For ease of reference, wireless communications signals from analyte sensor system **104** to display devices **120** can be referred to as "uplink" signals **112**. Wireless communications signals from, e.g., display devices **120** to analyte sensor system **104** can be referred to as "downlink" signals **114**. Wireless communication signals between two or more of display devices **120** may be referred to as "crosslink" signals **116**. Additionally, wireless communication signals may include data transmitted by one or more of display devices **120***a-d* via "long-range" uplink signals **136** (e.g., cellular signals) to one or more remote servers **140** or network entities, such as cloud-based servers or databases, and receive long-range downlink signals **138** transmitted by remote servers **140**.

[0041] The sensor electronics module **106** includes sensor electronics that are configured to process sensor information and generate transformed sensor information. In certain embodiments, the sensor electronics module **106** includes electronic circuitry associated with measuring and processing data from continuous analyte sensor **108**, including prospective algorithms associated with processing and calibration of the continuous analyte sensor data. The sensor electronics module **106** can be integral with (non-releasably attached to) or releasably attachable to the continuous analyte sensor **108** achieving a physical connection therebetween. The sensor electronics module **106** may include hardware, firmware, and/or software that enables analyte level measurement. For example, the sensor electronics module **106** can include a potentiostat, a power source for providing power to continuous analyte sensor **108**, other components useful for signal processing and data storage, and a telemetry module for transmitting data from itself to one or more display devices **120**. Electronics can be affixed to a printed circuit board (PCB), or the like, and can take a variety of forms. For example, the electronics can take the form of an integrated circuit (IC), such as an Application-Specific Integrated Circuit (ASIC), a microcontroller, and/or a processor. Examples of systems and methods for processing sensor analyte data are described in more detail herein and in U.S. Pat. Nos. 7,310,544 and 6,931,327 and U.S. Patent Publication Nos. 2005/0043598, 2007/0032706, 2007/0016381, 2008/0033254, 2005/0203360, 2005/0154271, 2005/0192557, 2006/0222566, 2007/0203966 and 2007/0208245, all of which are incorporated herein by reference in their entirety for all purposes.

[0042] Referring again to FIG. **1**, display devices **120** are configured for displaying, alarming, and/or basing medicament delivery on the sensor information that has been transmitted by the sensor electronics module **106** (e.g., in a customized data package that is transmitted to one or more of display devices **120** based on their respective preferences). Each of the display devices **120** can include a display such as a touchscreen display for displaying sensor information to a user (most often host **102** or a care taker/medical professional) and/or receiving inputs from the user. In some embodiments, the display devices **120** may include other types of user interfaces such as a voice user interface instead of or in addition to a touchscreen display for communicating sensor information to the user of the display device **120** and/or receiving user inputs. In some embodiments, one, some or all of the display devices **120** are configured to display or otherwise communicate the sensor information as it is communicated from the sensor electronics module **106** (e.g., in a data package that is transmitted to respective display devices **120**), without any additional prospective processing required for calibration and real-time display of the sensor information.

[0043] In the embodiment of FIG. **1**, one of the plurality of display devices **120** may be a custom display device **120***a* specially designed for displaying certain types of displayable sensor information associated with analyte values received from the sensor electronics module **106** (e.g., a numerical value and an arrow, in some embodiments). In some embodiments, one of the plurality of display devices **120** may be a handheld device **120***c*, such as a mobile phone based on the Android or iOS operating system, a palm-top computer and the like, where handheld device **120***c* may have a relatively larger display and be configured to display a graphical representation of the continuous sensor data (e.g., including current and historic data). Other display devices can include other hand-held devices, such as a tablet **120***d*, a smart watch **120***b*, a medicament delivery device **120***e*, a blood glucose meter, and/or a desktop or laptop computer.

[0044] As alluded to above, because the different display devices **120** provide different user interfaces, content of the data packages (e.g., amount, format, and/or type of data to be displayed, alarms, and the like) can be customized (e.g., programmed differently by the manufacture and/or by an end user) for each particular display device and/or display device type. Accordingly, in the embodiment of FIG. **1**, one or more of display devices **120** can be in direct or indirect wireless communication with the sensor electronics module **106** to enable a plurality of different types and/or levels of display and/or functionality associated with the sensor information, which is described in more detail elsewhere herein.

[0045] Continuous Analyte Sensor

[0046] Continuous analyte sensor **108** of FIG. **1** may be, for example a subcutaneous, transdermal (e.g., transcutaneous), or intravascular device. In some embodiments, continuous analyte sensor **108** can analyze a plurality of intermittent blood samples, although continuous analyte sensor **108** can be configured to use any method of analyte-measurement, including enzymatic, chemical, physical, electrochemical, spectrophotometric, polarimetric, calorimetric, iontophoretic, radiometric, immunochemical, and the like.

[0047] Continuous analyte sensor **108** can use any known method, including invasive, minimally invasive, and non-invasive sensing techniques (e.g., fluorescent monitoring), to provide a data stream indicative of the concentration of a measured analyte in host **102**. In some embodiments, this data stream is typically a raw data signal, which is converted into a calibrated and/or filtered data stream that is used to provide a useful value of the measured analyte to a user, such as host **102** or a caretaker (e.g., a parent, a relative, a guardian, a teacher, a doctor, a nurse, or any other individual that has an interest in the well-being of host **102**). It should be understood that the devices and methods described herein can be applied to any device capable of detecting a concentration of an analyte and providing an output signal that represents the concentration of the analyte.

[0048] In some embodiments, continuous analyte sensor **108** may be capable of measuring a concentration of glucose in host **102**, one of which is described below as utilizing an implantable continuous glucose sensor. For example, continuous analyte sensor **108** may be an implantable glucose sensor, such as described with reference to U.S. Pat. No. 6,001,067 and U.S. Patent Publication No. US-2005-0027463-A1. In another embodiment, continuous analyte sensor **108** may be a transcutaneous glucose sensor, such as described with reference to U.S. Patent Publication No. US-2006-0020187-A1. In still other embodiments, continuous analyte sensor **108** may be configured to be implanted in a host vessel or extracorporeally, such as is described in U.S. Patent Publication No. US-2007-0027385-A1, co-pending U.S. Patent Publication No. US-2008-0119703-A1 filed Oct. 4, 2006, co-pending U.S. Patent Publication No. US-2008-0108942-A1 filed on Mar. 26, 2007, and co-pending U.S. Patent Application No. US-2007-0197890-A1 filed on Feb. 14, 2007. In one alternative embodiment, continuous analyte sensor **108** comprises a transcutaneous sensor such as

described in U.S. Pat. No. 6,565,509 to Say et al., for example. In another alternative embodiment, continuous analyte sensor **108** comprises a subcutaneous sensor such as described with reference to U.S. Pat. No. 6,579,690 to Bonnecaze et al. or U.S. Pat. No. 6,484,046 to Say et al., for example. In another alternative embodiment, continuous analyte sensor **108** comprises a refillable subcutaneous sensor such as described with reference to U.S. Pat. No. 6,512,939 to Colvin et al., for example. In another alternative embodiment, continuous analyte sensor **108** comprises an intravascular sensor such as described with reference to U.S. Pat. No. 6,477,395 to Schulman et al., for example. In another alternative embodiment, continuous analyte sensor **108** comprises an intravascular sensor such as described with reference to U.S. Pat. No. 6,424,847 to Mastrototaro et al., for example.

[0049] FIGS. **2**A and **2**B are perspective and side views of analyte sensor system **104** shown in FIG. **1** according to certain aspects of the present disclosure. Analyte sensor system **104** may include a mounting unit **214** and sensor electronics module **106** attached thereto in certain embodiments, shown in its functional position, where mounting unit **214** and sensor electronics module **106** are matingly engaged therein. In some embodiments, the mounting unit **214**, also referred to as a housing or sensor pod, comprises a base **234** adapted for fastening to a host's skin. The base **234** can be formed from a variety of hard or soft materials, and can have a low profile for minimizing protrusion of the device from the host during use. In some embodiments, the base **234** is formed at least partially from a flexible material, which can provide numerous advantages over conventional transcutaneous sensors that may suffer from motion-related artifacts associated with movement of the host when the host is using the device. The mounting unit **214** and/or sensor electronics module **106** can be located over a sensor insertion site to protect the site and/or provide a minimal footprint (i.e., utilization of the surface area of the host's skin).

[0050] In some embodiments, a detachable connection between the mounting unit **214** and sensor electronics module **106** is provided, enabling improved manufacturability. That is, mounting unit **214** (which may be relatively inexpensive) can be disposed of when replacing continuous analyte sensor **108** after its usable life, while the relatively more expensive sensor electronics module **106** can be reusable with additional, replacement continuous analyte sensors **108**. In some embodiments, the sensor electronics module **106** is configured with signal processing (programming) functionality, for example, filtering algorithms, calibration algorithms, and/or other algorithms useful for calibration and/or the display of sensor information. However, an integral (non-detachable) sensor electronics module **106** is also contemplated for use in accordance with other embodiments.

[0051] In some embodiments, the contacts **238** are mounted on or in a subassembly hereinafter referred to as a contact subassembly **236** configured to fit within the base **234** of the mounting unit **214** and a hinge **248** that allows the contact subassembly **236** to pivot between a first position (for insertion) and a second position (for use) relative to the mounting unit **214**. The term "hinge" as used herein is a broad term and is used in its ordinary sense, including, without limitation, to refer to any of a variety of pivoting, articulating, and/or hinging mechanisms, such as an adhesive hinge, a sliding joint, and the like; the term hinge does not necessarily imply a fulcrum or fixed point about which the articulation occurs. In some embodiments, the contacts **238** are formed from a conductive elastomeric material, such as a carbon black elastomer, through which the continuous analyte sensor **108** extends.

[0052] In certain embodiments, the mounting unit **214** is provided with an adhesive pad **208**, disposed on a back surface of mounting unit **214** and includes a releasable backing layer. Thus, removing the backing layer and pressing the base portion **234** of the mounting unit **214** onto the host's skin **204** adheres the mounting unit **214** to the host's skin **204**. Additionally or alternatively, an adhesive pad can be placed over some or all of the analyte sensor system **104** after insertion of a continuous analyte sensor **108** is complete to ensure adhesion, and optionally to ensure an airtight seal or watertight seal around the wound exit-site (or continuous analyte sensor **108** insertion site) (not shown). Appropriate adhesive pads can be chosen and designed to stretch, elongate, conform to, and/or aerate the region (e.g., host's skin **204**). The embodiments described with reference to FIGS. **2**A and **2**B are described in more detail with reference to U.S. Pat. No. 7,310,544, which is incorporated herein by reference in its entirety. Configurations and arrangements can provide water resistant, waterproof, and/or hermetically sealed properties associated with the mounting unit/sensor electronics module **106** embodiments described herein.

[0053] Various methods and devices that are suitable for use in conjunction with aspects of some embodiments are disclosed in U.S. Patent Publication No. US-2009-0240120-A1, which is incorporated herein by reference in its entirety for all purposes.

[0054] FIG. **3** is a block diagram illustrating example components of analyte sensor system **104** and at least one of the plurality of display elements **120***a*, as well as the communications therebetween. The analyte sensor system **104** may include an implantable continuous analyte sensor **312** (one embodiment of continuous analyte sensor **108** of FIG. **1**) coupled to a sensor measurement circuit **310** for processing and managing sensor data. The sensor measurement circuit **310** may be coupled to a processor **314** (part of sensor electronics module **106** in FIG. **1**). In some embodiments, the processor **314** may perform part or all of the functions of the sensor measurement circuit **310** for obtaining and processing sensor measurement values from the implantable continuous sensor **312**. The processor may be further coupled to a radio unit or transceiver **316** (part of sensor electronics module **106** in FIG. **1**) for sending sensor information to and receiving requests and commands from an external device, such as display device **120***a*, which is used to display or otherwise provide the sensor information to a user. As used herein, the terms "radio unit" and "transceiver" are used interchangeably and generally refer to a device that can wirelessly transmit and receive data. The analyte sensor system **104** may further include a memory **318** (also part of sensor electronics module **106** in FIG. **1**) and a real time clock (RTC) **320** (again, part of sensor electronics module **106** in FIG. **1**) for storing and tracking sensor information.

[0055] Wireless communication protocols may be used to transmit and receive data between analyte sensor system **104** and display device **120***a*. The wireless communication protocol used may be designed for use in a wireless sensor network that is optimized for periodic and small data trans-

missions (that may be transmitted at low rates if necessary) to and from multiple devices in a close range (e.g., a personal area network (PAN)). For example, the wireless communication protocol may be optimized for periodic data transfers where transceivers may be configured to transmit data for short intervals and then enter low power modes for long intervals. The wireless communication protocol may have low overhead requirements both for normal data transmissions and for initially setting up communication channels (e.g., by reducing header overhead) to reduce power consumption. In some embodiments, burst broadcasting schemes (e.g., one way communication) may be used. This may eliminate overhead required for acknowledgement signals and allow for periodic transmissions that consume little power.

[0056] The wireless communication protocol may further be configured to establish communication channels with multiple display devices, e.g., two or more of display devices **120**, while implementing interference avoidance schemes. In some embodiments, the wireless communication protocol may make use of adaptive isochronous network topologies that define various time slots and frequency bands for communication with several ones of display devices **120**. The wireless communication protocol may thus modify transmission windows and frequencies in response to interference and to support communication with multiple ones of display devices **120**. Accordingly, the wireless protocol may use time and frequency division multiplexing (TDMA) based schemes. The wireless communication protocol may also employ direct sequence spread spectrum (DSSS) and frequency-hopping spread spectrum schemes. Various network topologies may be used to support short-distance and/or low-power wireless communication such as peer-to-peer, start, tree, or mesh network topologies such as WiFi, Bluetooth and Bluetooth Low Energy (BLE). The wireless communication protocol may operate in various frequency bands such as an open ISM band such as 2.4 GHz. Furthermore, to reduce power usage, the wireless communication protocol may adaptively configure data rates according to power consumption.

[0057] Display device **120***a* may be used for alerting and providing sensor information to a user, such as host **102**, and may include a processor **330** for processing and managing sensor information. Display device **120***a* may include a display **332**, a memory **334**, and a real time clock **336** for displaying, storing and tracking sensor information, respectively. Display device **120***a* may further include a radio unit or transceiver **338** for receiving sensor information and for sending requests, instructions, and data to the analyte sensor system **104**. The transceiver **338** may further employ a wireless communication protocol. The memory **334** may also be used for storing an operating system and/or a custom (e.g., proprietary) application designed for wireless data communication between a transceiver, e.g., transceiver **316** and display device **120***a*. The memory **334** may be a single memory device or multiple memory devices and may be a volatile or non-volatile memory for storing data and/or instructions for software programs and applications. The instructions may be executed by the processor **330** to control and manage the transceiver **338**.

[0058] It should be understood that in the case of display device **120***e*, which may be a medicament delivery device in addition to or instead of a display device, the alerts and/or sensor information provided by continuous analyte sensor **108** vis-à-vis sensor electronics module **106**, can be used to initiate and/or regulate the delivery of the medicament to host **102**.

[0059] In some embodiments, when a standardized communication protocol is used, commercially available transceiver circuits may be utilized that incorporate processing circuitry to handle low level data communication functions such as the management of data encoding, transmission frequencies, handshake protocols, and the like. In these embodiments, processors **314** and **330** do not need to manage these activities, but rather provide desired data values for transmission, and manage high level functions such as power up or down, set a rate at which messages are transmitted, and the like. Instructions and data values for performing these high level functions can be provided to the transceiver circuits **316** and **338**, respectively, via a data bus and transfer protocol established by the manufacturer of the transceiver circuits **316** and **338**.

[0060] Components of the analyte sensor system **104** may require replacement periodically. For example, implantable continuous analyte sensor **312** that may be attached to sensor electronics module **106** which itself includes the sensor measurement circuit **310**, the processor **314**, memory **318**, and transceiver **316**, and battery (not shown) may require periodic replacement (e.g., every 7-30 days). The sensor electronics module **106** may be configured to be powered and active for much longer than implantable continuous analyte sensor **312** (e.g., for 3 months, 6 months or more) until the battery needs replacement. Replacing these components may be difficult and require the assistance of trained personnel. Reducing the need to replace such components, including the battery if replaceable, significantly improves the convenience of the analyte sensor system **104** to the host **102**.

[0061] When sensor electronic module **106** is used for the first time (or reactivated once a battery has been replaced in some cases), it may be connected to implantable continuous analyte sensor **312**. As will be further described below, there may be a process for initially establishing communication between display device **120***a* and sensor electronics module **106** when it is first used or re-activated (e.g., the battery is replaced). Once display device **120***a* and sensor electronics module **106** have established communication, display device **120***a* and sensor electronics module **106** may periodically and/or continuously be in communication over the life of several ones of implantable continuous analyte sensor **312** until, for example, the battery or the entirety of sensor electronics module **106** needs to be replaced. Each time continuous analyte sensor **312** is replaced, notifications of a new continuous analyte sensor **312** can be sent/exchanged via the previously established communication between the sensor electronics module **106** and display device **120***a*.

[0062] In accordance with one embodiment, analyte sensor system **104** gathers and processes analyte measurements from continuous analyte sensor **312**, and periodically sends sensor information representative of the analyte measurements to display device **120***a*. Measurements are gathered and transmitted over the life of continuous analyte sensor **312** (e.g., in the range of 1 to 30 days or more). New measurements may need to be transmitted often enough to adequately monitor analyte levels. Rather than having the transmission and receiving circuitry of each of the analyte sensor system **104** and display device **120***a* continuously communicating, the analyte sensor system **104** and display

device **120***a* may regularly and periodically establish a communication channel between them. Thus, analyte sensor system **104** can communicate wirelessly with display device **120***a* at predetermined time intervals. The duration of the predetermined time interval can be selected to be long enough so that the analyte sensor system **104** does not consume too much power by transmitting data more frequently than needed, yet frequent enough to provide substantially real-time sensor information (e.g., measured analyte values) to one or more of display devices **120** for output (e.g., display) to a user. While the predetermined time interval is every five minutes in some embodiments, it is appreciated that this time interval can be varied to be any desired length of time. It should be noted that other contemplated embodiments involve irregular or aperiodic transmissions of sensor information, e.g., from analyte sensor system **104** to one or more of display devices **120**.

[0063] FIG. **4** is an example advertising/connection sequence between analyte sensor system **104** and display device **120***a* which is capable of wirelessly receiving analyte measurement values from the analyte sensor system **104** according to certain aspects of the present disclosure. The various tasks performed in connection with the advertising/connection illustrated in FIG. **4** may be performed by a processor executing instructions embodied in a non-transitory computer-readable medium. For example, the tasks performed in connection with the procedure may be performed by hardware, software, firmware, or any combination thereof incorporated into one or more of computing devices, such as analyte sensor system **104** and display device **120***a* of FIG. **1** and/or FIG. **3**. It should be appreciated that the procedure may include any number of additional or alternative tasks. The tasks shown in FIG. **4** need not be performed in the illustrated order, and the procedure may be incorporated into a more comprehensive procedure or process having additional functionality not described in detail herein.

[0064] In the example described below, the analyte values are glucose values based on one or more measurements of glucose levels by the implantable continuous analyte sensor **312** for illustration purposes. However, it should be understood that the analyte values can be any other analyte value described herein. The wireless data communication between the analyte sensor system **104** and the display device **120***a* may happen periodically, at times separated by an update interval denoted "$T_{interval}$" that may correspond to a time duration between two consecutive wireless communication sessions between the transceiver **316** of the analyte sensor system **104** and the transceiver **338** of display device **120***a*. Alternatively, the update interval may be thought of as a period of obtaining and sending a recently measured glucose value. Transmitting advertisement signals, establishing a data connection (e.g., a communication channel) and requesting and sending data may occur during wireless communication sessions each lasting an active time or period denoted "T_{Active}" within an update interval $T_{interval}$. In between two consecutive wireless communication sessions, the transceiver **316** goes into an inactive or sleep mode for an inactive period denoted as "$T_{inactive}$" to conserve battery life and/or reduce peak voltage requirements, for example.

[0065] FIG. **4** shows two such wireless communication sessions, namely, a first wireless communication session **410** and a second wireless communication session **420**. Each wireless communication session **410**, **420** starts with the analyte sensor system **104** establishing a data connection with display device **120***a*. To establish a data connection with display device **120***a*, the transceiver **316** of the analyte sensor system **104** transmits a series of advertisement signals **412** during the first wireless communication session **420**. Each advertisement signal may be considered an invitation for display device **120***a* to establish a data connection with the transceiver **316**. In some embodiments, advertisement signals **412** may be embodied as advertising beacons, as will be discussed in greater detail below.

[0066] In the illustrated example of FIG. **4**, it is assumed that the analyte sensor system **104** needs to engage in an initial system setup because the analyte sensor system **104** has been just turned on for the first time and/or is not current paired with display device **120***a*. Typically, a user of display device **120***a* identifies a new or never-been used analyte sensor system **104** that needs to be paired with display device **120***a* by entering identification information (e.g., a serial number) associated with the new/unpaired analyte sensor system **104** via a custom application running on display device **120***a* using a user interface (e.g., a touchscreen display). During the first wireless communication session **410**, an authentication procedure can be performed as part of a data connection process **414**. To establish a data connection with the analyte sensor system **120**, the display device **120***a* listens continuously until an advertisement signal transmitted by the transceiver **316** of the analyte sensor system **104** is received. Once the transceiver **316** begins transmitting advertisement signals **412**, it may take one, two, or more advertisement signals for the display device **120***a* to receive at least one of the advertisement signals and respond to at least one of the advertisement signals. In some embodiments, the transceiver **316** stops sending additional advertisement signals once display device **120***a* receives an advertisement signal and responds to that advertisement signal, for example, via an acknowledgement. In other embodiments, the transceiver **316** may continue to send additional advertisement signals even after receiving a response from display device **120***a* so that another display device, e.g., one or more of display devices **120***b-e*, may receive and respond to at least one of the additional advertisement signals. After an advertisement signal is successfully received by display device **120***a*, display device **120***a* and the analyte sensor system **104** engage in a first data connection process **414**. During the first data connection process **414**, the display device **120***a* requests a challenge value from the analyte sensor system **104** and the analyte sensor system **104** sends the change value to the display device **120***a* in response. Upon receiving the challenge value, the display device **120***a* calculates a hash value based on the challenge value and the identification information associated with the analyte sensor system **104** and/or the transceiver **316** and sends the hash value to the transceiver **316**. The transceiver **316** receives the hash value from the display device **120***a*, decodes the identification information from the hash value, and verifies that the received identification information matches identification information associated with the analyte sensor system **104** and/or transceiver **316** previously stored in the memory **318** of the analyte sensor system **104**, such as during manufacturing of the analyte sensor system **104**. Upon verification, the transceiver **316** sends a signal confirming a successful authentication to the display device **120***a*. Once authenti-

cated, the analyte sensor system **104** and display device **120***a* may exchange information to determine how data will be exchanged (e.g., a specific frequency, time slot assignment, encryption, etc.).

[0067] After completion of the first data connection process **414**, the analyte sensor system **104** and now-connected display device **120***a* engage in a first data communication **416** during which display device **120***a* requests and receives desired information (e.g., analyte measurement data, control information, identification information, and/or instructions) from the analyte sensor system **104**. When the first data communication **416** is completed, the data connection is terminated (e.g., by closing the established communication channel) and the transceiver **316** and/or the processor **314** of the analyte sensor system **104** (and possibly the transceiver **338** and/or the processor **330** of the display device **120***a* as well, depending on implementation preference) can be deactivated by causing the transceiver **316** and/or the processor **314** to enter a sleep or inactive mode. In some embodiments, the transceiver **316** is completely powered down during a sleep mode. In other embodiments, the transceiver **316** is in a low power mode using only a small fraction (e.g., 1-10%) of the normal current/power. As will be discussed further below, transceiver **316** may be woken up, for example, by an NFC on-demand request from one of display devices **120** for sensor information to be sent to another one of display devices **120**, e.g., display device **120***a*, accelerometer movement that triggers a wake up of transceiver **316**, etc. It should be noted that in some embodiments, advertising signals themselves can have specific headers so that directed or targeted advertising can be performed. For example, one of display devices **120** listed in a whitelist (discussed in greater detail below) may not respond to advertising signals unless the advertising signals are directed specifically to that display device.

[0068] The active period T_{Active} corresponding to a duration of each wireless communication session may be a small fraction of the update interval $T_{interval}$ corresponding to a period between two consecutive wireless communication sessions. For example, $T_{interval}$ may be between about 200 and 400 seconds and T_{Active} may be between 20 and 40 seconds. As such, the transceiver **316** of the analyte sensor system **104** may be powered fully for only 10 percent (e.g., 30 seconds) of a five minute $T_{interval}$. This may significantly reduce power consumption and peak voltage demand. In some cases, the transceiver **316** is not completely powered down, but enters a low-power mode when not transmitting. After an inactive time or period $T_{Inactive}$, a second wireless communication session **420** starts when the transceiver **316** (and the transceiver **338**) powers up again, begins transmitting a second series of advertisement signals **422**, engages in a second data connection process **424** and a second data communication process **426** with the transceiver **338** of display device **120***a* as shown in FIG. **4**. Unlike the first data connection process **414**, however, the second data connection process **424** need not involve an authentication procedure because the analyte sensor system **104** and the display device **120***a* have been successfully paired or bonded during the first wireless communication session **410** as described above. This process may continue, with new data connections and communications being completed at the predetermined intervals. During all or part of each inactive period $T_{Inactive}$ during which the transceiver **316** is in a sleep mode, the processor **314** can take measurement(s) of one or more analyte values using the analyte sensor **312** and the sensor measurement circuitry **310**. For example, the processor **314** may take multiple analyte value measurements and average them to generate a single averaged analyte value to be transmitted in a next wireless communication session.

[0069] Continuously re-establishing a new communication channel to allow for partially or wholly powering down the transceiver **316** during each update interval $T_{interval}$ can provide significant power savings and can allow the sensor electronics module **106** (FIG. **1**) to operate continuously for, e.g., 1 month, 3 months, 6 months, 1 year, etc., without requiring a battery replacement. It should be noted that in some embodiments, battery replacement may be a function of the actual expiration of battery power or some predetermined level of remaining battery power. Furthermore, rather than blindly transmitting glucose data points during the update interval $T_{interval}$, establishing specific data connections (e.g., communication channels) with only desired display devices, e.g., display device **120***a*, can prevent unauthorized use and interception of glucose measurement values. In some embodiments, only a subset of multiple display devices **120** can be configured to receive different data such as glucose measurement values and/or alarm conditions. For example, in addition to a display device identifier(s), a whitelist may be populated with a data type identifier indicative of a type of data to be sent to that particular display device(s) populating the whitelist. In other embodiments, the sensor electronics module **106** may be pre-programmed with preference or profile information, which can be accessed to determine what type(s) of data are to be sent to what display device(s). Thus, prior to the exchange of sensor information, the sensor electronics module **106**, for example, can access the whitelist (or bonding list in some embodiments) and/or preference/profile information to determine what type(s) of data should be sent to a display device. In still other embodiments, initial communications between sensor electronics module **106** and a display device, the display device can transmit type information to sensor electronics module **106**. This has a benefit of preventing all of display devices **120** from issuing alarms, thereby confusing and/or frustrating the user. In addition, by establishing a secure two-way communication channel, requests for specific glucose measurement values or communication of calibration or configuration information may be transmitted on an as-needed/requested basis between the analyte sensor system **104** and display device **120***a*.

[0070] Also, in some embodiments, the transceiver **316** may not be activated for data communication every update interval $T_{interval}$. Instead, the transceiver **316** may be activated every second, third or fourth update interval $T_{interval}$, for example, so that communication between the analyte sensor system **104** with the display device **120***a* occurs less frequently than every update interval $T_{interval}$. Doing so can further reduce power consumption. Activation could also depend on the sensor information. For example, the transceiver **316** need only be activated if data meets certain thresholds, such as a current rate of change, current high value, current low value, absolute difference from a previously exchanged value, percentage difference from a previously exchanged value, and the like. In some embodiments, instead of skipping certain fixed update intervals, the length of each interval can be made to vary based on the sensor information or other criteria. For example, if the sensor information indicates a low glucose value and/or a hypo-

glycemic reaction is detected, the update interval value can be shortened from a normal (longer) update interval value so that more frequent readings are taken and/or transmitted.

[0071] In some embodiments, one or more of the update interval $T_{interval}$, the active period T_{Active} and a frequency $F_{Activation}$ by which the transceiver is activated (e.g., every second, third or fourth update interval) may be variable. In certain embodiments, the above-identified parameters can be user configurable (e.g., by inputting a value for the variable using user interface of display device **120***a*) and/or automatically varied by the analyte sensor system **104** or display device **120***a* based on one or more criteria. The criteria can include: (i) a monitored battery power of the sensor system **104**, (ii) a currently measured, previously measured and/or predicted glucose concentrations meeting or exceeding a predetermined threshold, (iii) a glucose concentration trend of the host based on currently measured, previously measured and/or predicted glucose concentrations, (iv) a rate of change of glucose concentration of the host based currently measured, previously measured and/or predicted glucose concentrations meeting or exceeding a predetermined threshold, (v) whether the host is determined to be in or near hyperglycemia based on currently measured, previously measured and/or predicted glucose concentrations, (vi) whether the host is determined to be in or near hypoglycemia based on currently measured, previously measured and/or predicted glucose concentrations, (vii) user inputted activity of the host (e.g., exercising or sleeping), (viii) time since a sensor session has started (e.g., when a new sensor **10** is used), (ix) one or more errors detected by sensor system **104** or display device **120***a* and (x) type of display device **120***a* (where the display device **120***a* can be connected or populating the whitelist or bonding list).

[0072] $T_{interval}$, T_{Active}, $F_{Activation}$ and/or other configuration items described herein may form part of a communication protocol profile that may be stored on any device that implements the fundamental communication protocol to allow for a customized use of the protocol for communicating analyte measurement values in the analyte sensor system **104** and one or more of display devices **120**.

[0073] Power Savings and Connection Reliability

[0074] As discussed above, reducing the need to replace components significantly improves the convenience of the analyte sensor system **104** to the user. Accordingly, various embodiments are directed to power saving schemes and/or mechanisms to increase battery life of analyte sensor system **104**, e.g., sensor electronics module **106**. Although generalized concepts of putting a transceiver, such as transceiver **316**, into a sleep or low power mode, and continuously re-establishing a new communication channel to allow for partially or wholly powering down transceiver **316** have been described, specific parameters or variables for communicating as well as conditions for dictating how those specific parameters or variables are adjusted will be further discussed below. The result of adjusting such parameters or variables as governed by certain communication conditions are efficient systems and methods for initiating or requesting communications (intelligent advertising) as well as transmitting data (intelligent communications).

[0075] Still another result of the adjustment of parameters and variables in response to communication conditions is increased connection reliability between analyte sensor system **104**, e.g., sensor electronics module **106**, and one or more of display devices **120**. For example, and in the context of advertising, advertising variables can be set or selected based on some minimum reliability to avoid or lessen the occurrence of missed advertising beacons when the advertising interval is short (to avoid excessive battery drain on sensor electronics module **106** as a result of longer advertising intervals). Thus, the optimizing of communications is in and of itself an advantage realized by various embodiments beyond the increase in power savings.

[0076] Radio Software and Architecture

[0077] From a radio design/implementation perspective, the radio software and architecture utilized to implement various embodiments are configured in accordance with intelligent advertising and communication considerations. Accordingly, various embodiments implement radio software based on background and foreground processing for application control, where the foreground processing can be referred as "main-loop" processing, which manages wireless connections and passing data within sensor electronics module **106** using four commands with sleep (low power mode) support. The four commands include "start communication," "stop communication," "CGM receive," and "CGM transmit" and will be described in greater detail below.

[0078] FIG. **5** is a block diagram illustrating various elements of sensor electronics module **106** (of FIG. **1**) involved in the transmission of sensor information in a continuous analyte monitoring system **100** in accordance with various embodiments described in the present disclosure. It should be noted that the following embodiments are described in the context of a continuous glucose monitoring (CGM) system (an embodiment of continuous analyte monitoring system **100**), where one example wireless communication protocol used for communications between analyte sensor system **104** and one or more of display devices **120** is the Bluetooth® Low Energy (BLE) standard. However, it should be understood that other continuous analyte monitoring systems and other transceivers or radios may be utilized such as those operating in accordance with other low power/short-range communications protocols.

[0079] After startup or powering on of sensor electronics module **106**, a radio **508** is initialized and may enter a "sleep mode" waiting for a command from a CGM processor **506**. It should be appreciated that radio **508** may be an embodiment of transceiver **316** (FIG. **3**), CGM processor **506** may be an embodiment of processor **314**, and the sleep mode may refer to one of the inactive periods $T_{inactive}$ described with reference to FIG. **4**. An Analog Front End (AFE) **500** initializes to its default state and also waits for configuration commands.

[0080] FIG. **6** illustrates an example transceiver processing/connection sequence which will be described in conjunction with the elements of sensor electronics module **106** shown in FIG. **5**. Whereas FIG. **4** and its corresponding description provide a broader description of wireless communications between analyte sensor system **104** and display device **102***a*, FIG. **6** describes the wireless communications from a more detailed perspective of the one or more components comprising sensor electronics module **106**.

[0081] As illustrated in FIG. **6**, radio **508** is operative to transmit advertisements (e.g., advertisements **412** of FIG. **4**). Such advertisements may comprise small packets of data broadcast at, e.g., regular intervals. In particular, advertising may be a one-way communication method, where system elements that want to be discovered (such as display devices, when analyte sensor system **104** wishes to send sensor

information to be displayed on at least one display device **120**) broadcasts advertisement beacons or packets in predetermined intervals. Upon receipt of such advertisements, at least one of display device **120** can establish communications with analyte sensor system **104** (data connection process **414** of FIG. **4**) to receive sensor information, for example, and display the sensor information (e.g., analyte and/or estimated glucose values), initiate an alarm, etc.

[0082] CGM processor **506**, as described above, may be one embodiment of the aforementioned processor **314**, which can take a measurement(s) of one or more analyte values, in this example, glucose values, using implantable continuous analyte sensor **312** and sensor measurement circuitry **310** or AFE **500**. For example, CGM processor **506** may take multiple glucose value measurements and process the multiple glucose value measurements (e.g., via one or more processing algorithms, noise filters, etc.) to arrive at one or more transformed glucose values to be transmitted via radio **508**. Moreover, AFE **500** may be one or more sets of analog signal conditioning circuitry utilizing, e.g., operational amplifiers, filters, ASICs, and/or other circuitry to allow the sensor to interface with CGM processor **506**.

[0083] In accordance with some embodiments, staged task processing may be utilized to limit the run-time of processors (i.e., CGM processor **506** and radio **508**) to avoid overlapping as much as possible, thereby reducing stress on the battery (and minimizing asynchronous messaging issues). In particular, and after initialization, AFE **500** samples raw sensor data **504** for, e.g., 5 minutes, while CGM processor **506** and radio **508** are in low power mode (a $T_{inactive}$ period of FIG. **4**). Once AFE **500** is ready, a wake event is triggered by sending a "wake up" message to CGM processor **506** (process **600**) causing the processor **506** to be awake, and during which raw sensor data transfer between AFE **500** and CGM processor **506** can be completed (process **602**). AFE **500** may then return to low power mode acquisition of raw sensor data, for example. CGM processor **506** then calculates and stores estimated glucose value (EGV) data (process **604**). CGM processor **506** may signal radio **508** to "start communication," (process **606**) after which CGM processor **506** enters low power mode (process **608**).

[0084] The start communication command is the first command radio **508** sees and can include data such as a transmitter ID, a communication interval, system mode, RTC value, and API version. Sending such data with each start command allows radio **508** to reset without having to issue an asynchronous command for configuration data. It also allows CGM processor **506** to control the state of radio **508** dynamically (i.e. setting storage mode). Once the start communication command is acknowledged, CGM processor **506** enters low power mode. It should be noted that CGM processor **506** can be designed to stay in sleep mode until real-time events and data processing is complete, thus minimizing main loop processing current draw to save battery power.

[0085] Radio **508** may begin advertising, and if one of display devices **120**, e.g., display device **120***a*, creates a radio frequency (RF) link (process **610**) (i.e., a wireless communication session is initiated and established per the transmission of advertisement signals **412** and data connection establishment **414** of FIG. **4**), display device **120***a* and CGM processor **506** exchange commands/data (processes **612**, also referred to as, e.g., first data connection **416**, second data connection **426**, etc. of FIG. **4**). It should be noted that when display device **120***a* (not shown in FIG. **6**) is connected, sensor electronics module **106** enters a "connection request mode," the purpose of which is to remove the asynchronous messaging complexity from the RF communication link. This connection request mode can be implemented using, e.g., control point/indication responses of the wireless communication protocol being utilized. Moreover, a connection request/response protocol may be used for all messages, where display device **120***a* only issues connection requests, and radio **508** only issues connection responses. Moreover, radio **508** may be placed in a connection "pass-thru" mode, using a message transport layer, and CGM processor **506** may process the appropriate connection (processes **614**, **616**). When display device **120***a* has an active RF communication link, both the CGM application and radio application are in low power mode. The radio stack keeps the RF communication link open, and only when a connection request is sent from display device **120***a*, will the radio/CGM applications exit low power mode.

[0086] In particular, a CGM receive command is triggered when the display devices sends a connection request on the wireless communications protocol API. This command takes the payload and sends it to CGM processor **506**. In some embodiments, the payload is 20 bytes and any extra room is used to send real-time radio status data to CGM processor **506** for every command received. As described previously, the content of data packages, for example, can be customized depending on the display device type. Thus, in some embodiments, an indication of the type of display device that is active (currently engaged in data communications with analyte sensor system **104**) can be provided in the payload. A CGM transmit command comprises a response to a display command request for performing the reverse operations of the CGM receive command, i.e., it takes the payload and sends it to the radio stack to be transmitted on the RF link. A stop communication command may be used to ensure radio **508** does not exceed a predefined "communication window," which in some embodiments is, e.g., 30 seconds, since RF noise can affect AFE sensor measurements. This stop command accordingly can be sent, e.g., 26 seconds after the start communication command is sent.

[0087] It should be further noted that radio **508** may also enter low power mode while CGM processor **506** is processing the connection request (process **618**) and there are no main loop tasks to process. Once the display device **102***a* and CGM processor **506** complete the exchange of commands/data, both CGM processor **506** and radio **508** can enter low power mode (process **620** and also referred to as a $T_{inactive}$ period of FIG. **4**).

[0088] Battery Life

[0089] As previously discussed, various embodiments are directed to maximizing/preserving battery life. To that end, sensor electronics module **106** is configured to operate in two low power modes, a storage mode and an active mode, with a wake source being utilized to wake sensor electronics module **106** from low power mode.

[0090] Storage mode (also referred to as shelf mode) is a mode in which sensor electronics module **106** is placed before being packaged. In accordance with one embodiment, sensor electronics module **106** can stay in this mode until it detects a sensor has been inserted and, at that time, automatically enters active mode. Storage mode places radio **508** in "deep sleep" as well as places CGM processor **506** into a

no-clock mode to keep battery power consumption to absolute minimum levels. Active mode also implements a low power mode, but leaves the real-time clock active. This results in current being drawn, but allows CGM processor **506** to keep accurate time. Wake source **502** is a periodic event that wakes sensor electronics module **12** from low power mode and triggers it to start processing. Wake source **502** is typically provided by AFE **500**, and this event first wakes up CGM processor **506** to configure system hardware and software to transfer raw sensor data **504**.

[0091] Certain wireless communication protocols, such as the aforementioned BLE protocol, use a client/server model. For example, sensor electronics module **106** (including radio **508**), also referred to as a peripheral, may act as a server while a display device (e.g., display device **120***a*), also referred to as a central, acts as a client. The peripheral makes advertisements as described above (e.g., **412**, **422** of FIG. **4**), while the central scans for advertisements. This model can operate using the concept of a Generic Attribute Profile (GATT) which defines how a server and client transfer data back and forth based on "services" (breaking up data into logic entities that contain data referred to as "characteristics") once a data connection has been established.

[0092] Advertising/Connection Protocol

[0093] In accordance with various embodiments, an advertising and connection protocol may be used to control how often and/or when sensor electronics module **106** (the peripheral) advertises for and connects to one or more display devices **120** (the central(s)). The advertising and connection protocol can allow for many different advertisement/connection scenarios. For example, the advertising and connection protocol can: advertise for and connect to a single central at a time; advertise for a plurality (e.g., two) centrals on each communication interval; and connect to a plurality of unique types of centrals on each communication interval. A connection order priority can be implemented for the different types of centrals, where each type of central may have a unique advertising interval and/or timeout period as will be discussed in greater detail below.

[0094] The advertising and connection protocol may utilize "clear text data exchange" as well as "encrypted data exchange." Moreover, the advertising and connection protocol may include various categories or modes of advertising. One mode can be referred to as general advertising, another mode can be referred to as whitelist advertising, and still another mode can be referred to as directed advertising. General advertising refers to a mode where any central can connect with the peripheral, whereas whitelist advertising refers to a mode of advertising in which all connection requests from centrals to the peripheral may be denied except for a connection request from a targeted central. Directed advertising may occur if a user wishes to request that the peripheral transmit sensor information to a desired central, e.g., in the case of a NFC-enabled display device **120***c* "tapping" analyte sensor system **104** to request a connection therebetween.

[0095] During general advertising, the whitelist may be empty, and populated with, e.g., a Generic Access Profile (GAP) Address or an Identity Resolving Key (IRK) entry upon a display device, i.e., a dedicated display device **120***a*, sending its configuration during a bonding exchange when a wireless connection is being established. It should be noted that the whitelist can be dynamically updated to reflect a desired priority for advertising and connection. For example, processor **314** of FIG. **3** can store connection statistics or history in memory **318** such that a certain one of display devices **120** is preferred over another based on time, location, and/or other considerations. The whitelist can also be dynamically updated based upon most recent connections. That is, bonded devices maintained in the bonding list and be filtered in accordance with the historical statistics and/or recent connections information to create the whitelist.

[0096] FIG. **7**A illustrates an example advertising sequence or profile associated with the advertising and connection protocol. As discussed above, radio **508** may be in low power mode when CGM processor **506** is woken up via wake source **502**. CGM processor **506** may then transmit raw sensor data **504** from AFE **500**, apply one or more algorithms to create/calculate an EGV value, and store that EGV value in memory, e.g., flash database. At this point, advertising can begin and CGM processor **506** can signal radio **508** to start advertising (e.g., 3 seconds after the wake event).

[0097] Radio **508** may advertise to one or more display devices/centrals, e.g., a handheld mobile device or a dedicated receiver, such as a CGM display device. As illustrated in FIG. **7**A, radio **508** may send first advertising beacons **700** (also referred as advertisement signals **412** in FIG. **4**) at a certain interval referred to as an advertising interval, A_{ip}, e.g., 90 ms. Such advertising beacons **700** are sent according to the advertising interval A_{ip} for a predetermined time referred to as an advertising duration, A_{dp}. The advertising duration A_{dp} is considered to be an amount of time radio **508** will transmit advertising beacons to one or more of display devices **120**. In this example, the advertising duration A_{dp} for a handheld device such as display device **120***c* may be 7 seconds. In the event a connection is made, advertising will end so that a wireless connection can be established. Radio **508** may also send second advertising beacons **702** to advertise to the CGM display device, e.g., display device **120***a*. Again, advertising beacons **702** are transmitted in accordance with a particular advertising interval, A_{ir}, which can be the same or different than advertising interval A_{ip}, for some advertising duration A_{dr}, which can be the same or different than advertising duration A_{dp}. For ease of reference, advertising interval may be generally described as A_i and advertising duration may be generally described as A_d, where the aforementioned A_{ip}, A_{ir}, A_{dp}, and A_{dr}, are examples of advertising intervals and durations associated with particular ones of display devices **120**, discussed in greater detail below.

[0098] Advertising intervals, e.g., A_{ip} or A_{ir} and/or advertising durations, e.g., A_{dp} or A_{dr}, may differ due to the type of display device/central to which radio **508** is advertising. In the above-described example, one display device, display device **120***c*, may be a handheld device, such as an iPhone®, which, due to its communication(s) characteristics stemming from the fact that it is a general purpose handheld device may necessitate a longer advertising duration A_{dp} in order to receive an advertising beacon **700** and send a connection request back to radio **508**. The CGM display device, i.e., display device **120***a*, being a dedicated receiver, may not need as long an advertising duration A_{dr} because it is specifically configured to communicate with radio **508** of analyte sensor system **104**. As alluded to above and discussed in greater detail below, advertising interval, e.g., A_{ip} or A_{ir} themselves may also differ based on the sensor information to be communicated to the display device,

historical performance, etc. Additionally, and as discussed previously, different types of advertising can be achieved in accordance with various embodiments. For example, in whitelist advertising, only a targeted display device is allowed to engage in data exchange with sensor electronics module **106**, where advertising beacons, such as advertising beacon **700** may include a specifically configured header or other identifier targeting a specific display device. Referring to FIG. **7**B, if the connection request comes from the targeted display device, establishment of the connection can proceed. However, if the connection request comes from an un-targeted display device, connection establishment will not occur. As to directed advertising, a user may use an NFC-enabled display device **120***c* to, e.g., wake up sensor electronics module **106**, which in turn may advertise to a particular display device, e.g., display device **120***a*, with advertising beacons targeted to display device **120**, i.e., advertising beacon **702** having an advertising interval, A_{ir}, and advertising duration, A_{dr}. In one example, in addition to waking up the sensor electronics module **106**, during the NFC based communication, the targeted display device may provide an advertising request to the sensor electronics module **106**. In addition, the display device may, in some examples, may provide preferred advertisement intervals and advertisement durations parameters to the sensor electronics module. The electronics module **106** may then advertise to the targeted display device according to the provided parameters.

[0099] It should be noted that display devices contemplated by the present disclosure need not be limited to mobile communication devices, such as smart phones, and dedicated receivers, but can include any type of receiver appropriate for receiving sensor information in one or more forms/formats. For example, another type of display device/central may be a smart watch, e.g., display device **120***b*. In accordance with various embodiments, sensor electronics module **106** can categorize display devices based on their ability to scan, connect, and/or act as a proxy. That is, display device **120***a*, an example of a dedicated receiver in one embodiment, can connect only to analyte sensor system **104** via sensor electronics module **106**, and may also scan for transmission packets (e.g., advertising beacons **700**, **702** or EGV values) from radio **508** if a communication link is lost or dropped. Display device **120***c* may connect to analyte sensor system **104** via sensor electronics module **106**, but may also connect to other devices, e.g., a WiFi access point, a mobile communications network, etc. Additionally, a handheld device, such as display device **120***c*, like a customized display device, i.e., display device **120***a*, may scan for transmission packets and may also act as a proxy for sending sensor data such as EGV data to a scan display. A display device, such as the aforementioned smart watch, i.e., display device **120***b*, may be categorized as being a "scan only" device, capable only of scanning for transmission packets with regard to analyte sensor system **104** if an existing connection is lost or dropped. That is, a scan only device cannot wirelessly connect directly to radio **508**. As will be discussed in greater detail below, the capabilities of such display devices may change in other embodiments.

[0100] FIG. **7**B illustrates an advertising and connection sequence or profile such as that illustrated in FIG. **4** in accordance with one example. Similar to the example illustrated in FIG. **7**A, radio **508** may be in low power mode when CGM processor **506** is woken up via a wake event from wake source **502**. CGM processor **506** may then obtain raw sensor data **504** from AFE **500**, apply one or more algorithms to create/calculate an EGV value, and store that EGV value in memory, e.g., a flash database. At this point, advertising can begin and CGM processor **506** can signal radio **508** to start advertising (e.g., 3 seconds after the wake event). Radio **508** may advertise to, e.g., display device **120***c*, by sending advertising beacons/packets **700** in accordance with advertising interval A_{ip}. Although the predetermined advertising duration A_{dp} for display device **120***c* may be 7 seconds, in this example, display device **120***c* to which advertising beacons **700** are targeted sends a command (connection) request sooner, reflecting a certain time-til-connection value, C_{ip}. Time-til-connection value, C_{ip} is an example of a time-til-connection value, C_t, associated with the time it takes for a display device, in this case, display device **120***c*, to transmit a connection request to radio **508** in response to an advertising beacon broadcast by radio **508**. Thereafter, a wireless connection is established between display device **120***c* and radio **508**. A connection duration, generally described as C_d, can refer to the time period during which a display device is connected/in communication with radio **508**. In this example, time period C_{dp} specifies a connection duration for display device **120***c*. Once the requested commands have been processed, radio **508** may resume advertising, e.g., to another display device (advertising beacons **702**). As will also be discussed below, varying connection duration and/or varying advertising and connection parameters based upon time-til-connection values can help extend battery life in accordance with various embodiments.

[0101] FIG. **7**C illustrates an example operating interval/frequency of transmission, O_i, which is indicative of time between when radio **508** is in low power mode/sleeping and when radio **508** wakes up and begins to advertise (as illustrated in FIG. **6**). For example, if display device **120***a* has an active RF communication link, both the CGM application and radio application are in low power mode. The radio stack keeps the RF communication link open, and only when a command request is sent from display device **120***a*, will the radio/CGM applications exit low power mode.

[0102] Adjustable Variables

[0103] A plurality of options exist for varying or adjusting aspects of the advertising and connection protocol to minimize processing tasks, conserve battery power, improve connection reliability, etc. In accordance with some embodiments, one or more of the aforementioned communication aspects of the advertising and connection protocol can be treated as an adjustable variable.

[0104] Transmission Variables

[0105] Examples of communication variables include those aspects of the advertising and connection protocol relevant to the manner in which data is transmitted, e.g., transmission frequency or operating interval (e.g., T_{active} of FIG. **4**, O_i of FIG. **7**, etc.), the transmission protocol utilized (Bluetooth, WiFI, NFC, ANT+, Zigbee, etc.), whether communications are one-way or two-way, and whether data is transmitted on-demand or whether the transmission of data occurs automatically. For example, it may be desirable to optimize communications based on the desired transmission protocol and/or transmission type to avoid wasting radio resources and/or battery life. In accordance with one embodiment, communication variables are adjusted to meet the desired transmission protocol and/or transmission type.

In particular, and if, for example, the desired communication type is one-way communication, e.g., transmitting EGV data embedded in advertising beacons **700** and **702** from sensor electronics module **106** to display devices **120***a* and **120***c*, CGM processor **506** and radio **508** can be instructed/configured to operate such that no time is "set aside" for a connection duration C_d, i.e., C_d=0. Alternatively, CGM processor **506** and radio **508** can be instructed/configured to operate without any connection duration, C_d.

[0106] Advertising Variables

[0107] Other examples of communication variables include aspects of the advertising and connection protocol, and may include the following: how a data packet is formatted, e.g., the advertising beacon packet may include sensor data rather than merely radio identification information, scan device data, etc.; the manner in which a data packet is encrypted; the advertising duration A_{dx}; the advertising interval A_{ix}; and the power used when broadcasting advertisements (e.g., dBm of radio **508**).

[0108] Referring to the above example, and as illustrated in the example of FIG. **7**A, the advertising durations, e.g., A_{dp}, A_{dr}, can abut each other if communications are one-way. Again, this may be the case if EGV measurements or EGV trend information is included in one or more advertising beacons **700**, **702** and connections to display devices **120***a* and **120***c* are not warranted/needed. Moreover, the advertising duration A_d and advertising interval A_i may be decreased because radio **508** is not expecting to establish an actual wireless communication session with display devices **120***a* and **120***c*. Operating interval O_i can commensurately be increased. In some embodiments, the configuring of advertising durations, A_d, may be ignored or bypassed altogether.

[0109] Still other examples of communication variables include the type of the display device (e.g., general purpose handheld device such as display device **120***c*, dedicated receiver such as display device **120***a*, diagnostic device, consumer device, etc.); the number of display devices available to connect to the analyte sensor system **104**; the order in which the display devices **120** connect to the analyte sensor system **104**; how and/or whether or not a display device is determined to be a primary display device; and the broadcast mode commensurate with the role (primary or peripheral) of the display device.

[0110] As can be appreciated, and as alluded to previously, advertising intervals A_i and advertising durations A_d may be varied according to the type of display device for which the advertising beacons are intended. For example, display device **120***a*, a dedicated CGM display device, may have a shorter advertising duration A_{dr} than that of display device **120***c*, a handheld device, e.g., mobile phone. In accordance with another example, in a scenario where only a single display device, e.g., display device **120***c*, has been able to connect to radio **508**, its respective advertising duration A_{dp} may be increased in order to ensure that sensor information is transmitted and observable by a user. In the event that more than one of the display devices **120** have established previous wireless connection sessions with radio **508** (e.g., by accessing and reviewing the bonding list), respective advertising durations A_d may be shortened under the assumption that establishing a wireless connection session between sensor analyte system **104** and any particular one of display devices **120** is less critical.

[0111] Conditions for Adjusting Variables

[0112] As discussed above, certain communication variables can be adjusted to affect battery usage and improve connection reliability. The manner in which those communication variables can be adjusted may be dependent upon one or more conditions for communication described in greater detail below that include, but are not limited to display devices populating the whitelist and/or bonding list that can be indicative of historical and/or predictive connections, as well as the condition of the user/host **102**.

[0113] Whitelist, Current and Historical Communications/Connections, and Time

[0114] Examples of communication conditions upon which adjusting the above-described communication variables are based can include conditions having to do with which display device(s) populate the whitelist and/or which display device is currently connected or unconnected. Returning to the above example, the existence of multiple display devices **120** to connect to, which can result in a decrease in respective advertising durations A_d may be based upon multiple display devices **120** populating the whitelist, while an advertising duration A_d may be increased in the event that only one corresponding display device, e.g., display device **120***a*, populates the whitelist.

[0115] Another example of communication conditions can include historical or previous communications such as the following: the number of previously missed communications; a previous advertising interval/duration "budget;" and historical time-til-connection associated with a particular display device. That is, CGM processor **506** may remove a display device populating the whitelist in the event that a predetermined threshold amount of time during which the display device has failed to connect with sensor electronics module **106** has been exceeded. Still other examples of communication conditions may include, e.g., the time of the last communication with one or more display devices and/or a current time of day or date. That is, if the number of previously missed communications, i.e., advertising beacons, such as advertising beacons **700** for display device **120***c* go unanswered for some predetermined time threshold, the advertising duration A_{dr} for display device **120***c* may be reduced or eventually set to 0. This may be the case, for example, if a user returns to his/her home and turns his/her mobile phone off or stores it in some location not reachable by the currently implemented wireless communication protocol. Similarly and regarding previous advertising interval/duration budget, the CGM processor **506** may have radio **508** advertise to one or more of display devices **102** in accordance with a previous advertising interval, A_i and duration, A_d unless missed communications and/or historical time-til-connection statistics indicate to the CGM processor **506** that the advertising interval, A_i and duration, A_d should be adjusted to comport with current communication conditions. For example, CGM processor **506** can review historical time-til connection C_{tp} values associated with display device **120***c*. If the time-til connection C_{tp} values are short (e.g., in the event that the user is at work and may consistently have his/her phone in his/her possession), CGM processor **506** can advertise to display device **120***c* in accordance with a shortened advertising duration A_{dp}. In other words, communication conditions in which a display device connects sooner than expected can be interpreted by CGM processor **506** to indicate that connection reliability is sufficiently good and that the current advertising interval/

duration budget may be too generous thereby resulting in an unnecessary expenditure of battery power.

[0116] Sensor Data and User/Sensor Condition

[0117] In accordance with some embodiments, communication conditions upon which adjusting communication variables are based may include a user condition. For example, depending on one or more of actual and/or predicted sensor or EGV data or sensor or EGV data trends can affect one or more communication variables. The same may be true of alarm or alert conditions, e.g., low, high, trending, or boundary alarms. The condition of sensor analyte system **104** itself, such as whether or not sensor calibration of continuous analyte sensor **108** is required, completed, or results in error, or whether continuous analyte sensor **108** is nearing or at the end of its useful life can affect one or more communication variables. Temperature of host **102** is also another communication condition, as is sensed physical movement. Additionally, signal noise is yet another communication condition that may be measured and relied upon as a basis for adjusting one or more communication variables.

[0118] FIG. **8**A is a flow chart illustrating example processes performed for advertising, connecting to, and communicating analyte data in accordance with various embodiments. At operation **800**, a wake event is received, e.g., by a CGM processor **506** of the analyte sensor system **104**. At operation **802**, sensor information is received by the CGM processor **506**. At operation **804**, analyte data, e.g., EGV data, is calculated and stored by the CGM processor **506**. For example, the sensor information received by CGM processor **506** may be raw sensor data, which can then be processed to arrive at the analyte value data. In some embodiments, the sensor information, e.g., raw sensor data, can be passed to CGM processor **506** directly. At operation **806**, one or more communication conditions is determined as described above. That is, conditions that may have an effect on the advertising to one or more of display devices **120** and/or resulting wireless communication sessions established between the one or more display devices **120** and CGM processor **506** can be considered for adjusting or optimizing communication variables. At operation **808**, a transceiver, e.g., radio **508**, is instructed to advertise to at least a first display device, e.g., display device **120***c*, in accordance with one or more communication variables (e.g., A_{ip}, A_{dp}, C_{tp}) based upon the one or more communication conditions. At operation **810**, the first display device, display device **120***c*, may connect to the transceiver, radio **508**, of analyte sensor system **104**. At operation **812**, analyte data is transmitted to the first display device, display device **120***c*. It should be noted that as will be discussed below, a myriad of different/alternative advertising and/or communication schemes can be used. Accordingly, at operation **814**, the transceiver, radio **508** of the analyte sensor system **104** may connect to and/or transmit analyte value data to a second display device, e.g., display device **120***a*. As will also be discussed below, the first and second display devices may connect to each other in addition to or as an alternative to connecting to the analyte sensor system **104**.

[0119] FIG. **8**B illustrates a plurality of communication conditions **806***a*-**806***f* (discussed previously) that may be determined or measured in accordance with operation **806** of FIG. **8**A. FIG. **8**C illustrates a plurality of advertising, communication, and display device-based variables that can be adjusted in accordance with operation **808** of FIG. **8**A.

[0120] Intelligent Advertising

[0121] As previously discussed, various embodiments contemplate adjusting one or more variables based on one or more communication conditions in order to optimize the advertising and connection process such that advertising and connections can be achieved with sufficient reliability to provide meaningful sensor data while extending battery power. In other words, various embodiments achieve a balance between battery power and connection reliability. For example, and in the context of advertising, advertising variables can be set or selected based on some minimum reliability to avoid or lessen the occurrence of missed advertising beacons when the advertising interval is short (to avoid excessive battery drain on radio **508** as a result of longer advertising intervals).

[0122] In some embodiments, the order of display devices **120** and/or which of display devices **120** connect to sensor electronics module **106** can impact battery power and/or connection reliability. Accordingly, whitelist conditions can be determined. That is, CGM processor **508** can access the whitelist to determine which display device(s) **120** are currently present within the whitelist. For example, CGM processor **508** may adjust the advertising interval/duration budget to include only the requisite advertising interval/duration for display devices present in the whitelist so that, as previously described, battery power and radio resources are not wasted, e.g., by advertising to display devices that have a low likelihood of connecting. Thus, advertising beacons are not sent to display devices not currently included in the whitelist. Moreover, advertising to only those display devices present in the whitelist can result in the ability to provide, e.g., a greater advertising duration for those display devices, thereby increasing connection reliability. That is, if an advertising duration has an X-second budget for advertising to display device **120***c* (e.g., X_p seconds) and display device **120***a* (e.g., X_r seconds), but display device **120***a* is not present in the whitelist, the radio **508** can be instructed to allocate an additional X_r seconds (or some amount of time based on X_r seconds) when advertising to display device **120***c*, or to advertise to another display device **120***b, d*, or *e*.

[0123] As alluded to previously, NFC-capable display devices may alter the "normal" establishment of communications. For example, a user may wish to have analyte sensor system **104** transmit sensor information prior to a scheduled transmission. This can be due to the user/host **102** feeling the onset of a hypoglycemic condition, or the user may wish to have a backlog of sensor data transmitted in a "data dump" to one of display devices **120**. In operation, a user can invoke directed advertising through the use of NFC-capable display device, e.g., display device **120***c*. As previously discussed, directed advertising allows a display device, e.g., display device **120***c* to "tap" display device **120***c* on analyte sensor system **104** (e.g., bringing the display device substantially close to the analyst sensor system to effectuate an NFC communication) thereby instructing CGM processor **506** to wake up (where sensor electronics module **106** may have a separate NFC transceiver (not shown)). CGM processor **506** may then instruct radio **508** to begin advertising to display device **120***c* or to another one of display devices, e.g., in accordance with an advertising order based on the whitelist, for example, a most recent connection, or some other preferred display device. CGM processor **506** may also access historical EGV data (discussed further below) and

determine that the user/host **102** is trending towards a potential hypoglycemic condition in which case, CGM processor **506** may attempt to establish a wireless connection with display device **120***a* and may further increase the advertising duration A_{dr} in order to increase the chances of establishing a wireless communication session. Alternatively still, upon the user invoking directed advertising, analyte sensor system **104** may access the whitelist to determine which of display devices **120** populates the initial position, which in some embodiments can indicate the "preferred" or "primary" display device. Analyte sensor system **104** would then attempt to establish a wireless communication session with that preferred/primary display device.

[0124] It may be beneficial to have display devices optimal for a particular scenario present/populating the whitelist so that a wireless communication session can be established quickly. Thus, in accordance with some embodiments the whitelist is updated in accordance with condition of the whitelist itself. That is, the presence of certain display devices having certain capabilities can be used to initiate, e.g., the removal of other display devices not compliant with those capabilities. For example, the existence of an NFC-capable device, e.g., display device **120***c*, in the whitelist may prompt the removal of a non-NFC-capable display device, e.g., display device **120***d* because a user may rely on the NFC capabilities of display device **120***c* to obtain EGV data, or alternatively, to pair/initiate the wireless communication session, thereby disqualifying display device **120***d*.

[0125] FIG. **8**D illustrates example processes performed for updating the whitelist in accordance with this embodiment. At operation **801**, a wake event is received, the wake event being initiated by an NFC-capable device. That is, display device **120***c*, which may be a smart phone, can be tapped on analyte sensor system **104** to initiate a wake up signal to be sent from AFE **500** (FIG. **5**) to CGM processor **506**. Similar to FIG. **8**A, CGM processor **506** can receive sensor information at operation **802**, and analyte data is calculated and stored at operation **804**. At operation **806***f*, whitelist conditions are determined. As described above, in this example, at least one NFC-capable device is populating the whitelist, e.g., display device **120***c*, along with a non-NFC-capable device, e.g., display device **120***d*. At operation **807**, the non-NFC-capable display device is removed from the whitelist. At operation **809**, a wireless communication session is initiated with the at least one NFC-capable display device. Thus, an NFC process can be used to effectuate the wireless communication session with display device **120***c*, or with another NFC-capable device, e.g., display device **120***b*. At operation **812**, the analyte data is transmitted to one of display device **120***c* or display device **120***b*. In this way, time and resources need not be wasted advertising to display device **120***d*. It should be noted that although this embodiment is disclosed in the context of removing a non-NFC-capable device, other conditions and actions regarding device capabilities and whitelist updates, whether display devices are added, removed, re-ordered, etc. are contemplated. In some embodiments, display devices, for example, display device **120***c* may include both NFC and non-NFC communication protocol (e.g., a BLE communication protocol). As such, when it is determined that the display device **120***c* has NFC capability, device **120***c* may also be taken out of the whitelist, so that analyte sensor device **104** communicates analyte sensor data to the display device **120***c* only via NFC communication, rather than via BLE communication protocol.

[0126] As alluded to previously, adhering to set advertising and/or connection parameters may result in wasting radio resources as well as result in less reliable communications. In some embodiments, historical communication conditions can be determined or analyzed in order to optimize the advertising duration. For example, the advertising and connection software can be configured to operate using an algorithm that varies the advertising duration based upon historical statistics or information regarding time-til-connection periods. That is, the CGM processor **506** can instruct the radio **508** to progressively lessen the advertising duration by some predetermined amount until a measured connection rate for one or more display devices drops below a predetermined connection rate or percentage threshold. Alternatively, the advertising duration can be progressively decreased depending the lack of a connection, e.g., if a display device, e.g., display device **120***c* (having an advertising duration A_{dp} of X_p seconds) has not connected to the analyte sensor system **104** within the last 5 minutes, the advertising duration A_{dp} for display device **120***c* will be reduced to X_p' seconds from X_p seconds, and so on. The lack of connection may suggest the absence of display device **120***c*, and battery power can be conserved by stepping down the advertising duration A_{dp} or eventually stopping the transmission of advertising beacons **700** altogether, and, e.g., advertising to another display device. If, however, display device **120***c* comes back into range of analyte sensor system **104**, e.g., prior to the end of the transmission of advertising beacons **700**, or if the user initiates directed advertising to display device **120***c*, the algorithm can reinstate the advertising duration A_{dp} for display device **120***c* (either in full, e.g., X_p seconds, or in a progressively increasing manner based upon additional, subsequent wireless communication sessions being established).

[0127] The algorithm may alternatively or additionally predictively estimate what display devices are likely to be within range of the analyte sensor system, and tailor the advertising duration(s) to those display devices. In particular, the algorithm may instruct CGM processor **506** to access memory **318**, for example, to analyze historical connection statistics. Based on the historical connection statistics, the algorithm may generate an advertising profile that optimizes the likelihood of connection to one or more display devices **120**. Historical connection statistics can include, e.g., the times of day that a particular display device connects to analyte sensor system **104**. Historical connection statistics can also include, as previously discussed, previous advertising interval/duration budgets as well as historical time-til-connection durations, C_d.

[0128] For example, based on the historical connection statistics, it may be determined that from the hours of 6 pm to 6 am, display device **120***c* does not usually respond to advertising beacons **700**, whereas display device **120***a* does. Accordingly, radio **508** can be instructed to only advertise (using advertising beacons **702**) to display device **120***a* from the hours of 6 pm to 6 am using the appropriate advertising duration A_{dr} for display device **120***a*. As another example, the algorithm may determine the number of recent connections that occur for particular display devices, the amount of missed advertising packets associated with particular display devices, etc. and instruct radio **508** to advertise to those

display devices (using the appropriate advertising duration) having successfully connected during some recent time period, and to skip advertising to those display devices associated with missed advertising packets.

[0129] Still other embodiments may operate based on an analysis of EGV and/or raw sensor data. For example, the CGM processor **506** may alter advertising duration and/or advertising intervals for one or more display devices according to a user's state based on the EGV and/or raw sensor data. That is, if EGV data indicates that the user is going hypoglycemic, the advertising duration for one or more display devices can be increased and/or the advertising interval can be shortened in order to reduce the chance that advertising beacons will be missed. Yet, during non-critical periods, e.g., when the EGV data indicates that the user is in a healthy state, the same advertising duration can be shortened and/or the same advertising interval can be increased, as providing the EGV data is less critical. Thus, the establishment of a wireless communication session can be delayed.

[0130] FIG. **8**E is a flow chart illustrating example processes performed in accordance with the above example scenario, and will be described with reference to previously described FIGS. **1**, **6**, and **7** for ease of understanding.

[0131] CGM processor **506** may calculate analyte data and store that calculated analyte data (operation **804** and process **604** of FIG. **6**). It should be understood that operations **800** and **802** (illustrated in FIG. **8**A) may have already been performed, i.e., a wake event may have already been received, and CGM processor **506** may have already received sensor information from analyte sensor system **104**, thereby allowing CGM processor **506** to calculate the analyte data. In accordance with one or more algorithms utilized in controlling CGM processor **506**, CGM processor **506** may be instructed to determine one or more communication conditions (operation **806**). In this example, CGM processor **506** may be instructed to analyte EGV data (operation **806***c*) which includes historical EGV data. Thus, CMG processor **506** may access its database and review some predetermined number of (or for some predetermined amount of time) calculated EGV values to determine a recent trend of analyte (in this case, glucose) measurements. If the observed trend of analyte measurements indicates that the user (e.g., host **102** of FIG. **1**) may be falling into a hypoglycemic condition, CGM processor **506** can determine the existence of an alarm condition (operation **806***d*). As such, CGM processor **506** can start advertising (operation **808** and process **606** of FIG. **6**) sooner than may be "normally" configured with radio **508**, prompting radio **508** to begin advertising to one or more display devices **120**. Moreover, the advertising interval A_{ip} (FIG. **7**) for one or more of display devices **120**, e.g., display device **120***c*, may be shortened, resulting in more frequent advertising beacons **702** being transmitted in an attempt to increase the chance of connection. Alternatively or in addition, the advertising duration A_{dr} can be increased for display device **120***a*. For example, given that display **120***a*, a dedicated CGM display device, may have the greatest chance for connection to radio **508** of sensor electronics module **106**, the advertising duration A_{dr} can be increased for that specific display device. It should be noted that the requisite connections/wireless communications sessions/transfer of EGV data can occur as illustrated in FIG. **8**A.

[0132] Returning to FIG. **7**, it can be appreciated that the advertising duration, A_d, can be altered depending on the transmission protocol currently being/to be utilized. That is, certain transmission protocols may have a smaller "operative distance" between peripheral and central(s). For example, when utilizing NFC, CGM processor **506** can generate/calculate advertising durations for one or more of display devices **120** that have been shortened based on the assumption that the one or more display devices **120** will be close to analyte sensor system **104** and will not likely require extended advertising durations. Additionally, the advertising durations of non-NFC display devices may be negated when the wireless communication session initiation/pairing is accomplished using NFC.

[0133] In other embodiments, a user's temperature and/or predicted or determined activity level or lack thereof can be used as a condition upon which advertising is based. For example, analyte sensor system **104** may employ one or more accelerometers or other sensors capable of determining the activity level of a user/host **102**. Upon CGM processor **506** determining, based on feedback from analyte sensor system **104** that a user is assumed to be sleeping, e.g., based on sensed lack of movement or time of day, advertising durations A_d for one or more display devices **120** may be reduced unless a critical or alarm condition is sensed. Alternatively, CGM processor **506** may determine, based on feedback from analyte sensor system **104** that a user/host **102** is assumed to be engaged in some activity, e.g., running. In this case, CGM processor **506** can instruct radio **508** to advertise only to a display device that the user is likely to have on his/her person, such as a smart watch, i.e., display device **120***b*, rather than another display device, such as a tablet PC, i.e., display device **120***d*. The determination regarding which display device(s) the user is likely to have on his/her person can be made based on which display device(s) are populating the whitelist, one or more display device type identifiers, historical information, time of day information, etc. (discussed previously).

[0134] It should be noted that the existence or absence of alerts/alarm conditions or triggers, approaching an alert/alarm condition, EGV/raw sensor trending data or predictions can be leveraged in the same manner. For example, EGV or raw sensor data can be analyzed by CGM processor **506** to determine whether a user is trending towards, e.g., a hypoglycemic condition, and/or predictive algorithms can be used to predict a user's current or future state, and advertising duration A_d and/or advertising interval A_d variables can be adjusted commensurate with that data/prediction(s). It should also be noted that the amount of power used for transmitting each advertising beacon can be adjusted based on the same or similar communication conditions used to adjust the advertising duration and/or interval. For example, if display device **120***b*, i.e., a smart watch, connects to analyte sensor system **104**, CGM processor **506** may instruct radio **508** to reduce the power used to transmit advertising beacons inasmuch as it may be assumed that display device **120***b* will be on the user's body/wrist, near sensor electronics module **106**. Thus, less power is likely needed for the advertisement beacons. It should be noted that the transmission power for communicating sensor information/analyte data may also be decreased.

[0135] Relying solely on the sensor electronics module **106** of analyte sensor system **104** to effectuate data transfer to one or more of display devices **120** can be taxing from a

battery power perspective. In accordance with other embodiments, networking techniques or architectures can be leveraged, e.g., mesh networking, to reduce advertising as well as connection frequency. For example, a first display device, e.g., display device **120***c*, may connect to analyte sensor system **104**. Thereafter, display device **120***c* may advertise to one or more additional devices, e.g., display devices **120***b* and **120***d*, so analyte sensor system **104** need not have to deplete its own battery power to transmit advertising beacons, connect to other display devices, etc. Moreover, depending on the type of display devices present, analyte sensor system **104** may not be an optimal connection/communication candidate. Accordingly, and again, networking or "direct" communications between display devices may result in better connection reliability. For example, display devices **120***b* and **120***c* may be optimized for data transfer therebetween, such that data communications between display devices **120***b* and **120***c* are more reliable than between, e.g., display device **120***b* and analyte sensor system **104**.

[0136] In some scenarios, it may be beneficial to allow a user to control which display device(s) **120** connect to analyte sensor system **104** to receive sensor data. Thus, in accordance with some embodiments, the whitelist can be user-modifiable or updatable. In particular, a user may specify a desired display device to connect to by accessing the whitelist which can be stored, e.g., in memory **318**, and interacting with the whitelist through a user interface provided on one or more of display devices **120**. In this way, radio **508** need not transmit advertising beacons to a display device that the user does not intend to rely on. As described previously, a whitelist may be a list of display devices reflecting those display devices that have successfully been paired or bonded with the sensor electronics module **106**.

[0137] FIG. **8**F is a flow chart illustrating example processes performed in accordance with the above-described scenario. Like FIG. **8**A, a wake event is received at operation **800**, sensor information is received, e.g., by CGM processor **506**, at operation **802**, and at operation **804**, analyte data can be calculated and stored by CGM processor **506** based on the received sensor information. At operation **806**, whitelist conditions are determined, one aspect of communication conditions, as discussed above. As alluded to above, the whitelist can be configured/updated by the user either directly or indirectly (e.g., via manipulation of another display device list that is different than the whitelist). Thus, at operation **820**, the whitelist is accessed, e.g., by CGM processor **506** vis-à-vis an instruction by a user interface providing user control over the whitelist. At operation **822**, the whitelist is configured in accordance with the user's display device preferences. Returning to operation **808**, a transceiver, e.g., radio **508**, can be instructed by CGM processor **506** to advertise to at least a first display device in accordance with one or more communication variables based upon the one or more communication conditions. In this instance, the advertising is performed based on the whitelist configured/updated by the user. If that specified display device does not connect, the radio **508** can be instructed to return to a default or previous advertising scheme (with the appropriate advertising duration/time/power) at operation **813**. For example, the user may specify that display device **120***b* is to be used for the establishment of a wireless communication session and transfer of EGV data from some period of time. This may occur, for example, if the user is exercising and wishes to receive sensor information on a convenient display device, in this case, display device **120***b*, a smart watch. However, if the user forgets to wear display device **120***b*, after some threshold time of failing to establish a wireless communication session with display device **120***b*, radio **508** can be instructed to begin transmitting advertising beacons in accordance with a default whitelist population. At operation **814**, connection to a second display device is established (based upon the default or previous advertising scheme).

[0138] In still other embodiments, the order in which display devices connect to the analyte sensor system **104** may also be leveraged to save battery power as well as increase connection speed and connection reliability. For example, if EGV data suggests that a user is nearing a hypoglycemic state, radio **508** may transmit advertising beacons **702** to a last connected display device or a default display device, such as display device **120***a*, a dedicated CGM display device, so that the likelihood of connection is heightened while also potentially reducing wasted battery power by advertising to a display device that is unlikely to connect. Moreover, advertising can be adapted such that advertisement beacons are only sent to a particular display device depending on which display device(s) has/has not connected, e.g., advertisements to display device **120***b* associated with a display device **120***c* may be transmitted only if display device **120***c* is/has connected to radio **508**.

[0139] In accordance with another embodiment, the whitelist may be used to force a connection with a preferred display device, e.g., display device **120***b* (in the previously described example) and then the aforementioned mesh networking scheme can be leveraged such that the preferred display device, once connected, can assume the role of advertising to additional display devices. That is, and in this instance, display device **120***b*, may connect to analyte sensor system **104**. Thereafter, display device **120***b* may advertise to one or more additional devices, e.g., display devices **120***a* and *d*, so analyte sensor system **104** need not have to deplete its own battery power to transmit advertising beacons, connect to other display devices, etc.

[0140] FIG. **8**G is a flow chart illustrating example processes performed in accordance with the above example scenario, and will be described with reference to previously described FIGS. **1**, **6**, and **7** for ease of understanding. Like the flow chart of FIG. **8**E, CGM processor **506** may calculate an EGV value and store that calculated EGV value (operation **804** and process **604** of FIG. **6**). It should be understood that operations **800** and **802** (illustrated in FIG. **8**A) may have already been performed. In accordance with one or more algorithms utilized in controlling CGM processor **506**, CGM processor **506** may be instructed to determine one or more communication conditions (operation **806**). In this example, CGM processor **506** may be instructed to analyte EGV data (operation **806***c*) which includes historical EGV data. Thus CMG processor **506** may access its database and review some predetermined number (or for some predetermined amount of time) calculated EGV values to determine a recent trend of analyte (in this case, glucose) measurements. If the observed trend of analyte measurements indicates that the user (e.g., host **102** of FIG. **1**) may be falling into a hypoglycemic condition, CGM processor **506** can determine the existence of an alarm condition (operation **806***d*). However, in this example, display device variables are taken into consideration, where the order of display

device connection (determined via the whitelist conditions at operation **806***f*) may be the following: display device **120***c* connected first; display device **120***a* connected second. Thus, per the above scenario, radio **508** is instructed to transmit advertising beacons **702** (FIG. **7**) to display device **120***a*, the last connected display device (operation **808**). Display device **120***a* may then connect to analyte sensor system **104** (in particular, radio **508**) and a wireless communication session can be established (operation **810**). Moreover, the role of the display device may also be considered. In this scenario, display device **120***a* is configured to act as an advertising entity. Thus, display device **120***a* may continue with advertising to display device **120***c* and connect thereto (operation **810**). EGV data my then be transmitted per operation **812** of FIG. **8**A and so on.

[0141] Intelligent Communication

[0142] While intelligent advertising schemes or techniques can be utilized to conserve battery power, actual communications between analyte sensor system **104** and one or more display devices **120** can also be made more efficient to also reduce the drain on the sensor electronics module's battery.

[0143] To achieve efficient communications, some embodiments may adjust the frequency with which EGV data is transmitted (illustrated as, e.g., first data communication **416**, second data communication **424**, etc.), i.e., the update frequency. As described above, with regard to actual, trending, and/or predicted data, alerts/alert boundaries, as well as alarms/alarm conditions, the frequency with which data is sent can vary, i.e., less frequently when the user is in a clinically "safe" zone and more frequently when the user is in or is nearing a potentially clinically unsafe condition, e.g., a hypoglycemic state. In accordance with one embodiment, EGV data is only transmitted upon the satisfaction of an alert condition, thereby significantly reducing the battery power that would be conventionally consumed if such data were being sent more frequently.

[0144] A user may also be allowed to set the update frequency (discussed above) to conserve battery power. For example, the user may be allowed to specify that if a last EGV calculation is within some range (e.g., percentage) of a median bound, then a particular update frequency can be employed. Similar to updating the whitelist described above, a user interface may be provided in one or more display devices **120** (or directly on analyte sensor system **104**, e.g., on sensor electronics module **106**). The user interface can be accessed by the user, where the user interface provides a mechanism for indicating an EGV threshold that is used as a basis for update frequency. However, in the event of a recent calibration, a recent dose of insulin (e.g., from display device **120***e*, a medicament delivery device), or consumption of carbs, communications can be established immediately and/or the update frequency can be increased.

[0145] In order to increase battery life and/or connection reliability, it may be beneficial to allow transmission modes to be specified or controlled to comport with certain communication conditions. For example, two-way communications which require power to be supplied to, e.g., sensor electronics module during transmission and receipt of data, may be unnecessary in certain scenarios. Thus, a user's condition may be used as a basis for determining a mode of transmission. In particular, some embodiments may allow CGM processor **506** to base a mode of transmission on sensor or EGV data, where one-way or two-way communications can be effectuated depending on the data received/calculated by the CGM processor. For example, if a user's is not in a critical state, transmissions can occur using, e.g., a one-way burst transmission (as described above), but if the user enters or nears a critical state, the transmission mode may switch to two-way communications or other communication protocols, where the user can request EGV data on-demand (e.g., via NFC). Still other circumstances where a transmission mode can be adapted include times when analyte sensor system **104** is undergoing calibration. As another example, a transmission mode can be adjusted in response to a situation where a wireless communications session cannot be established over one or more update periods resulting in missed sensor information that should be backfilled.

[0146] FIG. **8**H is a flow chart illustrating example processes performed in accordance with the above example scenario, and will be described with reference to previously described FIGS. **1**, **6**, and **7** for ease of understanding. CGM processor **506** may calculate an EGV value and store that calculated EGV value (operation **804** and process **604** of FIG. **6**). It should be understood that operations **800** and **802** (illustrated in FIG. **8**A) may have already been performed. In accordance with one or more algorithms utilized in controlling CGM processor **506**, CGM processor **506** may be instructed to determine one or more communication conditions (operation **806**). In accordance with one example, CGM processor **506** may be instructed to analyze EGV data (operation **806***c*) which includes historical EGV data. Thus CGM processor **506** may access its database and review some predetermined number (or for some predetermined amount of time) calculated EGV values to determine a recent trend of analyte (in this case, glucose) measurements. If the observed trend of analyte measurements indicates that the user (e.g., host **102** of FIG. **1**) may be falling into a hypoglycemic condition, CGM processor **506** can determine the existence of an alarm condition (operation **806***d*). Based on this determination that an alarm condition exists, the type of communications will be set to 2-way communications or a different wireless protocol may be implemented, and advertising can commence (operation **808**). Accordingly, a display device, e.g., display device **120***c*, connects to analyte sensor system **104** and establishes a wireless communication session (operation **810**). Moreover, the EGV data is transmitted at operation **812**. If desired, the user can request EGV data on-demand (via, e.g., NFC-directed advertising), and operation returns to operation **800**. However, if it is determined that an alarm condition does not exist, the type of communications will be set to 1-way communications, in which case, the advertising beacons can be configured to include EGV trend data, for example, and a wireless communications session need not be established (operation **808**).

[0147] Further to the above, data packet formatting can be affected as well, e.g., one-way transmission of data can occur with unencrypted data, while two-way communication of data utilizes encrypted data, and vice-versa. Moreover, update alerts can be transmitted to one or more (secondary) display devices, such as display device **120***b* and/or display device **120***c*, instructing them to establish communications with a (primary) display device, such as display device **120***a*, to transmit a status update. Additionally still, previously stored/analyzed raw sensor data and/or EGV data can be used to predict possible user states, determine patterns associated with the user's states, e.g., throughout the day,

learn the user's behavior that may impact his/her state, etc. Such data may then be utilized to determine what or when the next transmission of data should occur. Hence, the aforementioned mode of transmission and/or frequency of transmission can be adapted accordingly.

[0148] Additionally, the state of the analyte sensor system **104** can be a condition upon which communications may be altered. For example, as alluded to previously, a communication command may be used to ensure radio **508** does not exceed a predefined communication window. That is, and referring back to processes **612** of FIG. **6**, a CGM transmit command comprises a response to a connection request for performing the reverse operations of the CGM receive command, i.e., it takes the payload and sends it to the radio stack to be transmitted on the RF link. A stop communication command may be used to ensure radio **508** does not exceed a predefined "communication window," which in some embodiments is, e.g., 30 seconds, since RF noise can affect AFE sensor measurements. This stop command accordingly can be sent, e.g., 26 seconds after the start communication command is sent. Moreover, the presence of excessive signal noise may suggest that communications with a particular display device should be stopped, and the transmission of data should continue with an alternative display device.

[0149] Direct transmission of analyte data can be implemented in an encrypted manner in/on an advertising beacon. That is, advertising beacons containing encrypted analyte data can be used to directly communicate those measured analyte values, e.g., glucose values, without establishing a two-way communication protocol. A display device can be allowed to select source information based on the establishment or lack of another connection. For example, in some embodiments, connection of a first display device can be determined, e.g., a wireless connection between analyte sensor system **104** and display device **120***c*. Data transmission of sensor information can be effectuated directly from display device **120***c* to a second display device, e.g., display device **120***b*. Otherwise, data transmission can occur between the analyte sensor system **104** and display device **120***b*. Additionally, an encryption scheme can be established using two-way communication pursuant to an initial transmission of data, e.g., a static display device encryption key can be used to avoid setting up two-way communication for each transmission.

[0150] The formatting of data packets may also include using one or more data compression techniques. In accordance with some embodiments, analog waveform compression techniques such as Fourier transformation, etc. can be used to compress the EGV data resulting in much smaller transmissions, which in turn results in reduced battery use. For example, and referring back to FIG. **4**, first and second data connections **416** and **424** can be shortened in duration. In accordance with other embodiments, the transmission of data can be reduced by, e.g., not transmitting backfill data, calibration data, etc. unless needed. For example, if a user's state is not critical or an analyzed data trend suggests that the user's state is safely within a "cone of possibilities," backfill data need not be transmitted from analyte sensor system **104** to one or more of display devices **120**. In still other embodiments, an initial data transmission (or an advertising beacon, e.g., advertising beacons **700** of FIG. **7**) can include information indicating to one or more display devices, e.g., display device **120***c*, what type of data will be forthcoming in a subsequent transmission. In this way, a user can refuse or deny backfill data if it is not needed, or display device **120***c* may be able to determine on its own that such data need not be received.

[0151] A scenario in which this may arise is when the user may have forgotten one or more of his/her display devices **120**, and thus, an extended period of time goes by in which analyte sensor system **104** does not connect to any of the display devices **120**. Upon the user, e.g., returning to his/her home, and at least one of display devices **120** responding to an advertising beacon, e.g., display device **120***c* responding to advertising beacons **700** (also illustrated as authentication/channel establishment/data connection establishment **414** of FIG. **4**), the user can decide whether or not to receive backfill sensor information. That is, if the user is sufficiently certain that he/she is not approaching or in potentially adverse condition, he/she can refuse the backfill sensor information. Alternatively, display device **120***c* may receive an initial EGV that suggests that the user is in a stable condition, in which case, display device **120***c* may determine (according to a predictive algorithm) that backfill sensor information is not needed.

[0152] In accordance with some embodiments, alternative or additional communication protocols/methods can be leveraged to reduce battery consumption, e.g., NFC. For example, a connected display device, e.g., display device **120***b*, may only receive communications from the analyte sensor system **104** that triggers a notification to be presented to the user or an indicator to light and/or emit sound instructing the user to swipe or touch display device **120***b* or another display device, e.g., **120***c*, to the analyte system sensor **104** in order to receive data transmission via NFC, rather than consuming battery power with conventional wireless communication of the data. Moreover, out-of-band NFC pairing of a display device, e.g., display device **120***c*, to the analyte sensor system **104** can be used, where a user need only tap display device **120***c* to the analyte sensor system **104** to connect to and initiate data transmission from analyte sensor system **104**. This negates the need to wait for advertising beacons (described previously) and the need to send a command request (illustrated as **412** in FIG. **4**. and **614** in FIG. **6**, respectively). The whitelist as well, may be populated and/or updated in a similar manner to achieve "user-selective" pairing, where the exchange of keys and bonding information, as well as the passing of authentication/authorization information can also occur via NFC. It should be noted that sensor electronics module **106** (described above) can be configured to include an NFC transceiver in addition to the radio **508**.

[0153] As with intelligent advertising, intelligent communication can also utilize alternative networking techniques, e.g., mesh, peer-to-peer, or cloud networking. Similar to allowing a display device, such as display device **120***c*, to advertise to additional display devices, such as display device **120***b*, display device **120***c* can also be utilized to connect to and transmit EGV data to display device **120***b*, thereby limiting the amount of connections to/transmissions from the analyte sensor system **104**. The transmitting display device, in this case display device **120***c*, can be used to perform the necessary setup/handshaking between the additional display devices, in this case display device **120***b*, e.g., exchange of encryption keys, determining display device type, etc.

[0154] FIG. **9** illustrates an example continuous analyte monitoring system **900** (which may be an embodiment of the continuous analyte monitoring system **100** of FIG. **1**) and a plurality of alternative networking options contemplated in accordance with various embodiments. In accordance with one embodiment described above, display device **120***c* and be used to advertise (transmit advertising beacons) to additional display devices, in this example, display device **120***b*. Crosslink signals **116***a* and *b* can be used to effectuate the aforementioned encryption key exchange, setup/handshaking, display device type determination, etc.

[0155] In some embodiments, such alternative networking techniques may be used to backfill data on one or more display devices. For example, and referring again to FIG. **9**, a primary display device, such as display device **120***a*, may have up-to-date and complete EGV data, where display device **120***a* can then be used to transmit backfill data to one or more secondary display devices if needed, rather than relying on the analyte sensor system **104** to transmit backfill data, again, reducing battery power consumption on the analyte sensor system **104**. FIG. **9** illustrates that display device **120***a* may obtain EGV data and/or engage in wireless communications with analyte sensor system **104** using uplink signals **114** and downlink signals **112**. In the case of cloud networking, secondary display devices, such as display device **120***d*, may receive requisite data that has been uploaded to the cloud network (network **930** which can include a remote server **932** and/or associated database **934**) via the primary display device, display device **120***a* again reducing the strain on the analyte sensor system **104**. In some embodiments, the entity providing analyte sensor system **104** may maintain server **932** and database **934**. Further still, the analyte system sensor **104** and/or display device **120***a*, for example, can be made aware of secondary display devices that may require data, in which case, analyte sensor system **104** may then engage in selective data transmission rather than broadcast transmission. This may be the case with display device **120***e*, for example.

[0156] It should be noted that a plurality of methods and/or techniques may be used to effectuate the embodiments disclosed in the present disclosure. That is, the above-described communication conditions and adjustment of communication variables can be rules or instructions (e.g., in the form of a matrix or matrices) used by one or more algorithms that can control operation of the analyte sensor system **104**, in particular, CGM processor **506** and/or the transceiver, e.g., radio **508**, NFC transceiver, etc. Moreover, the analyte sensor system **104** can learn from itself and "create" such rules. It should also be noted that various combinations of the above-mentioned embodiments/operational scenarios can be combined in different ways to achieve one or more desired operational characteristics in a continuous analyte measurement system. Although various embodiments have been described in the context of continuous analyte measurement, e.g., continuous glucose monitoring, the various embodiments can be adapted for use in other context as well, e.g., for monitoring vital signals.

[0157] As used herein, the term module might describe a given unit of functionality that can be performed in accordance with one or more embodiments of the present application. As used herein, a module might be implemented utilizing any form of hardware, software, or a combination thereof. For example, one or more processors, controllers, ASICs, PLAs, PALs, CPLDs, FPGAs, logical components, software routines or other mechanisms might be implemented to make up a module. The modules, circuitry, processors, etc. may be affixed to a printed circuit board (PCB), or the like, and may take a variety of forms. In implementation, the various modules described herein might be implemented as discrete modules or the functions and features described can be shared in part or in total among one or more modules. In other words, as would be apparent to one of ordinary skill in the art after reading this description, the various features and functionality described herein may be implemented in any given application and can be implemented in one or more separate or shared modules in various combinations and permutations. Even though various features or elements of functionality may be individually described or claimed as separate modules, one of ordinary skill in the art will understand that these features and functionality can be shared among one or more common software and hardware elements, and such description shall not require or imply that separate hardware or software components are used to implement such features or functionality.

[0158] Where components or modules of the application are implemented in whole or in part using software, in one embodiment, these software elements can be implemented to operate with a computing or processing module capable of carrying out the functionality described with respect thereto. One such example computing module is shown in FIG. **10** which may be used to implement various features of the system and methods disclosed herein. Various embodiments are described in terms of this example computing module **1000**. After reading this description, it will become apparent to a person skilled in the relevant art how to implement the application using other computing modules or architectures.

[0159] Referring now to FIG. **10**, computing module **1000** may represent, for example, computing or processing capabilities found within a self-adjusting display, desktop, laptop, notebook, and tablet computers; hand-held computing devices (tablets, PDA's, smart phones, cell phones, palmtops, etc.); workstations or other devices with displays; servers; or any other type of special-purpose or general-purpose computing devices as may be desirable or appropriate for a given application or environment. For example, computing module **1000** may be one embodiment of one of display devices **120**, sensor electronics module **106**, etc. Computing module **1000** might also represent computing capabilities embedded within or otherwise available to a given device. For example, a computing module might be found in other electronic devices such as, for example, portable computing devices, and other electronic devices that might include some form of processing capability.

[0160] Computing module **1000** might include, for example, one or more processors, controllers, control modules, or other processing devices, such as a processor **1004**. Processor **1004** might be implemented using a general-purpose or special-purpose processing engine such as, for example, a microprocessor, controller, or other control logic. In the illustrated example, processor **1004** is connected to a bus **1002**, although any communication medium can be used to facilitate interaction with other components of computing module **1000** or to communicate externally.

[0161] Computing module **1000** might also include one or more memory modules, simply referred to herein as main memory **1008**. For example, preferably random access

memory (RAM) or other dynamic memory might be used for storing information and instructions to be executed by processor **1004**. Main memory **1008** might also be used for storing temporary variables or other intermediate information during execution of instructions to be executed by processor **1004**. Computing module **1000** might likewise include a read only memory ("ROM") or other static storage device coupled to bus **1002** for storing static information and instructions for processor **1004**.

[0162] The computing module **1000** might also include one or more various forms of information storage mechanism **1010**, which might include, for example, a media drive **1012** and a storage unit interface **1020**. The media drive **1012** might include a drive or other mechanism to support fixed or removable storage media **1014**. For example, a hard disk drive, a solid state drive, a magnetic tape drive, an optical disk drive, a compact disc (CD) or digital video disc (DVD) drive (R or RW), or other removable or fixed media drive might be provided. Accordingly, storage media **1014** might include, for example, a hard disk, an integrated circuit assembly, magnetic tape, cartridge, optical disk, a CD or DVD, or other fixed or removable medium that is read by, written to or accessed by media drive **1012**. As these examples illustrate, the storage media **1014** can include a computer usable storage medium having stored therein computer software or data.

[0163] In alternative embodiments, information storage mechanism **1010** might include other similar instrumentalities for allowing computer programs or other instructions or data to be loaded into computing module **1000**. Such instrumentalities might include, for example, a fixed or removable storage unit **1022** and an interface **1020**. Examples of such storage units **1022** and interfaces **1020** can include a program cartridge and cartridge interface, a removable memory (for example, a flash memory or other removable memory module) and memory slot, a PCMCIA slot and card, and other fixed or removable storage units **1022** and interfaces **1020** that allow software and data to be transferred from the storage unit **1022** to computing module **1000**.

[0164] Computing module **1000** might also include a communications interface **1024**. Communications interface **1024** might be used to allow software and data to be transferred between computing module **1000** and external devices. Examples of communications interface **1024** might include a modem or softmodem, a network interface (such as an Ethernet, network interface card, WiMedia, IEEE 802.XX or other interface), a communications port (such as for example, a USB port, IR port, RS232 port Bluetooth® interface, Bluetooth Low Energy, or other port), or other communications interface. Software and data transferred via communications interface **1024** might typically be carried on signals, which can be electronic, electromagnetic (which includes optical) or other signals capable of being exchanged by a given communications interface **1024**. These signals might be provided to communications interface **1024** via a channel **1028**. This channel **1028** might carry signals and might be implemented using a wired or wireless communication medium. Some examples of a channel might include a phone line, a cellular link, an RF link, an optical link, a network interface, a local or wide area network, and other wired or wireless communications channels.

[0165] In this document, the terms "computer program medium" and "computer usable medium" are used to generally refer to transitory or non-transitory media such as, for example, memory **1008**, storage unit **1020**, media **1014**, and channel **1028**. These and other various forms of computer program media or computer usable media may be involved in carrying one or more sequences of one or more instructions to a processing device for execution. Such instructions embodied on the medium, are generally referred to as "computer program code" or a "computer program product" (which may be grouped in the form of computer programs or other groupings). When executed, such instructions might enable the computing module **1000** to perform features or functions of the present application as discussed herein.

[0166] While the disclosure has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive. The disclosure is not limited to the disclosed embodiments. Variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed disclosure, from a study of the drawings, the disclosure and the appended claims.

[0167] All references cited herein are incorporated herein by reference in their entirety. To the extent publications and patents or patent applications incorporated by reference contradict the disclosure contained in the specification, the specification is intended to supersede and/or take precedence over any such contradictory material.

[0168] Unless otherwise defined, all terms (including technical and scientific terms) are to be given their ordinary and customary meaning to a person of ordinary skill in the art, and are not to be limited to a special or customized meaning unless expressly so defined herein. It should be noted that the use of particular terminology when describing certain features or aspects of the disclosure should not be taken to imply that the terminology is being re-defined herein to be restricted to include any specific characteristics of the features or aspects of the disclosure with which that terminology is associated. Terms and phrases used in this application, and variations thereof, especially in the appended claims, unless otherwise expressly stated, should be construed as open ended as opposed to limiting. As examples of the foregoing, the term 'including' should be read to mean 'including, without limitation,' 'including but not limited to,' or the like; the term 'comprising' as used herein is synonymous with 'including,' 'containing,' or 'characterized by,' and is inclusive or open-ended and does not exclude additional, unrecited elements or method steps; the term 'having' should be interpreted as 'having at least;' the term 'includes' should be interpreted as 'includes but is not limited to;' the term 'example' is used to provide exemplary instances of the item in discussion, not an exhaustive or limiting list thereof; adjectives such as 'known', 'normal', 'standard', and terms of similar meaning should not be construed as limiting the item described to a given time period or to an item available as of a given time, but instead should be read to encompass known, normal, or standard technologies that may be available or known now or at any time in the future; and use of terms like 'preferably,' 'preferred,' 'desired,' or 'desirable,' and words of similar meaning should not be understood as implying that certain features are critical, essential, or even important to the structure or function of the present disclosure, but instead as merely intended to highlight alternative or additional features that may or may not be utilized in a particular embodiment. Likewise, a group of items linked with the conjunction

'and' should not be read as requiring that each and every one of those items be present in the grouping, but rather should be read as 'and/or' unless expressly stated otherwise. Similarly, a group of items linked with the conjunction 'or' should not be read as requiring mutual exclusivity among that group, but rather should be read as 'and/or' unless expressly stated otherwise.

[0169] Where a range of values is provided, it is understood that the upper and lower limit, and each intervening value between the upper and lower limit of the range is encompassed within the embodiments.

[0170] With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity. The indefinite article "a" or "an" does not exclude a plurality. A single processor or other unit may fulfill the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. Any reference signs in the claims should not be construed as limiting the scope.

[0171] It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to embodiments containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should typically be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should typically be interpreted to mean at least the recited number (e.g., the bare recitation of "two recitations," without other modifiers, typically means at least two recitations, or two or more recitations). Furthermore, in those instances where a convention analogous to "at least one of A, B, and C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In those instances where a convention analogous to "at least one of A, B, or C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B."

[0172] All numbers expressing quantities of ingredients, reaction conditions, and so forth used in the specification are to be understood as being modified in all instances by the term 'about.' Accordingly, unless indicated to the contrary, the numerical parameters set forth herein are approximations that may vary depending upon the desired properties sought to be obtained. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of any claims in any application claiming priority to the present application, each numerical parameter should be construed in light of the number of significant digits and ordinary rounding approaches.

[0173] Furthermore, although the foregoing has been described in some detail by way of illustrations and examples for purposes of clarity and understanding, it is apparent to those skilled in the art that certain changes and modifications may be practiced. Therefore, the description and examples should not be construed as limiting the scope of the present disclosure to the specific embodiments and examples described herein, but rather to also cover all modification and alternatives coming with the true scope and spirit of the present disclosure.

[0174] Exemplary Methods and Apparatus

[0175] Method 1. A computer-implemented method, comprising: receiving sensor information; calculating and storing estimated analyte measurement values based upon the received sensor information; determining one or more communication conditions; instructing a transceiver to advertise to at least a first display device in accordance with one or more communication variables based upon the one or more communication conditions; and transmitting the estimated analyte measurement values to the at least first display device.

[0176] Method 2. The computer-implemented method of Method 1, wherein the sensor information is received from a continuous glucose monitoring sensor.

[0177] Method 3. The computer-implemented method of Method 1 or 2, wherein the analyte measurement values comprise estimated glucose values.

[0178] Method 4. The computer-implemented method of Method 1 or 2, wherein determining the one or more communication conditions comprises determining at least one of the following: a time associated with the communication conditions; historical communication conditions; an existence of an alarm condition; a condition of the continuous glucose monitoring sensor; a condition of a user of the continuous glucose monitoring sensor; and whitelist conditions.

[0179] Method 5. The computer-implemented method of Method 4, wherein the first display device is determined to be proximate to the continuous glucose monitoring sensor based upon the time at which the estimated analyte measurement values are to be transmitted.

[0180] Method 6. The computer-implemented method of Method 5, wherein the one or more communication variables comprise at least one of an advertising duration parameter and an advertising interval parameter according to which advertising beacons are transmitted to the first display

device, and wherein the at least one of the advertising duration and advertising interval parameters are adjusted to the first display device.

[0181] Method 7. The computer-implemented method of Method 4, wherein the first display device comprises one of a last-connected display device populating the whitelist, a preferred display device populating the whitelist, and a display device configured to advertise to at least a second display device.

[0182] Method 8. The computer-implemented method of Method 4, wherein the alarm condition comprises a determination that the condition of the user is approaching or experiencing a medically critical state.

[0183] Method 9. The computer-implemented method of Method 8, wherein the one or more communication variables are optimized for establishing a wireless communication session with the first display device.

[0184] Method 10. The computer-implemented method of Method 9, wherein the optimization of the one or more communication variables comprise at least one of increasing a default advertising duration parameter and decreasing a default advertising interval parameter.

[0185] Method 11. The computer-implemented method of Method 1 or 2, wherein determining the one or more communication conditions comprises analyzing the estimated analyte measurement values.

[0186] Method 12. The computer-implemented method of Method 11, wherein the one or more communication variables are optimized for establishing a wireless communication session with the first display device upon a determination that the estimated analyte measurement values are indicative of a trend towards a medically critical state.

[0187] Method 13. The computer-implemented method of Method 11, wherein the one or more communication variables are adjusted for delaying establishment of a wireless communication session with the first display device upon a determination that the estimated analyte measurement values are indicative of a trend towards a medically non-critical state.

[0188] Apparatus 14. An apparatus, comprising: signal conditioning circuitry communicatively connected to a continuous analyte sensor for receiving sensor information from the continuous analyte sensor indicative of analyte levels of a host to which the continuous analyte sensor is operatively attached; a processor, wherein upon receiving the sensor information from the signal conditioning circuitry, instructs a radio to perform the following: transmit a plurality of advertising beacons to a first display device in accordance with one or more communication variables based upon one or more communication conditions determined by the apparatus; and upon the first display device responding to one of the plurality of advertising beacons, establish a wireless communication session with the first display device and transmit the sensor information or analyte values derived from the sensor information to the at least first display device.

[0189] Apparatus 15. The apparatus of Apparatus 14, wherein the sensor information comprises raw sensor data indicative of glucose levels of the host, and wherein the analyte values derived from the sensor information comprises estimated glucose values of the host.

[0190] Apparatus 16. The apparatus of Apparatus 14 or 15, wherein the one or more communication variables comprise at least one of: a transmission frequency variable indicating a frequency with which the sensor information or the analyte values are transmitted to the first display device; a transmission protocol indicating a wireless communication protocol to be utilized in the transmission of the sensor information or the analyte values to the first display device; a communications type variable indicating a one-way communication or a two-way communication with the first display during the transmission of the sensor information or the analyte values to the first display device; and a transmission occurrence variable indicating whether the transmission of the sensor information or the analyte values to the first display device are to occur in an on-demand or automatic manner.

[0191] Apparatus 17. The apparatus of Apparatus 14 or 15, wherein the one or more communication variables comprise at least one of: a data packet format type variable to be utilized for the transmission of the plurality of advertising beacons; an advertising duration variable indicative of a duration for which the first display device is to be advertised to; an advertising interval variable indicative of an amount of time between the transmission of each of the plurality of advertising beacons; and a power variable indicative of power to be used by the radio for the transmission of the advertising beacons.

[0192] Apparatus 18. The apparatus of Apparatus 14 or 15, wherein the one or more communication variables comprise at least one of: a display device type variable indicating a type of at least one of the first display device and additional display devices to which the sensor information or analyte values are to be sent; a display device number indicating a number of display devices available to receive the sensor information or analyte values; an order variable indicating a connection order of display devices previously having established a wireless communication session with the radio; a role variable indicating whether at least one of the first display device and the additional display devices are at least one of a primary display device, a secondary display device, a preferred display device, a scan-only display device, an advertising display device, and a sensor information or analyte values forwarding display device; and a broadcast mode variable indicating one-way or two-way broadcasting to be used in conjunction with at least one of the first display device and the additional display devices if the at least one of the first display device and the additional display devices comprise an advertising display device or a sensor information or analyte values forwarding display device.

[0193] Method 19. A computer-implemented method, comprising: calculating and storing estimated glucose value data based upon glucose measurements obtained by a continuous glucose monitoring sensor; determining one or more communication conditions; and advertising to one or more display devices in a manner based on the one or more communication conditions.

[0194] Method 20. The computer-implemented method of Method 19, wherein the determination of the one or more communication conditions comprises analyzing historical estimated glucose value data.

[0195] Method 21. The computer-implemented method of Method 19 or 20, wherein the analysis of the historical estimated glucose value data results in an observed trend.

[0196] Method 22. The computer-implemented method of Method 21, wherein the determination of the one or more

communication conditions further comprises determining whether an alarm condition exists based on the observed trend.

[0197] Method 23. The computer-implemented method of Method 22, wherein the advertising to the one or more displays comprises incorporating the estimated glucose value data in advertising beacons upon a determination that no alarm condition exists.

[0198] Method 24. The computer-implemented method of Method 23, wherein the estimated glucose value data is incorporated in the advertising beacons in an encrypted format.

[0199] Method 25. The computer-implemented method of Method 24, wherein the advertising to the one or more displays comprises transmitting advertising beacons to the one or more display devices upon a determination that an alarm condition exists.

[0200] Method 26. The computer-implemented method of Method 25, wherein the advertising beacons are transmitted in accordance with at least one of an advertising duration and an advertising interval optimized for the one or more display devices.

[0201] Method 27. The computer-implemented method of Method 26, further comprising establishing wireless communication sessions during which the estimated glucose value data is transmitted to the one or more display devices upon the one or more display devices responding to their respective advertising beacons.

[0202] Method 28. The computer-implemented method of Method 27, further comprising encrypting the estimated glucose value prior to transmission to the one or more display devices.

[0203] Apparatus 29. An apparatus, comprising: a continuous analyte sensor adapted to obtain raw analyte data; a processor and a memory unit having computer code configured to cause the processor to: calculate and store analyte value data derived from the raw analyte data; determine one or more communication conditions; and a radio adapted to advertise to one or more display devices in a manner based on the one or more communication conditions.

[0204] Apparatus 30. The apparatus of Apparatus 29, wherein the computer code configured to cause the processor to determine the one or more communication conditions comprises computer code configured to further cause the processor to analyze historical analyte value data.

[0205] Apparatus 31. The apparatus of Apparatus 29 or 30, wherein the computer code configured to further cause the processor to analyze the historical analyte value data comprises computer code configured to further cause the processor to determine a trend.

[0206] Apparatus 32. The apparatus of Apparatus 31, wherein the computer code configured to cause the processor to determine the one or more communication conditions comprises computer code configured to further cause the processor to determine whether an alarm condition exists based on the trend.

[0207] Apparatus 33. The apparatus of Apparatus 32, wherein the computer code configured to cause the processor to advertise to the one or more displays comprises computer code configured to further cause the processor to incorporate the analyte value data in advertising beacons upon a determination that no alarm condition exists.

[0208] Apparatus 34. The apparatus of Apparatus 33, wherein the analyte value data is incorporated in the advertising beacons in an encrypted format.

[0209] Apparatus 35. The apparatus of Apparatus 34, wherein the computer code configured to cause the processor to advertise to the one or more displays comprises computer code configured to cause the processor to transmit advertising beacons to the one or more display devices upon a determination that an alarm condition exists.

[0210] Apparatus 36. The apparatus of Apparatus 35, wherein the computer code configured to further cause the processor to transmit advertising beacons comprises computer code configured to cause the processor to transmit the advertising beacons in accordance with at least one of an advertising duration and an advertising interval optimized for the one or more display devices.

[0211] Apparatus 37. The apparatus of Apparatus 36, wherein the radio establishes wireless communication sessions with of the one or more display devices during which the analyte value data is transmitted to the one or more display devices upon the one or more display devices responding to their respective advertising beacons.

[0212] Apparatus 38. The apparatus of Apparatus 37, wherein the computer code is configured to further cause the processor to encrypt the analyte value data prior to transmission to the one or more display devices.

[0213] Apparatus 39. An apparatus, comprising: a memory; and a processor, the memory having computer code configured to cause the processor to: receive estimated glucose value data; and based upon observed communication conditions and communication variables adapted based on the observed communication conditions, transmit the estimated glucose value data to one or more display devices.

[0214] Apparatus 40. The apparatus of Apparatus 39, wherein the apparatus comprises a primary or preferred display device, and wherein the estimated glucose value data is received from a sensor electronics module of a continuous glucose monitoring sensor system.

[0215] Apparatus 41. The apparatus of Apparatus 40, wherein the estimated glucose value data is transmitted to a remote database for storage via a network and forwarded to the one or more display devices by a server operatively connected to the database via the network, wherein the one or more display devices comprise secondary display devices.

[0216] Apparatus 42. The apparatus of Apparatus 40 or 41, wherein the apparatus and the one or more display devices are denoted as being the primary or preferred display device and secondary display devices, respectively, within a whitelist maintained by the continuous glucose monitoring sensor system.

[0217] Apparatus 43. The apparatus of Apparatus 39, wherein the apparatus comprises a first display device configured to act as an advertising display device, and wherein the apparatus transmits advertising beacons to the one or more display devices on behalf of a continuous glucose monitoring sensor system.

[0218] Apparatus 44. The apparatus of Apparatus 39, wherein the apparatus comprises a first display device configured to act as a forward display device, and wherein the apparatus transmits the estimated glucose value data to the one or more display devices on behalf of a continuous glucose monitoring sensor system.

[0219] Apparatus 45. The apparatus of Apparatus 39, further comprising a near field communications module adapted to cause a sensor electronics module of a continuous glucose monitoring sensor system from which the estimated glucose value data is received, to initiate advertising processes for establishing a wireless communication session over which the estimated glucose value data is transmitted with at least one of the apparatus and the one or more display devices.

[0220] Any of the features of the exemplary methods and apparatus are applicable to all aspects and embodiments identified herein, including other exemplary methods and apparatus. Moreover, any of the features of the exemplary methods and apparatus are independently combinable, partly or wholly with other aspects and embodiments identified herein or other exemplary methods and apparatus described herein in any way, e.g., one, two, or three or more aspects, embodiments, exemplary methods and/or apparatus may be combinable in whole or in part. Further, any of the features of the exemplary methods and apparatus may be made optional to other aspects or embodiments. Any aspect or embodiment of a method may be performed by a system or apparatus of another aspect or embodiment, and any aspect or embodiment of a system or apparatus may be configured to perform a method of another aspect or embodiment.

What is claimed is:

1. A computer-implemented method, comprising:

receiving sensor information;

calculating and storing estimated analyte measurement values based upon the received sensor information;

determining one or more communication conditions;

instructing a transceiver to advertise to at least a first display device in accordance with one or more communication variables based upon the one or more communication conditions; and

transmitting the estimated analyte measurement values to the at least first display device.

2. The computer-implemented method of claim **1**, wherein the sensor information is received from a continuous glucose monitoring sensor.

3. The computer-implemented method of claim **1**, wherein the analyte measurement values comprise estimated glucose values.

4. The computer-implemented method of claim **1**, wherein determining the one or more communication conditions comprises determining at least one of the following:

a time associated with the communication conditions;

historical communication conditions;

an existence of an alarm condition;

a condition of the continuous glucose monitoring sensor;

a condition of a user of the continuous glucose monitoring sensor; and

whitelist conditions.

5. The computer-implemented method of claim **4**, wherein the first display device is determined to be proximate to the continuous glucose monitoring sensor based upon the time at which the estimated analyte measurement values are to be transmitted.

6. The computer-implemented method of claim **5**, wherein the one or more communication variables comprise at least one of an advertising duration parameter and an advertising interval parameter according to which advertising beacons are transmitted to the first display device, and wherein the at least one of the advertising duration and advertising interval parameters are adjusted to the first display device.

7. The computer-implemented method of claim **4**, wherein the first display device comprises one of a last-connected display device populating the whitelist, a preferred display device populating the whitelist, and a display device configured to advertise to at least a second display device.

8. The computer-implemented method of claim **4**, wherein the alarm condition comprises a determination that the condition of the user is approaching or experiencing a medically critical state.

9. The computer-implemented method of claim **8**, wherein the one or more communication variables are optimized for establishing a wireless communication session with the first display device.

10. The computer-implemented method of claim **9**, wherein the optimization of the one or more communication variables comprise at least one of increasing a default advertising duration parameter and decreasing a default advertising interval parameter.

11. The computer-implemented method of claim **1**, wherein determining the one or more communication conditions comprises analyzing the estimated analyte measurement values.

12. The computer-implemented method of claim **11**, wherein the one or more communication variables are optimized for establishing a wireless communication session with the first display device upon a determination that the estimated analyte measurement values are indicative of a trend towards a medically critical state.

13. The computer-implemented method of claim **11**, wherein the one or more communication variables are adjusted for delaying establishment of a wireless communication session with the first display device upon a determination that the estimated analyte measurement values are indicative of a trend towards a medically non-critical state.

14. An apparatus, comprising:

signal conditioning circuitry communicatively connected to a continuous analyte sensor for receiving sensor information from the continuous analyte sensor indicative of analyte levels of a host to which the continuous analyte sensor is operatively attached;

a processor, wherein upon receiving the sensor information from the signal conditioning circuitry, instructs a radio to perform the following:

transmit a plurality of advertising beacons to a first display device in accordance with one or more communication variables based upon one or more communication conditions determined by the apparatus; and

upon the first display device responding to one of the plurality of advertising beacons, establish a wireless communication session with the first display device and transmit the sensor information or analyte values derived from the sensor information to the at least first display device.

15. The apparatus of claim **14**, wherein the sensor information comprises raw sensor data indicative of glucose levels of the host, and wherein the analyte values derived from the sensor information comprises estimated glucose values of the host.

16. The apparatus of claim 15, wherein the one or more communication variables comprise at least one of:

a transmission frequency variable indicating a frequency with which the sensor information or the analyte values are transmitted to the first display device;

a transmission protocol indicating a wireless communication protocol to be utilized in the transmission of the sensor information or the analyte values to the first display device;

a communications type variable indicating a one-way communication or a two-way communication with the first display during the transmission of the sensor information or the analyte values to the first display device; and

a transmission occurrence variable indicating whether the transmission of the sensor information or the analyte values to the first display device are to occur in an on-demand or automatic manner.

17. The apparatus of claim 15, wherein the one or more communication variables comprise at least one of:

a data packet format type variable to be utilized for the transmission of the plurality of advertising beacons;

an advertising duration variable indicative of a duration for which the first display device is to be advertised to;

an advertising interval variable indicative of an amount of time between the transmission of each of the plurality of advertising beacons; and

a power variable indicative of power to be used by the radio for the transmission of the advertising beacons.

18. The apparatus of claim 15, wherein the one or more communication variables comprise at least one of:

a display device type variable indicating a type of at least one of the first display device and additional display devices to which the sensor information or analyte values are to be sent;

a display device number indicating a number of display devices available to receive the sensor information or analyte values;

an order variable indicating a connection order of display devices previously having established a wireless communication session with the radio;

a role variable indicating whether at least one of the first display device and the additional display devices are at least one of a primary display device, a secondary display device, a preferred display device, a scan-only display device, an advertising display device, and a sensor information or analyte values forwarding display device; and

a broadcast mode variable indicating one-way or two-way broadcasting to be used in conjunction with at least one of the first display device and the additional display devices if the at least one of the first display device and the additional display devices comprise an advertising display device or a sensor information or analyte values forwarding display device.

19. A computer-implemented method, comprising:

calculating and storing estimated glucose value data based upon glucose measurements obtained by a continuous glucose monitoring sensor;

determining one or more communication conditions; and

advertising to one or more display devices in a manner based on the one or more communication conditions.

20. The computer-implemented method of claim 19, wherein the determination of the one or more communication conditions comprises analyzing historical estimated glucose value data.

21. The computer-implemented method of claim 19, wherein the analysis of the historical estimated glucose value data results in an observed trend.

22. The computer-implemented method of claim 21, wherein the determination of the one or more communication conditions further comprises determining whether an alarm condition exists based on the observed trend.

23. The computer-implemented method of claim 22, wherein the advertising to the one or more displays comprises incorporating the estimated glucose value data in advertising beacons upon a determination that no alarm condition exists.

24. The computer-implemented method of claim 23, wherein the estimated glucose value data is incorporated in the advertising beacons in an encrypted format.

25. The computer-implemented method of claim 24, wherein the advertising to the one or more displays comprises transmitting advertising beacons to the one or more display devices upon a determination that an alarm condition exists.

26. The computer-implemented method of claim 25, wherein the advertising beacons are transmitted in accordance with at least one of an advertising duration and an advertising interval optimized for the one or more display devices.

27. The computer-implemented method of claim 26, further comprising establishing wireless communication sessions during which the estimated glucose value data is transmitted to the one or more display devices upon the one or more display devices responding to their respective advertising beacons.

28. The computer-implemented method of claim 27, further comprising encrypting the estimated glucose value prior to transmission to the one or more display devices.

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