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DIABETES MANAGEMENT SYSTEM

Abstract

A variety of location-based and/or proximity-based features related to diabetes management systems can be used to improve maintenance compliance and/or to provide important information to PWD designated assistance entities (e.g., family, friends, givers, HCPs, emergency medicine providers) under certain conditions. In some cases, a user's location can be tracked or determined to trigger and/or time alerts about upcoming maintenance tasks in a way that will increase the likelihood that the PWD will immediately perform the designated maintenance task. In some cases, methods, devices, and systems provided herein can use proximity to non-paired mobile computing devices to deliver data to PWD designated assistance entities.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation of U.S. application Ser. No. 17/450,865, filed Oct. 14, 2021, which is a continuation of U.S. application Ser. No. 16/947,227(now U.S. Pat. No. 11,147,915), filed Jul. 23, 2020, which is a continuation of U.S. application Ser. No. 16/290,096 (now U.S. Pat. No. 10,758,670), filed Mar. 1, 2019, which is a continuation of U.S. application Ser. No. 15/408,047 (now U.S. Pat. No. 10,293,101), filed Jan. 17, 2017, which claims the benefit of U.S. Provisional Application Ser. No. 62/278,977, filed Jan. 14, 2016, and entitled "Location-Based Maintenance Reminders for Diabetes Management System," the entire contents of each of which applications are hereby incorporated by reference.

TECHNICAL FIELD
[0002] This document relates to using location and proximity to provide improved features as part of a diabetes management system.
BACKGROUND
[0003] Diabetes mellitus is a chronic metabolic disorder caused by an inability of a person's pancreas to produce sufficient amounts of the hormone, insulin, such that the person's metabolism is unable to provide for the proper absorption of sugar and starch. This failure leads to hyperglycemia, i.e. the presence of an excessive amount of analyte within the blood plasma. Persistent hyperglycemia has been associated with a variety of serious symptoms and life threatening long-term complications such as dehydration, ketoacidosis, diabetic coma, cardiovascular diseases, chronic renal failure, retinal damage and nerve damages with the risk of amputation of extremities. Because healing is not yet possible, a permanent therapy is necessary that provides constant glycemic control in order to constantly maintain the level of blood analyte within normal limits. Such glycemic control is achieved by regularly supplying external drugs to the body of the patient to thereby reduce the elevated levels of blood glucose.
[0004] Historically, diabetes is treated with multiple, daily injections of rapid and long acting insulin via a hypodermic syringe. One or two injections per day of a long acting insulin is administered to provide a basal level of insulin and additional injections of a rapidly acting insulin is administered before or with each meal in an amount proportional to the size of the meal. Insulin therapy can also be administered using an insulin pump that provides periodic or continuous release of the rapidly acting insulin to provide for a basal level of insulin and larger doses of that same insulin at the time of meals. Insulin pumps allow for the delivery of insulin in a manner that bears

greater similarity to the naturally occurring physiological processes and can be controlled to follow standard or individually modified protocols to give the patient better glycemic control. In some circumstances, an insulin pump device can store (via input from a clinician or a user) a number of settings (e.g., dosage parameters or other settings) that are customized by the physician for the particular user.

[0005] People with diabetes (PWDs), their caregivers, and their health care providers (HCPs) bear a great deal of cognitive burden in managing diabetes. Delivering the correct amount of the medicine at the correct time is an extremely challenging endeavor, and an error that result in various conditions that can leave the PWD non-responsive. With the advent of the Nightscout Project (www.nightscout.info) and various commercial remote data monitoring solutions, PWDs have been able to share blood glucose data with caregivers, family, friends, etc., but these remote monitoring solutions each require the PWD to retain an operational smartphone that has internet connectivity and that is in close proximity to their CGM. Accordingly, there is a need for devices and systems that can alert caregivers and HCPs to potentially life-threatening situations even when the PWD's smartphone fails or lacks internet access.

[0006] Additionally, the use of an insulin pump and/or a CGM can require various routine and non-routine maintenance activities, which can interrupt the flow of daily life. Routine maintenance of a continuous glucose monitor can include calibrations and changing the sensor. If the PWD has an insulin pump, the PWD or their caregiver(s) must be ready to change our refill the insulin cartridge, recharge or replace the power source, change the infusion set, change the infusion site, etc. Constant alarms, alerts, and reminders for different conditions and maintenance tasks, however, can result in alarm fatigue, which can result in PWDs and the caregivers ignoring alarms to switching to less informative systems or forgetting to conduct routine maintenance tasks. Accordingly, there is a need to time alarms, alerts, and reminders to improve compliance with routine maintenance and reduce alarm fatigue.

SUMMARY

[0007] This document describes a variety of location-based and/or proximity-based features related to diabetes management systems. In some cases, a user's location can be tracked or determined to trigger and/or time alerts about upcoming maintenance tasks in a way that will increase the likelihood that the PWD will immediately perform the designated maintenance task. In some cases, a user's location can be determined and distributed to PWD designated assistance entities (e.g., family, friends, givers, HCPs, emergency medicine providers) under certain conditions, such a the detection of a potentially life-threatening situation. In some cases, methods, devices, and systems provided herein can use proximity to non-paired mobile computing devices to deliver data to PWD designated assistance entities, especially in cases where a paired mobile controlling device (e.g., the PWD's smartphone) is unavailable or fails or lacks an internet connection.

[0008] In a first set of implementations, methods, devices, and systems provided herein can improve user compliance with recommended maintenance activities by detecting locations where the user conducts maintenance activities and/or locations where the user is typically located for long periods of time, and determining when to provide a maintenance activity reminder based on the location of the user. In some of these implementations, methods, devices, and systems provided herein can ensure user privacy by encrypting location information and/or only storing location information on a mobile computing device.

[0009] According to example embodiment 1, a diabetes management system includes a mobile controller device and at least one of a continuous glucose monitor (CGM) or an insulin delivery device. In some cases example embodiment 1 can include both a CGM and an insulin delivery device. In some cases example embodiment 1 can have an insulin delivery device that determines a dosage of insulin based at least in part on glucose data from the CGM. The mobile controller device of example embodiment 1 can be adapted to (a) to receive blood glucose levels for a user from the continuous glucose monitor and/or (b) receive insulin delivery data from the insulin

delivery device. The mobile controller device of example embodiment 1 is adapted to to output maintenance reminders to the user based, at least in part, on location information. The mobile controller device of example embodiment 1 includes a location subsystem, a maintenance model, and a maintenance subsystem. The location subsystem of example embodiment 1 detects a location of the mobile controller device, the continuous glucose monitor, the insulin delivery device, or a combination thereof. The maintenance model of example embodiment 1 models the user's behavior with regard to maintenance reminders based, at least, on locations and context for the diabetes management system when the maintenance reminders are presented to the user. The maintenance subsystem of example embodiment 1 (i) continually updates the maintenance model by (a) detecting or receiving indications that the user has conducted maintenance tasks on the diabetes management system and (b) updating the maintenance model based on the conducted maintenance tasks, and (ii) continually provides maintenance reminders at optimal times for upcoming maintenance tasks by (a) obtaining a current location from the location subsystem, (b) determining a current context for the diabetes management system, and (c) identifying the optimal times and providing upcoming maintenance reminders for the upcoming maintenance tasks at the optimal times based on evaluation of the current context and the current location using the maintenance model.

[0010] According to example embodiment 2, a diabetes management system having the same features of example embodiment 1 can have the upcoming maintenance task be selected from the group consisting of recharging a continuous glucose monitor or an insulin delivery device, changing the sensor of a continuous glucose monitor, changing the infusion set of an insulin delivery device, changing the infusion location of an insulin delivery device, changing a sensor location for a continuous glucose monitor, refilling insulin into an insulin delivery device, changing an insulin containing cartridge in an insulin delivery device, replacing a battery in an insulin delivery device, or a combination thereof.

[0011] According to example embodiment 3, the diabetes management system of one of example embodiments 1 or 2 can include a mobile computing device adapted to connect to a Wi-Fi system and a location subsystem that detects the location of the mobile computing device based on available Wi-Fi systems at the location.

[0012] According to example embodiment 4, the diabetes management system of one of example embodiments 1 or 2 can include a mobile computing device that detects the location of the mobile computing device using a global positioning system (GPS).

[0013] According to example embodiment 5, the diabetes management system of one of example embodiments 1-4 can be configured such that the maintenance subsystem receives maintenance information from one or more of the insulin delivery device and the continuous glucose monitor about the conducted maintenance tasks and, in response to receiving the maintenance information, obtains (i) locations of the mobile controller device where the conducted maintenance tasks were performed and (ii) contexts of the diabetes management system when the conducted maintenance tasks were performed. The maintenance model of example embodiment 5 is updated based on combinations of (i) the conducted maintenance tasks, (ii) the locations where the conducted maintenance tasks were performed, and (iii) the contexts when the conducted maintenance tasks were performed.

[0014] According to example embodiment 6, the diabetes management system of example embodiment 5 can have the contexts of each of the conducted maintenance tasks were performed include, at least, a time of day when each of the conducted maintenance tasks were performed.

[0015] According to example embodiment 7, the diabetes management system of example embodiment 6 can have the contexts when each of the conducted maintenance tasks were performed further include, at least, a day of the week when each of the conducted maintenance tasks were performed.

[0016] According to example embodiment 8, the diabetes management system of one of example

embodiments 1-7 can be configured such that for a particular upcoming maintenance task, the maintenance subsystem begins monitoring for an optimal time to provide a particular maintenance reminder for the particular upcoming maintenance task upon a determination that the particular upcoming maintenance task is due within a threshold first period of time, The monitoring in example embodiment 8 includes repeatedly obtaining the current location, determining the current context, and identifying the optimal time to provide the particular maintenance reminder. The monitoring for the particular upcoming maintenance task in example embodiment 8 is not performed before the particular upcoming maintenance task is due within the threshold first period of time.

[0017] According to example embodiment 9, the diabetes management system of example embodiment 8 can have the maintenance subsystem automatically provide the particular maintenance reminder regardless of the current location and the current context when the particular maintenance task is due within a threshold second period of time that is less than the first period of time.

[0018] According to example embodiment 10, the diabetes management system of one of example embodiments 1-9 can be configured such that the continual updating of the maintenance model includes the maintenance system (i) determining a particular location where the user conducts a majority of maintenance tasks, (ii) tracking the timing of a diurnal pattern of maintenance tasks at the particular location, and (iii) incorporating a diurnal period of time when the user is likely to conduct maintenance tasks representing the diurnal pattern of maintenance tasks into the maintenance model. Continually providing maintenance reminders in example embodiment 10 includes providing the maintenance reminders during the diurnal period of time prior to the scheduled time for the maintenance tasks when the user is at the particular location where the user conducts the majority of the maintenance tasks.

[0019] According to example embodiment 11, the diabetes management system of example embodiment 10 can be configured such that the maintenance reminders are held until the user arrives at the particular location where the user conducts the majority of maintenance tasks when the user is not at the particular location during the diurnal period of time when the user conducts most maintenance tasks.

[0020] According to example embodiment 12, the diabetes management system of example embodiment 11 can be configured such that the maintenance reminders are displayed at particular times when the maintenance tasks are scheduled regardless of whether the user is at the particular location where the user conducts a majority of maintenance tasks.

[0021] In a second set of implementations, methods, systems, and devices provided herein can allow peripheral devices related to diabetes management and insulin delivery, such as insulin pumps, other insulin delivery devices, sensors, monitoring systems, that have lost connectivity to a mobile controller device (e.g., the PWD's paired smartphone) to use other computing devices that are located nearby the peripheral device to communicate status information, alarms, and/or alerts to PWD designated assistance entities, either directly or via a remote computer system (e.g., cloud computer system). In some of these implementations, the computing devices can be authenticated as being used by a PWD designated assistance entity, which can permit a PWD designated assistance entity in close proximity (e.g., within BLUETOOTH range) to the peripheral device(s) to receive status information, alarms, and/or alerts for the PWD even without internet access. For example, such a feature can be helpful if the PWD and one or more PWD designated assistance entities travel to an area without internet access, and the paired mobile controlling device (e.g., the PWD's paired smartphone) becomes lost or disabled (e.g., out of battery). In some of these implementations, the computing device can be any computing device adapted to receive and relay messages in close proximity (e.g., within BLUETOOTH range) of the peripheral device(s) to a remote computer system (e.g., a cloud computer system), which can then send data (which can include location data) to one or more PWD designated assistance entities. For example, such a

feature can be helpful if the PWD is unresponsive to a detected life-threatening alarm condition and the paired mobile controlling device is not available (e.g., experiencing communication issues, lost or far away, out of power) or failing to connect to the internet.

[0022] According to example embodiment 13, a wearable insulin delivery device can include an insulin pump device, one or more sensor interfaces, a wireless interface, a data storage device, an input subsystem, an output subsystem, and a controller. The insulin pump device is configured to administer insulin dosages to a patient wearing the insulin delivery device. The one or more sensor interfaces are adapted to obtain, at least, blood glucose levels for the patient. The wireless interface is configured to wirelessly communicate with one or more other computing. The data storage device stores a uniform resource locator (URL) for a remote server system and a unique identifier for the patient. The input subsystem receives input from the patient. The output subsystem outputs information to the patient. The controller is configured (i) to control the insulin pump device delivering insulin to the patient based, at least in part, on the blood glucose levels received through the one or more sensor interfaces, (ii) to securely communicate with a paired mobile computing device that is authorized to communicate with the remote server system regarding the patient, (iii) to automatically output an alarm via the output subsystem in response to an alarm condition, and (iv) to transmit a wireless beacon signal using the wireless interface in response to the patient failing to provide a response via the input subsystem within a threshold period of time of the alert being output. The beacon signal (i) includes, at least, the URL encoded with the unique identifier for the patient and (ii) is configured to prompt a third party computing device passively monitoring for beacon signals to transmit a request to the remote server system using the encoded URL.

[0023] In some cases, a computer in the remote server system of example embodiment 13 can analyze contextual information regarding a PWD to determine if an alarm is likely to represent an actual alarm condition. In some cases, the contextual information can include recent location data of the paired mobile computing device, recent blood glucose data for the PWD, and/or recent insulin delivery data for the PWD. In some cases, the alarm condition is a hypoglycemic event detected by a CGM. In some case, prior to transmitting the wireless beacon signal, one or more peripheral device issues an audible alarm of at least 45 decibels for at least 10 minutes without any user acknowledgement, which can be received via mobile computing device and/or one or more peripheral devices.

[0024] According to example embodiment 14, the insulin delivery device of example embodiment 13 is configured such that the wireless interface includes a BLUETOOTH wireless interface and the beacon signal is transmitted as a BLUETOOTH low energy (BLE) beacon signal with the encoded URL in a payload of the BLE beacon signal.

[0025] According to example embodiment 15, the insulin delivery device of one example embodiments 13 or 14 is configured such that the unique identifier for the patient is encoded in either a path of the URL or as a parameter appended to the URL and receipt of the encoded URL prompts the remote server system (i) to automatically determine one or more possible locations where the patient is currently located and (ii) to contact one or more of emergency personnel and authorized patient contacts as to the one or more possible locations where the patient is currently located. In some cases, example embodiment 15 can determine the one or more possible locations based at least in part on one or more locations of a location of the third party computing device. In some cases, example embodiment 15 can determine the one or more possible locations based at least in part on a last known location of the paired mobile computing device.

[0026] According to example embodiment 16, the insulin delivery device of one example embodiments 13-15 is configured such that the data storage device further stores health status information for the patient related to management of the patient's diabetes and the URL is further encoded with the health status information for the patient.

[0027] According to example embodiment 17, the insulin delivery device of one example embodiments 13-16 is configured such that the data storage device further location information for

the patient communicated from the paired mobile computing device and the URL is further encoded with the location information for the patient.

[0028] According to example embodiment 18, a diabetes management system can include a paired mobile computing device, one or more other computing devices, an insulin delivery device, one or more sensors interfaces, a wireless interface, a data storage device, and a controller. The paired mobile computing device of example embodiment 18 is registered with a remote server system in association with a patient. The one or more other computing devices of example embodiment 18 are registered with the remote server system in association with one or more other patients. These one or more other computing devices are (i) preauthorized by the patient to receive and present health-related information for to the patient and (ii) to passively monitor for the health-related information transmitted over one or more local wireless protocols. The insulin delivery device of example embodiment 18 includes an insulin pump device to administer insulin dosages to the patient. The one or more sensor interfaces obtain, at least, blood glucose levels for the patient. The wireless interface of example embodiment 18 wirelessly communicates with the paired mobile computing device and the one or more other computing devices. The data storage device of example embodiment 18 stores (i) a unique identifier for the patient, (ii) authentication information to pair and securely communicate with the paired mobile computing device, and (iii) encryption information to securely broadcast the health-related information to the one or more other computing devices. The controller of example embodiment 18 is configured (i) to control the insulin pump device delivering insulin to the patient based, at least in part, on the blood glucose levels received through the one or more sensor interfaces, (ii) to securely communicate with the paired mobile computing device, and (iii) to broadcast secure wireless signals including the health-related information for detection and presentation by the one or more other computing devices in response to detecting no connectivity with the paired mobile computing device.

[0029] According to example embodiment 19, the diabetes management system of example embodiment 18 is configured such that the one or more other computing devices are each programmed (i) to request authentication from the patient before presenting the health-related information that has been transmitted by the insulin delivery device and detected by the one or more other computing devices, (ii) to receive input from the patient, (iii) to verify the input with the remote server system, and (iv) to output the health-related information in response to the input being verified with the remote server system.

[0030] According to example embodiment 20, the diabetes management system of one of example embodiments 18 or 19 is configured such that the wireless interface comprises a BLUETOOTH wireless interface and the broadcast secure wireless signals are transmitted as a BLUETOOTH low energy (BLE) beacon signal using one or more secure transmission protocols.

[0031] The details of one or more implementations of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the invention will be apparent from the description and drawings, and from the claims.

Description

DESCRIPTION OF DRAWINGS
[0032] FIG. **1**A is an exploded perspective view of an example diabetes management system.
[0033] FIG. **1**B depicts details about an exemplary insulin pump.
[0034] FIG. **1**C depicts details about an exemplary insulin pump controller.
[0035] FIG. **2** is an example home screen of a mobile computing application for a diabetes management system.
[0036] FIG. **3** is a user interface providing system status information.
[0037] FIGS. **4**A-B depict an example system for optimizing the delivery of maintenance

reminders through the use of maintenance location tracking and other contextual information.

[0038] FIG. **5** is an example of a maintenance reminder in a user interface.

[0039] FIGS. **6**A-**6**D illustrate example screens for system maintenance.

[0040] FIG. **7** depicts an example system and corresponding method for the insulin pump to transmit alerts back to the server system without its paired mobile device via nearby third party computing devices.

[0041] FIG. **8** is a conceptual diagram of an example system for local beacon signal transmissions.

[0042] FIG. **9** depicts an example system and corresponding method for providing alerts and status information on nearby mobile computing devices.

[0043] Like reference symbols in the various drawings may indicate like elements.

DETAILED DESCRIPTION

[0044] Diabetes management systems provided herein can provide a user experience that improves routine maintenance compliance while avoiding alarm fatigue for a person with diabetes (PWD) and their caregivers. Diabetes management systems provided herein can also be adapted to provide alarms to PWD designated assistance entities (e.g., caregivers, loved ones, HCPs, and/or emergency medicine providers) if the PWD's mobile computing/controlling device fails. In some cases, a diabetes management system provided herein can include one or more of a mobile computing device (e.g., a smartphone), an insulin pump, a continuous glucose monitor, a blood glucose monitor, an insulin pen or syringe, and/or other components. Methods, devices, and systems provided herein can record when the user conducts a maintenance activity and record a user location for that activity. In some cases, methods, devices, and systems provided herein can upload location data, possibly in combination blood glucose data, insulin data, or other physiologically relevant data, to a remote server for distribution to one or more caregivers, HCPs, loved ones, emergency service providers, or any combination thereof. In some cases, methods, devices, and systems provided herein can broadcast secure wireless signals including the health-related information for detection and presentation by the one or more non-paired computing devices in response to detecting no connectivity with the paired mobile computing device (e.g., the paired smartphone).

[0045] Diabetes management systems and methods provided herein may be used and performed, respectively, by a user, for example, a type 1 or 2 diabetes patient or a caregiver of a diabetes patient. In some cases, the systems and methods may be adapted for use with additional chronic diseases or conditions, for example, unresponsive infections, cancer, cancer-related pain, chronic pain, gastrointestinal diseases or disorders, congestive heart failure, hemophilia, immune deficiencies, multiple sclerosis, and rheumatoid arthritis.

Diabetes Management System Overview

[0046] FIGS. **1**A and **1**B provide examples of a diabetes management system (DMS) **10** including an insulin pump assembly **15**, a mobile computing device **60**, a continuous glucose monitor **50**, and a blood glucose monitor **70**. FIG. **1**C depicts the details of an exemplary pump controller, which can be used with DMS **10**. Pump assembly **15** includes an infusion set **147** adapted to deliver insulin to an infusion site **146**. In some cases, DMS **10** can include an insulin pen **80** or other insulin delivery device that can also be used to deliver insulin to a user. As shown, mobile computing device **60** is in wireless communication with insulin pump assembly **15**. As shown, insulin pump assembly **15** is in wireless communication with continuous glucose monitor **50** and data from continuous glucose monitor **50** can be transferred to the mobile computing device **60** via insulin pump assembly **15**. In some cases, continuous glucose monitor **50** can wirelessly communicate directly with mobile computing device **60**. As shown, insulin pump assembly **15** is in wireless communication with blood glucose monitor **70** and data from blood glucose monitor **70** can be transferred to the mobile computing device **60** via insulin pump assembly **15**. In some cases, blood glucose monitor **70** can wirelessly communicate directly with mobile computing device **60**. In some cases, blood glucose monitor **70** can be unconnected from the system **10** and a user can

manually input a blood glucose monitor reading into mobile computing device **60** (or into insulin pump assembly **15**), either with or without a user prompt. In some cases, a blood glucose monitor **70** can be in wireless communication with the continuous glucose monitor **50**.

[0047] As shown, controller **200** can include a limited user interface consisting of illuminable icons **201-206**, which can provide indications regarding an operating mode of the pump assembly **15** and/or types of alarm or alert messages. In some cases, a user can view a more detailed message relating to an illuminated icon on the mobile computing device **60** via app **300**. Controller **200** can additionally or alternatively issue audible notices (e.g., comprising audible words), audible tones, and/or haptic vibrations to indicate the presence of an alarm or alert. In some cases, alarm conditions can require more immediate user intervention, and can thus be presented with louder tones than alert conditions. In some cases, a button **208** can be present on controller **200** to permit user to check a status, using illuminable icons **201-206**, and/or to snooze an alarm or alert. Although pump assembly **15** is depicted with a limited user interface intended to be used with a smartphone **60** and app **300** as the primary user interface, some implementations of the methods, devices, and systems provided herein can include a primary user interface directly on a pump assembly **15**. In some cases, although depicted having a multi-part reusable/disposable construction, pump assemblies that are entirely disposable or entirely reusable and/or that have a unitary construction are also contemplated.

[0048] The features that are described herein can be extended to DMSs **10** that use alternative insulin delivery devices (e.g., insulin pens, patch pumps, syringes) and/or devices delivering other medicines (e.g., glucagon). In some cases, insulin pen **80** can be in wireless communication with mobile computing device **60**. In some cases, user interfaces provided herein can be adapted to allow a user to manually input a bolus delivered using insulin pen **80**. User interfaces described herein can also be used with any suitable insulin pump device, including patch pumps and/or other commercially available pumps. In some cases, an insulin pump assembly used in DSM **10** can have a unitary construction and have a reservoir adapted to be filled with insulin.

Exemplary Mobile Computing Device

[0049] Mobile computing device **60** can communicate with the controller device **200** through a wireless and/or wired connection with the controller device **200** (e.g., via a Bluetooth wireless communication connection in some implementations). In some cases, mobile computing device **60** communicates wirelessly with other elements of the system **10**. Mobile computing device **60** can be any of a variety of appropriate computing devices, such as a smartphone, a tablet computing device, a wearable computing device, a smartwatch, a fitness tracker, a laptop computer, a desktop computer, and/or other appropriate computing devices able to detect a location of the mobile computing device. Sometimes location can be determined by detecting an available wifi network and/or other types of wireless networks/signals (e.g., detecting wireless beacon signals, BLUETOOTH signals, near field communication (NFC) signals). In some cases, location can be detected by using a global positioning system. In some cases, mobile computing device **60** can be used to transfer data from controller device **200** to the cloud. In some cases, the mobile computing device can be adapted to not share location information on the cloud or encrypt it so that it cannot be correlated to a physical address or latitude and longitude location. In some cases, the mobile computing device **60** provides a user interface (e.g., graphical user interface (GUI), speech-based user interface, motion-controlled user interface) through which users can provide information regarding maintenance activities and/or review upcoming scheduled maintenance tasks. Although mobile computing device **60** is depicted in FIG. **1** as including the primary user interface, with a limited user interface available on controller **200**, in some cases methods, devices, and systems provided herein can have a primary user interface as part of pump assembly **15** and can operate with a mobile computing device **60** acting as a secondary user interface.

[0050] In implementations where the primary user interface is part of a mobile computing device, accessing the details of an alarm or an alert can require access to the paired mobile computing

device. In some implementations of methods, systems, and devices provided herein, however, certain third-party devices can be authorized to allow connection to one or more peripheral devices of a diabetes management system (e.g., pump assembly **15**, CGM **50**, etc.) such that these authorized third-party devices (e.g., devices possessed by PWD designated assistance entities) can receive data from the peripheral devices, but not control the peripheral devices, even in the absence of an connected connected/operational paired mobile computing device. In some cases, the mobile computing device can be a mobile controlling device adapted to provide commands to the insulin pump assembly **15** (e.g., command the insulin pump assembly **15** to deliver a bolus).

User Interface

[0051] FIG. **2** depicts an exemplary home screen **2000** for DMS **10**, which can appear on a mobile computing device **60** when a user selects an icon for the DMS application. Home screen **200** is a user interface that can provide the user with a simplified view of the DMS status to help the user quickly understand whether the DMS system is operating appropriately and promote routine maintenance activities. As shown, homescreen **2000** includes a header **2020**, which can include mobile and Wi-Fi signal strength indicators **2040***a,* a mobile computing device power display **2040***b,* a logo **2040***c,* a time display **2040***d,* and a user name **2040***f.*

[0052] Home screen **2000** includes a glucose measurement field **2060**, a bolus entry user actionable display **2080**, a history field **2100**, a CGM monitor field **2120**, an insulin pump field **2140**, a maintenance field **2160** adapted to indicate to a user if the user will be expected to conduct any maintenance tasks in the near future (e.g., in the next 24 hours) and/or whether the DMS has detected any need for immediate maintenance, and an additional activities field **2180**. Each of the fields **2060-2180** can include one or more selectable elements (e.g., buttons, arrows, selectable areas) that a user can select to view additional information and/or to provide input related to the field. Such selectable elements can be, for example, the entire field or a graphical subcomponent thereof.

[0053] The maintenance field **2160** can indicate, for example, when an infusion set is due for replacement, when an infusion site should be changed, when disposable parts of a pumping assembly need to be replaced and/or when an insulin reservoir needs to be refilled, when the continuous glucose monitor sensor needs to be changed or moved to a new location on the body, when a blood glucose measurement should be made to calibrate the continuous glucose monitor, or combinations thereof. In some cases, static indicators can indicate the approximate deadline for conducting routine maintenance, optionally with color indicators indicating the urgency of each maintenance task (e.g., red, yellow and green). In some cases, maintenance field **2160** can indicate that no maintenance tasks are required. In the cases that immediate maintenance is required (e.g., if the system is out of insulin), DMS **10** can provide an alarm (e.g., on the mobile computing device **60**, pump assembly **15**, or a combination thereof) to get the user to look at the user interface to learn about the required maintenance task, such as providing a push notification on the mobile computing device **60**. In the cases that a maintenance task is less urgent (e.g., planned to be due in the next 12 hours or less, or within 10 hours, or within 8 hours, or within 6 hours, or within 4 hours, or within 3 hours, or within 2 hours, or within 1 hour), a maintenance alert can be triggered to get the user (e.g., the PWD) to acknowledge that a maintenance tasks is due shortly, with the exact timing of such alerts being based on the particular task. In some cases, methods, devices, and systems provided herein can time maintenance task alerts based on the location of the user.

[0054] Maintenance field **2160** is configured to reassure a user that system maintenance tasks are up-to-date, thus again reducing the cognitive burden on the user. Because the maintenance field **2160** is available for view at all times in the home screen **2000** (i.e., the maintenance field **2160** is persistently displayed on the home screen **2000**), a user will not typically require frequent reminders about upcoming system maintenance.

[0055] Additionally, a user can view system status information, in a user interface, such as the example user interface **3000** shown in FIG. **3**. As with the example home screen **2000**, the user

interface **3000** is presented on the mobile computing device **600**. The example user interface **3000** depicts status information for components of the DMS **10** that are either directly or indirectly connected to the mobile computing device, such as the status information for the insulin pump assembly **15**, the continuous glucose monitor **50**, the blood glucose monitor **70**, the infusion set **146**, the external medication delivery devices **80**, and/or other components of the DMS **10**, including components that may be actively used and/or currently unused as part of the DMS **10**. In the depicted example, the user interface **3000** depicts a first set of fields **3020** that provide status information for an insulin pump (e.g., insulin pump assembly **15**) and a second set of fields **3040** for a CGM (e.g., CGM **50**). This information includes, for example, remaining battery life, a time period until the component needs maintenance (e.g., number of days until the component needs to be changed), a status of the direct or indirect communication connection with the component (e.g., quality of a wireless or wired connection with the component), an age of the component (e.g., length over which the component has been used), a remaining supply of medicine or other consumable materials used by the components (e.g., remaining amount of insulin), and/or other information. The user interface **3000** can be presented, for example, in response to selection of the maintenance field **2160** when no actionable maintenance is requested of the user, which is the example status of the maintenance field **2160** depicted in FIG. **2**.

Location Based Reminders

[0056] FIGS. **4**A-B depict an example system **400** for optimizing the delivery of maintenance reminders through the use of maintenance location tracking and other contextual information. For example, the example system **400** is depicted as performing an example method that includes tracking where a user conducts routine maintenance tasks, the location of the user during the maintenance tasks, and a time of day when the maintenance task is completed (example contextual information), and providing reminders about upcoming maintenance activities based on the time of day (example contextual information) and the location of the user.

[0057] Referring to FIG. **4**A, the example system **400** includes some or all of the components of the DMS **10**, such as the mobile device **60**, the insulin pump **15**, the CGM **50**, the BGM **70**, the infusion set **146**, and optionally the external medicine delivery device **80**. The system **400** further includes a server system **402** (e.g., cloud computing system, web server system, application server system, frontend server system, backend server system, combinations thereof) that is specifically programmed to communicate with the mobile device **60** to administer the delivery of medicine to the user. The server system **402** is also specifically programmed to, in some case, monitor for and provide maintenance reminders for presentation on the mobile device **60**. The server system **402** maintains a maintenance database **404** (e.g., cloud data storage system, secure data storage system, and/or combinations thereof) that log maintenance activities performed by the user along with corresponding location and contextual information (e.g., time of day, day of week, week of month, type of maintenance performed, component of the DMS **10** to which maintenance was performed, responsiveness to maintenance reminder, supply of materials when maintenance performed). The server system **402** also maintains maintenance models **406** (e.g., stored in cloud data storage system, secure data storage system, and/or combinations thereof) that model user behavior with regard maintenance activities.

[0058] The maintenance models **406** can be generated from the log of maintenance activities in the maintenance database **404** and can continually be refined as users perform maintenance activities and respond to maintenance reminders. Maintenance models **406** can be based any of a variety of user behavior data modeling techniques, such as artificial intelligence algorithms (e.g., neural networks, clustering algorithms, genetic algorithms, reinforcement learning, or combinations thereof) providing predictive assessments of future user behavior based on previous behavior and emerging user behavior patterns. Such maintenance models **406** can take a variety of details as inputs, such as the maintenance activity to be performed, the current time/day, the user's current location, the deadline to perform the maintenance activity, available supply of maintenance

materials (e.g., insulin supply, replacement sensors), and/or other inputs, and can output an indication of whether the current time or a future time is an optimal one for providing a maintenance reminder to the user.

[0059] Still referring to FIG. **4**A, the mobile device **60** includes a location subsystem **410** that determines a current location of the mobile device **60**, which can be assumed to be the location of the user of the mobile computing device. The location of the user can additionally and/or alternatively be inferred as the location of other components of the DMS **10** that are able to detect a location. The location subsystem **410** can include one or more location modules, such as a global positioning system (GPS) module able to determine location from GPS satellite signals, a Wi-Fi positioning system programmed to correlate Wi-Fi base stations to a geographic location of the device **60**, and/or other location positioning systems. The mobile computing device **60** further includes a maintenance subsystem **412** that is programmed to detect and log maintenance activities performed on the DMS **10**, and to determine and provide maintenance reminders at optimal times. The maintenance subsystem **412** may operate alone or in combination with the server system **402** to provide maintenance features, such as detecting maintenance activities, logging maintenance activities, generating and updating maintenance models, determining when and what type of maintenance reminder to provide, and delivering maintenance reminders to users. For example, in some cases the maintenance subsystem **412** performs such maintenance features alone and without the server system **402**. In other cases, the maintenance subsystem **412** identifies and provides maintenance data to the server system **402**, which performs the maintenance reminder processing and provides maintenance reminders to the maintenance subsystem **412** to output on the mobile device **60**. The mobile device **60** also includes a local maintenance database **414** (similar to the maintenance database **404**) and a local maintenance model **416** (similar to the maintenance model **406**) that the maintenance subsystem **412** can use to provide maintenance features.

[0060] Turning to the algorithm to provide maintenance reminders on the system **400**, FIG. **4**A depicts a sequence of steps A-F (**420-430**) for building a maintenance model for a user of the mobile device **60** and FIG. **4**B depicts a sequence of steps G-J (**432-444**) for using the maintenance model to deliver maintenance reminders to the user at an optimal time. Referring to FIG. **4**A, maintenance information for maintenance activities that are performed on the components of the DMS **10** is obtained by the mobile device **60**, as indicated by step A (**420**). This information can be obtained directly or indirectly from these components by the mobile device **60**, and can include information identifying, for example, recharging a continuous glucose monitor or an insulin delivery device, changing the sensor of a continuous glucose monitor, changing the infusion set of an insulin delivery device, changing the infusion location of an insulin delivery device, changing a sensor location for a continuous glucose monitor, refilling insulin into an insulin delivery device, changing an insulin containing cartridge in an insulin delivery device, replacing a battery in an insulin delivery device, or a combination thereof.

[0061] Once a maintenance activity has been identified, the mobile device **60** can determine the location of the user (step B, **422**) and other contextual information (step C, **424**) for the maintenance activity. The location can be determined, for example, using the location of the mobile device **60** as determined by the location subsystem **410**. For instance, in some cases the location is detected by detecting a Wi-Fi network available. In some cases, the location is detected using a global positioning system (GPS). The contextual information can include, for example, the current time and date, the day of the week, the week of the year, the type of maintenance activity that is being performed, an existing supply of maintenance materials (e.g., extra insulin, replacement sensors), and/or other relevant contextual information related to settings and/or conditions that prompted the user to perform the maintenance. The maintenance can be recorded with the location and contextual information (step D, **426**) and can be used to generate and/or update the maintenance model for the user (step E, **428**), such as being recorded in the maintenance database **414** and updating the model **416**. Additionally, the mobile device **60** can provide the maintenance

information to the server system **402** (step F, **430**), which can store the maintenance information in the database **404** and can use the maintenance information to generate/update the maintenance model **406** for the user. The maintenance model may be generated/updated by the mobile device **60**, the server system **402**, or combinations thereof. The server system **402** and the mobile device **60** may store redundant copies of the maintenance information and the maintenance model, and may sync data with each other when processing capacity and network bandwidth permit (e.g., during low bandwidth periods of time, like the middle of the night). The steps A-F (**420-430**) can be repeatedly and continually performed, and can be performed concurrently with the delivery of maintenance reminders via steps G-J (**432-444**).

[0062] Referring to FIG. **4**B, the mobile device **60** can determine that the user is within a first threshold period of time of a maintenance deadline, as indicated by step G (**432**). The first threshold period of time can be, for example, a period within which maintenance is warranted but within which there is little to no health risk to the user if the maintenance is not immediately performed. For example, the first threshold period of time can be one day before the maintenance needs to be performed. Other timeframes can additionally or alternatively be used for the first threshold period of time. The first threshold period of time can vary depending on the type of maintenance being performed, the maintenance model for the user, and/or other factors. The maintenance activities and corresponding deadlines that are being monitored for can include, for example, recharging a continuous glucose monitor or an insulin delivery device, changing the sensor of a continuous glucose monitor, changing the infusion set of an insulin delivery device, changing the infusion set or infusion site of an insulin delivery device, changing a sensor location for a continuous glucose monitor, refilling insulin into an insulin delivery device, changing an insulin containing cartridge in an insulin delivery device, replacing a battery in an insulin delivery device, or a combination thereof.

[0063] In response to determining that the user has entered the first threshold period of time for a maintenance activity, the mobile device **60** can begin actively monitoring the user's location (step H, **434**), similar to the location determinations described above with regard to step B (**422**). By delaying active location monitoring until the user is within the first threshold period of time of a maintenance activity deadline, the performance of the mobile device **60** in aggregate (during and outside of the first periods of time) can be improved. For example, location determination tasks performed by a mobile computing device can be resource intensive—meaning that they can consume a large amount of processor cycles, battery life, memory, network traffic, internal bus use, and/or other computing resources. Continually obtaining the location of the device **60** can be a drain on resources and can hamper performance of the device **60**. Accordingly, the device **60** can be programmed to only determine its location during periods when its location is relevant to maintenance activities, such as when a maintenance activity is performed (step B, **422**) and when the user is within the first threshold period of time of a maintenance activity deadline (step H, **434**). By doing this, the performance of the device **60** can be increased without decreasing the quality of maintenance reminder-related services that are provided on device **60**. Additionally, by polling for location information at limited times, the user privacy via the device **60** can be maximized while still providing the same quality of maintenance reminder-related services.

[0064] Location information and current context information for the device **60** can be obtained and fed into a maintenance model for the user to determine whether the user is currently in an optimal location and context to receive a maintenance reminder (step I, **438**). For instance, in a simplified example, the model may indicate that the user is likely to perform a particular maintenance activity when the user is at his/her home on weekdays from 6-8 pm or on weekends from 10 am-noon. Such times and locations can, for example, be times and locations where the user has previously conducted that maintenance activity. The location information and context for the user can be repeatedly and continually fed into the maintenance model for the user to get a determination as to whether the user is currently at an optimal location and within an optimal context to receive a

maintenance reminder. In response to receiving an indication that the current location and context are appropriate for a maintenance reminder, the mobile device can provide a maintenance reminder notification on the device (step J, **442**). For example, a notification can be surfaced on the device **60** identifying the type of maintenance to be performed and the timeframe to perform the maintenance. Additionally and/or alternatively, the server system **403** can perform the steps H-J, as indicated by steps H′-J′ (**436**, **440**, **444**). Example notifications that can be presented to a user are depicted in FIGS. **5-6**.

[0065] In some cases, the system **400** (via the device **60** and/or the server system **402**) can produce a maintenance reminder regardless of location and/or context when it is determined that the maintenance task is due within a threshold second period of time that is less than the first period of time. For example, if the first period of time is one week, the second period of time may be one day. In such a configuration, the device **60** can monitor for an optimal location and time to provide a reminder starting one week out from the deadline and up to one day before the deadline, after which the device **60** can automatically provide the maintenance reminder regardless of the location and context since failure to comply with the deadline poses potential health risks to the users. The second threshold period of time can be any of a variety of time periods (e.g., 6 hours, 12 hours, 1 day, 2 days, 1 week), and can vary depending on the type of maintenance activity to be performed and the maintenance model for the user.

[0066] In some cases, the system **400** determines a location where the user conducts a majority of maintenance activities and tracks the timing of diurnal pattern of maintenance activities at that location and determines one or more time periods when the user is likely to conduct maintenance activities and the device **60** provides the maintenance activity reminder during the diurnal period of time prior to the scheduled time for the maintenance activity if the user is at the location where the user conducts the majority of maintenance activities. In some cases, the maintenance reminder is held by the device **60** until the user arrives at the location where the user conducts a majority of maintenance activities if the user is not at that location during the diurnal period of time when the user conducts most maintenance activities. In some cases, the maintenance reminder is displayed by the device **60** at the time that the maintenance is scheduled regardless of whether the user is at the location where the user conducts a majority of maintenance activities. In some cases, the system **400** can recognize patterns regarding when a user leaves from and arrives at a location where they perform routine maintenance activities and schedule a reminder a predetermined time prior to when the user is expected to leave the location and/or holds reminders until the user arrives at the location if the user is expected to arrive at the location prior to when the time when the maintenance activity is scheduled.

[0067] FIG. **5** depicts an exemplary maintenance reminder in a user interface **500**. The maintenance reminder includes a banner message **502** briefly identifying the maintenance activity and indicating the severity of the deadline (e.g., via color, symbols, font size, font effects), a detailed message **504** describing what the user has to do to comply with the maintenance activity, and a confirmatory interface element **506** through which the user has to provide explicit input indicating that the user has viewed the notification in order for it to be dismissed.

Maintenance Activity User Interfaces

[0068] FIGS. **6**A-**6**D depict an example pump maintenance user interface **600**, which can be presented to the user when conducting pump maintenance. Referring to FIG. **6**A, the interface **600** allows a user to select between conducting cannula fill operations **602** and tube priming operations **604**. Once an option is selected, the user can press the continue button **606** to go to the next screen of the user interface **600**, as depicted in FIG. **6**B. In FIG. **6**B, the user can confirm the selected cannula fill operation **608** by selecting the continue button **610**, or can select the tubing prime tab **611**. In response to selecting the tab **611**, the user interface **600** allows the user to select from among tubing prime operations and to confirm the selected tubing prime operation **612** by selecting the continue button **614**, as depicted in FIG. **6**C. In response to selecting the continue **614** button,

the user interface of FIG. **6**D is presented to provide a warning **616** that the tubing is about to be primed. The warning **616** can include a confirmation text box over a shaded background, for example.

Providing Alarms to a Remote Server System Via Nearby Third Party Devices

[0069] Methods, devices, and systems provided herein can also trigger alarms regarding situations when a user needs to act quickly in order to keep the user safe. In some cases, however, a PWD may experience a condition where the user becomes non-responsive (e.g., a severe hypoglycemic event). Accordingly, to keep a PWD user safe, methods, device, and systems provided herein can send data, including location data, to a remote service for distribution to people selected by the PWD, such as a family member or HCP, using a paired mobile computing device. For example, a PWD and parent may wish to have the parent review all CGM data and/or insulin delivery data, along with location data, in order for the parent to be comfortable that their child PWD is safe. In other cases, a PWD may wish to configure methods and systems provided herein so that their loved ones are only sent emergency alarms (e.g., blood glucose values greater than 400 mg/dl or below 55 mg/dl). A paired mobile computing device 60, however, can be left behind and/or run out of battery or otherwise lose the ability to connect with a pump assembly **15** and/or a CGM **50**. Accordingly, in some cases, such as those discussed below, methods, devices, and systems provided herein can send data to a remote server for distribution to people selected by the PWD, HCPs, and/or emergency medicine providers though non-paired mobile computing devices under certain conditions.

[0070] FIG. **7** depicts an example system **700** and corresponding method (steps A-H, **720-726** and **732-740**) for the insulin pump **15** to transmit alarms back to the server system **402** without its paired mobile device **60** via nearby third party computing devices **730**. Normally, without the mobile device **60**, the insulin pump **15** may not otherwise be able to communicate with the outside world-meaning it would not be able to provide medical alerts back to the server system **402**, which can be used to alert a user's doctor and/or emergency medical personnel, as needed if the insulin pump **15** detects an emergency situation.

[0071] The system **700** and the corresponding method (steps A-H, **720-726** and **732-740**) can be used to provide a solution to these and other potential problems that may arise when the insulin pump **15** is left without a direct connection to the mobile device **60** and/or an indirect connection to the server system **402**. In particular, the insulin pump **15** can transmit a local beacon signal (e.g., BLUETOOTH low energy (BLE) beacon signal, Wi-Fi beacon signal, near field communication (NFC) beacon) that other computing devices (e.g., mobile computing devices, non-mobile computing devices), such as the third party device **730**, are programmed to listen for, detect, and use to request additional information. Such beacon signals can include a uniform resource locator (URL) that causes the result for additional information to be routed to the server system **402** along with a unique identifier for the mobile device **60**, insulin pump **15**, and/or user. The beacon signals can, in some cases, also include additional details related to the current status of the mobile device **60**, the insulin pump **15**, and/or the user, such as the last BG reading for the user, the most recent dosing information, the user's current medical condition, the last known location of the mobile device **60**, and/or other relevant information that may be conveyed within a beacon signal having a limited number of bits. The third party device **730** can detect the beacon signal and automatically request the URL, which is designed to point to the server system **402** to alert the server system **402** of a potential medical danger/emergency with the user of the insulin pump **15**.

[0072] Referring to step A (**720**), in response to detecting no connection with the mobile device **60**, the insulin pump **15** can initial provide a local alert using an output subsystem on the pump **15** (step B, **722**). The output subsystem of the insulin pump **15** can include, for example, a display **704** and a speaker **706** to visually and audibly alert the user as to the lost connection with the mobile device **60**. The alert can include information identifying that the connection with the mobile device **60** has been lost and can advise the user to reconnect as soon as possible. The alert can also include

a prompt for the user to provide input indicating that he/she has received and understood the alert. The user input can be provided via an input subsystem **708** on the insulin pump **15**, which can include, for instance, one or more physical buttons, keypads, motion sensors, microphones, and/or other input mechanisms. If no response is received from the user within a threshold period of time of the alert being provided, then the insulin pump **15** can transition to transmitting beacon signals to nearby third party devices (step C, **724**). For example, if the user is non-responsive or does not otherwise detect the alert, the lack of a connection with the mobile device **60** can pose a health risk for the user which can cause the automated escalation to transmitting beacon signals. Similarly, even if the user does acknowledge the alert with appropriate user input within the threshold period of time, but an alarm condition persists for a threshold period of time and is not acknowledged after a re-announcement of the alarm, then the insulin pump **15** may also begin transmitting beacon signals.

[0073] As indicated by step D (**726**), the insulin pump **15** can transmit a broadcast signal that includes a URL **712** for the server system **402** and optional status information **714**. The URL **712** and status information **714** can be stored in a local storage system **710** (e.g., flash memory, non-volatile memory, volatile memory) on the insulin pump **15**. The URL **712** can have embedded within it a unique identifier for the mobile device **60**, the insulin pump **15**, and/or the user. Such a unique identifier can be, for example, includes as a portion of the URL string or as a parameter included with the URL. The URL **712** can additionally include an encoding indicating that the transmission is a third-party alert based on the connection with the mobile device **60** being lost and not reestablished. Such an encoding can also be part of the URL string or a parameter in the URL. The beacon can optionally include the status information **714**, which can indicate a recent status of the insulin pump **15**, the mobile device **60**, and/or the user, such as health information for the user (e.g., recent BG level), a health condition for the user, a recent location for the mobile device **60**, and/or other relevant details. The status information can also be encoded as part of the URL string or as a parameter in the URL.

[0074] Any of a variety of appropriate wireless protocols and chipsets **702** can be used for the broadcast the beacon signal, such as standardized and widely adopted wireless protocols on mobile devices like BLE, Wi-Fi, and NFC. The local transmission area **750** (defining nearby devices that are able to receive and act upon the beacon signal) can depend on the chipset and wireless protocol that is used for the broadcast signal. For example, if the broadcast signal is transmitted using the Wi-Fi standard and chipset, the local transmission area **750** can be up to 30 m-40 m. For example, the insulin pump **15** can be programmed to use one or more wireless beacon protocols (e.g., APPLE's iBeacon, AltBeacon, URIBeacon, GOOGLE Beacons) to transmit BLE beacon signals that include the URL **712** in the payload of the beacon message. Additionally, insulin pump **15** can be programmed to transmit the broadcast signal over multiple different wireless protocols (e.g., both Wi-Fi and BLE) to enhance the opportunity that the signal will be received by a nearby listener.

[0075] The third party device **730** can passively monitor for and detect beacon signals, such as the beacon signal **726**, and to automatically request the URL **712** in response to detecting the signal **726**. For example, the third party device **730** can be run with settings and/or a mobile app that is programmed to passively monitor for BLE beacon signals and, when detected, to request the URL **712** specified in the signal.

[0076] The BLE beacon signals can include one or more header fields and/or payload bits that computing devices are programmed to recognize, which can help filter beacon signals at the device level instead of having to reconcile the beacon signal with a remote system and/or a beacon platform that translates beacon identifiers into additional beacon-related data.

[0077] In response to detecting the signal, the third party device **730** can automatically request the URL (step E, **732**), which causes the request to be routed to the server system **402**. In response to receiving the request, the server system **402** can identify the user who is the subject of the alert

from the URL based on the unique identifier included in the URL (step F, **740**). The server system **402** can also attempt to infer a possible user location based on the request (step G, **742**). For example, the server system **402** can examine any breadcrumbs that may point to the user's current whereabouts, including evaluating the maintenance database **404** for a most recent recorded location for the user and the maintenance model **406** to infer one or more likely locations for the user given the user's historical behavior patterns. Additionally, the server system **402** can attempt to infer the location of the user based on location information that may be provided with the request from the third party device **730**, such as an IP address for the third party device **730** that can be correlated to a rough geographic location. In some cases, the status information **714** transmitted as part of the request may include at least a partial location indicator, such as a most recent location determined by the mobile device **60** (and shared with the insulin pump **15**) and/or unique identifiers for nearby Wi-Fi base stations (e.g., MAC address for nearby Wi-Fi base station). Using as much information as possible about the user and his/her current location, at step H (**744**) the server system **402** can transmit alerts to people preapproved for the user (e.g., user's doctor, user's emergency contact) as well as to nearby emergency medical personnel, if warranted.

[0078] FIG. **8** is a conceptual diagram of an example system **800** for local beacon signal transmissions. The system **800** includes the insulin pump **15** transmitting the beacon signal **726**, which is detected by the third party device **730**. The beacon signal **726** is transmitted as a data packet with a header **806**, a payload **804**, and a footer **802**. The payload **804** includes the URL **808** for the server system **402** and parameters **810** appended to the end of the URL **808** with flags to indicate parameter names and values, and to differentiate between parameters. The URL **808** includes the server system address **812** (e.g., IP address, domain name, shortened URL for the server system **402**), a unique identifier **814** for the pump/user, status encoding information **816**, and any possible location information **818** available on the insulin pump **15**. The server system address **812** can be included in the URL **808**. The pump/user identifier **814**, the status encoding **816**, and the location info **818** can be included in either the URL **808** (e.g., part of the URL string) or in the parameters **810**. How much of the status encoding **816** and the location info **818** that can be included in the packet can depend on the size of the information in bits. The beacon signal **726** can be limited to a certain number of bits, and the insulin pump **15** can be programmed to cap the information included in the packet at the bit limit for the packet.

Providing Alerts and Status Information on Nearby Mobile Computing Devices

[0079] Methods, devices, and systems provided herein can also allow for third-party mobile computing devices owned by PWD designated assistance entities (e.g., family members, friends, and/or caregivers) or otherwise authenticated to view data from one or more peripheral devices of a diabetes management system (e.g., data from an insulin pump) by direct wireless communication with the peripheral device. For example, if a PWD is traveling with a group of friends and/or family to a remote location without internet access using the system depicted in FIG. **1** having a primary user interface of the PWD's paired mobile computing device, the PWD may have concerns that the PWD won't be able to view system data if the PWD's paired mobile computing device becomes disabled, thus the PWD may decide to permit other mobile computing devices owned by friends and/or family to access data. In some cases, the PWD's paired mobile computing device can be adapted to issue commands to the insulin pump assembly, but the third party mobile computing devices can only be authorized to view data, which can mitigate against risks associated with multiple mobile computing devices being able to issue commands.

[0080] FIG. **9** depicts an example system **900** and corresponding method (steps A-H, **902-914**) for providing alerts and status information on nearby mobile computing devices. The system **900** and corresponding method solve similar problems to those addressed above in FIGS. **7-8**, but do so by leveraging nearby mobile computing devices that are preapproved to display and possibly control operation of the insulin pump **15** in the event that the connection with the mobile device **60** is lost. As indicated by step A (**902**), the mobile device **60** can provide approval for contingency control of

the insulin pump **15** by other devices **60′** (e.g., other mobile computing devices registered with the server system **402** to control other insulin pumps for other users). The server system **402** can receive the approvals and provide information for the other devices **60′** to the mobile device **60** (step B, **904**), which can relay them to the insulin pump **15** (step C, **906**). The information for the other devices **60′** can include information that the insulin pump **15** can use to establish a secure and authenticated connection with the other devices **60′** (and not unauthorized devices). Such information can include, for example, a MAC address for the other devices **60′**, a shared secret between the insulin pump **15** and the other devices **60′**, an authentication key and/or certificate for the other devices **60′**. The insulin pump **15** can locally store this information for use in the event that the direct connection with the mobile device **60** and/or the indirect connection with the server system **402** (via the mobile device **60**) is lost.

[0081] Similarly, the server system **402** can transmit information for the insulin pump **15** that the other devices **60′** can use to establish a secure and authentic connection with the insulin pump **15**. Such information can include, for example, a MAC address for the insulin pump **15**, a shared secret between the other devices **60′** and the insulin pump **15**, and an authentication key and/or certificate for the insulin pump **15**. The other computing devices **60′** can store the information for use in the event that the insulin pump **15** attempts to establish a connection in the event that the direct connection with the mobile device **60** and/or the indirect connection with the server system **402** (via the mobile device **60**) is lost.

[0082] In the depicted example, the connection with the mobile device **60** and/or the server system **402** is lost (step E, **910**), which causes the insulin pump **15** to seek out any of the preapproved other devices **60′** that are located nearby to establish a connection (step F, **912**). In some cases, the insulin pump **15** does not establish a connection with the other devices **60′**, and instead simply broadcasts health-related information for the user that is passively monitored for by the other devices **60′**. To ensure user privacy and safety, once a connection is established with one of the other devices **60′** or once the other devices **60′** detect the health-related information broadcast by the insulin pump **15**, the user may need to authenticate himself/herself and/or otherwise provide consent for the other device **60′** to display alerts, control, and/or operate the insulin pump **15** (step G, **914**). The authentication can be performed between the other device **60′** and the server system **402** (e.g., username/password verification, entering a PIN number, voice recognition, image recognition, fingerprint identification). Once authenticated, services for the insulin pump **15** and/or the health-related information for the user can be provided via the other device **60′** and the server system **402** (step H, **916**).

Continuous Glucose Monitor

[0083] Continuous glucose monitor **50** can include a housing **52**, a wireless communication device **54**, and a sensor shaft **56**. The wireless communication device **54** can be contained within the housing **52** and the sensor shaft **56** can extend outward from the housing **52**. In use, the sensor shaft **56** can penetrate the skin **20** of a user to make measurements indicative of characteristics of the user's blood (e.g., the user's blood glucose level or the like). In some cases, the sensor shaft **56** can measure glucose or another analyte in interstitial fluid or in another fluid and correlate that to blood glucose levels. In response to the measurements made by the sensor shaft **56**, continuous glucose monitor **50** can employ the wireless communication device **54** to transmit data to a corresponding wireless communication device **247** housed in the pump system **15**. In some cases, the monitoring device **50** may include a circuit that permits sensor signals (e.g., data from the sensor shaft **56**) to be communicated to the communication device **54**. The communication device **54** can transfer the collected data to the controller device **200** (e.g., by wireless communication to the communication device **247**). Alternatively, the monitoring device **50** can employ other methods of obtaining information indicative of a user's blood characteristics and transferring that information to the controller device **200**. For example, an alternative monitoring device may employ a micropore system in which a laser porator creates tiny holes in the uppermost layer of a user's skin, through

which interstitial glucose is measured using a patch. In the alternative, the monitoring device can use iontophoretic methods to non-invasively extract interstitial glucose for measurement. In other examples, the monitoring device can include non-invasive detection systems that employ near IR, ultrasound or spectroscopy, and particular implementations of glucose-sensing contact lenses. Invasive methods involving optical means of measuring glucose could also be added. In yet another example, the monitoring device can include an optical detection instrument that is inserted through the skin for measuring the user's glucose level. Furthermore, it should be understood that in some alternative implementations, the monitoring device **50** can be in communication with the controller device **200** or another computing device via a wired connection.

Blood Glucose Meter

[0084] DMS **10** may optionally communicate with blood glucose meter **70** in addition to (or as an alternative to) continuous glucose meter **50**. For example, one or more test strips (e.g., blood test strips) can be inserted into a strip reader portion of blood glucose meter **70** and then receive blood to be tested. In some cases, blood glucose meter **70** is configured to analyze the characteristics of the user's blood and to communicate (e.g., via a Bluetooth wireless communication connection) the information to the controller device **200**. In some cases, a user can manually input a glucose meter reading. Blood glucose meter **70** can be manually operated by a user and may include an output subsystem (e.g., display, speaker) that can provide the user with blood glucose readings that can be subsequently entered into the controller or user interface (to collect the data from an unconnected BGM into the system). Blood glucose meter **70** may be configured to communicate data (e.g., blood glucose readings) obtained to the controller device **200** and/or other devices, such as the mobile computing device **60**. Such communication can be over a wired and/or wireless connection, and the data can be used by the controller device **200** and/or the mobile computing device **60** to perform multiple delivery modes and/or a secondary feedback loop for the insulin delivery system **10**.

External Insulin Delivery Devices

[0085] DMS **10** may include one or more external medication delivery devices **80** (e.g., syringe, an insulin pen, a smart syringe with device communication capabilities, or the like) through which additional medicine dosages (e.g., insulin, glucagon) can be manually administered to a user. In some cases, user interfaces provided herein allow users to input a medication, a dosage amount, and the timing so that a closed-loop control algorithm can account for the additional medication. In some cases, mobile computing device **60** can make a recommendation for an amount of insulin to be delivered using an external delivery device.

Pump Assembly

[0086] Referring again to FIG. **1**, pump assembly **15** can include pump device **100** configured to removably attach to the controller device **200** in a manner that provides a secure fitting, an overall compact size, and a reliable electrical connection. Additional details about the particularly depicted pump assembly **15** are described in more detail below in connection with FIGS. **1**B and **1**C.

[0087] Pump assembly **15** can be pocket-sized so that the pump device **100** and controller device **200** can be worn in the user's pocket or in another portion of the user's clothing. In some circumstances, the user may desire to wear the pump assembly **15** in a more discrete manner. Accordingly, the user can pass the tube **147** from the pocket, under the user's clothing, and to the infusion site where the adhesive patch can be positioned. As such, the pump assembly **15** can be used to deliver medicine to the tissues or vasculature of the user in a portable, concealable, and discrete manner.

[0088] In some cases, the pump assembly **15** can be configured to adhere to the user's skin directly at the location in which the skin is penetrated for medicine infusion. For example, a rear surface of the pump device **100** can include a skin adhesive patch so that the pump device **100** can be physically adhered to the skin of the user at a particular location. In these cases, the cap device **130** can have a configuration in which medicine passes directly from the cap device **130** into an

infusion set **146** that is penetrated into the user's skin. In some examples, the user can temporarily detach the controller device **200** (while the pump device **100** remains adhered to the skin) so as to view and interact with the user interface **220**.

[0089] Referring now to FIG. **1**B, the pump device **100** in this example includes a housing structure **110** that defines a cavity **116** in which a fluid cartridge **120** can be received. The pump device **100** also can include a cap device **130** to retain the fluid cartridge **120** in the cavity **116** of the housing structure **110**. The pump device **100** can include a drive system (e.g., including a battery powered actuator, a gear system, a drive rod, and other items that are not shown in FIG. **5**) that advances a plunger **125** in the fluid cartridge **120** so as to dispense fluid therefrom. In this example, the controller device **200** communicates with the pump device **100** to control the operation of the drive system. Optionally, the controller device **200** may be configured as a reusable component that provides electronics and a user interface to control the operation of the pump device **100**. In such circumstances, the pump device **100** can be a disposable component that is disposed of after a single use. For example, the pump device **100** can be a "one time use" component that is thrown away after the fluid cartridge **120** therein is exhausted. Thereafter, the user can removably attach a new pump device (having a new fluid cartridge) to the reusable controller device **200** for the dispensation of fluid from a new fluid cartridge. Accordingly, the user is permitted to reuse the controller device **200** (which may include complex or valuable electronics, as well as a rechargeable battery) while disposing of the relatively low-cost pump device **100** after each use. Such a pump assembly **15** can provide enhanced user safety as a new pump device (and drive system therein) is employed with each new fluid cartridge. Additional and/or alternative implementations of the controller device **200** are also possible, including magnetic drive turbine (M DT) monolithic architecture pumps and/or omnipods.

[0090] The pump assembly **15** can be a medical infusion pump assembly that is configured to controllably dispense a medicine from the cartridge **120**. As such, the fluid cartridge **120** can contain a medicine **126** to be infused into the tissue or vasculature of a targeted individual, such as a human or animal patient. For example, the pump device **100** can be adapted to receive a fluid cartridge **120** in the form of a carpule that is preloaded with insulin or another medicine for use in the treatment of Diabetes (e.g., Exenatide (BY ETTA, BY DUREON) and liraglutide (VICTOZA) SY M LIN, or others). Such a cartridge **120** may be supplied, for example, by Eli Lilly and Co. of Indianapolis, IN. Other examples of medicines that can be contained in the fluid cartridge **120** include: pain relief drugs, hormone therapy, blood pressure treatments, anti-emetics, osteoporosis treatments, or other injectable medicines. The fluid cartridge **120** may have other configurations. For example, the fluid cartridge **120** may comprise a reservoir that is integral with the pump housing structure **110** (e.g., the fluid cartridge **120** can be defined by one or more walls of the pump housing structure **110** that surround a plunger to define a reservoir in which the medicine is injected or otherwise received).

[0091] In some cases, the pump device **100** can include one or more structures that interfere with the removal of the fluid cartridge **120** after the fluid cartridge **120** is inserted into the cavity **116**. For example, the pump housing structure **110** can include one or more retainer wings (not shown) that at least partially extend into the cavity **116** to engage a portion of the fluid cartridge **120** when the fluid cartridge **120** is installed therein. Such a configuration may facilitate the "one-time-use" feature of the pump device **100**. In some cases, the retainer wings can interfere with attempts to remove the fluid cartridge **120** from the pump device **100**, thus ensuring that the pump device **100** will be discarded along with the fluid cartridge **120** after the fluid cartridge **120** is emptied, expired, or otherwise exhausted. In another example, the cap device **130** can be configured to irreversibly attach to the pump body **110** so as to cover the opening of the cavity **116**. For example, a head structure of the cap device **130** can be configured to turn so as to threadably engage the cap device **130** with a mating structure along an inner wall of the cavity **116**, but the head structure may prevent the cap device from turning in the reverse direction so as to disengage the threads.

Accordingly, the pump device **100** can operate in a tamper-resistant and safe manner because the pump device **100** can be designed with a predetermined life expectancy (e.g., the "one-time-use" feature in which the pump device is discarded after the fluid cartridge **120** is emptied, expired, or otherwise exhausted).

[0092] Still referring to FIG. **1**B, the controller device **200** can be removably attached to the pump device **100** so that the two components are mechanically mounted to one another in a fixed relationship. In some cases, such a mechanical mounting can also form an electrical connection between the removable controller device **200** and the pump device **100** (for example, at electrical connector **118** of the pump device **100**). For example, the controller device **200** can be in electrical communication with a portion of the drive system (show shown) of the pump device **100**. In some cases, the pump device **100** can include a drive system that causes controlled dispensation of the medicine or other fluid from the cartridge **120**. In some cases, the drive system incrementally advances a piston rod (not shown) longitudinally into the cartridge **120** so that the fluid is forced out of an output end **122**. A septum **121** at the output end **122** of the fluid cartridge **120** can be pierced to permit fluid outflow when the cap device **130** is connected to the pump housing structure **110**. For example, the cap device **130** may include a penetration needle that punctures the septum **121** during attachment of the cap device **130** to the housing structure **110**. Thus, when the pump device **100** and the controller device **200** are mechanically attached and thereby electrically connected, the controller device **200** communicates electronic control signals via a hardwire-connection (e.g., electrical contacts along connector **118** or the like) to the drive system or other components of the pump device **100**. In response to the electrical control signals from the controller device **200**, the drive system of the pump device **100** causes medicine to incrementally dispense from the fluid cartridge **120**. Power signals, such as signals from a battery (not shown) of the controller device **200** and from the power source (not shown) of the pump device **100**, may also be passed between the controller device **200** and the pump device **100**.

[0093] Cap device **130** of the pump device **100** can be configured to mate with an infusion set **146**. In general, the infusion set **146** can be a tubing system that connects the pump assembly **15** to the tissue or vasculature of the user (e.g., to deliver medicine into the tissue or vasculature under the user's skin). The infusion set **146** can include a flexible tube **147** that extends from the pump device **100** to a subcutaneous cannula **149** that may be retained by a skin adhesive patch (not shown) that secures the subcutaneous cannula **149** to the infusion site. The skin adhesive patch can retain the infusion cannula **149** in fluid communication with the tissue or vasculature of the user so that the medicine dispensed through the tube **147** passes through the cannula **149** and into the user's body. The cap device **130** can provide fluid communication between the output end **122** (FIG. **5**) of the fluid cartridge **120** and the tube **147** of the infusion set **146**.

[0094] Referring now to FIG. **1**C, the controller device **200** (shown in an exploded view) houses a number of components that can be reused with a series of successive pump devices **100**. In particular, the controller device **200** can include control circuitry **240** and a rechargeable battery pack **245**, each arranged in the controller housing **210**. The rechargeable battery pack **245** may provide electrical energy to components of the control circuitry **240**, other components of the controller device (e.g., the display device **222** and other user interface components, sensors, or the like), or to components of the pump device **100**. The control circuitry **240** may be configured to communicate control or power signals to the drive system of the pump device **100**, or to receive power or feedback signals from the pump device **100**.

[0095] The control circuitry **240** of the controller device **200** can include one or more microprocessors **241** configured to execute computer-readable instructions stored on one or more memory devices **242** so as to achieve any of the control operations described herein. At least one memory device **242** of the control circuitry may be configured to store a number of user-specific dosage parameters. Various user-specific dosage parameters can be automatically determined and/or updated by control operations implemented by the control circuitry **240** of the controller

device **200**. Additionally, the control circuitry **240** can cause the controller device **200** to periodically communicate the user-specific dosage parameters to the mobile computing device **60** for future use during operations by the mobile computing device **60** or for subsequent communication to cloud-based computer network.

[0096] In some cases, the control circuitry **240** can receive input data or other information from the mobile computing device **60** (e.g., via user input at the mobile computing device **60**) and thereby cause the controller device **200** to output information to the mobile computing device **60** for display on the screen of the mobile computing device **60**, such as settings and data (e.g., review data that shows the medicine dispensing rate, the total amount of medicine dispensed in a given time period, the amount of medicine scheduled to be dispensed at a particular time or date, the approximate amount of medicine remaining the cartridge **120**, the amount of battery life remaining, or the like). The control circuitry **240** can be programmable to cause the control circuitry **240** to change any one of a number of settings or modes of operation for the insulin delivery system **10**. In some cases, the control circuitry **240** can include a cable connector (e.g., a USB connection port or another data cable port) that is accessible on an external portion of the controller housing **210**. As such, a cable can be connected to the control circuitry **240** to upload or download data or program settings to the control circuitry.

[0097] A number of implementations have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. Accordingly, other implementations are within the scope of the following claims.

Claims

1. A diabetes management system, comprising: one or more of a continuous glucose monitor sensor and an insulin delivery device; and a mobile controller device in wireless communication with the continuous glucose monitor sensor, the insulin delivery device, or a combination thereof, the mobile controller device including a user interface operable to present one or more fields that present information and have one or more selectable elements, wherein the mobile controller device is operable to: determine a disposable portion of the insulin delivery device is low on an amount of insulin stored in the disposable portion; and in response to the determination, present in at least one field of the one or more fields of the user interface an indication the disposable portion of the insulin delivery device needs to be replaced.

2. The diabetes management system of claim 1, wherein the mobile controller device is further operable to: present alternative fields in the user interface indicating when an infusion set is due for replacement, when an infusion site should be changed, when an insulin reservoir needs to be refilled, when the continuous glucose monitor sensor needs to be changed or moved to a new location on a user's body, when a blood glucose measurement should be made to calibrate the continuous glucose monitor sensor, or combinations thereof.

3. The diabetes management system of claim 1, wherein the mobile controller device is further operable to: present additional fields in the user interface indicated different information related to the insulin delivery device and/or user treatment.

4. The diabetes management system of claim 3, wherein the additional fields include one or more of a glucose measurement field, a bolus entry user actionable display field, a history field, a continuous glucose monitor field, or an insulin pump field.

5. The diabetes management system of claim 1, wherein the mobile controller device is further operable to: present, in a first set of fields of the one or more fields of the user interface, status information of the insulin delivery device.

6. The diabetes management system of claim 5, wherein a maintenance field is one of the first set of fields of the one or more fields of the user interface.

7. The diabetes management system of claim 5, wherein the mobile controller device, when

presenting the status information of the continuous glucose monitor or the insulin delivery device, is further operable to: present, contemporaneously with the first set fields, a second set of fields of the one or more fields of the user interface, wherein the second set of fields includes status information of a continuous glucose monitor communicatively coupled to the mobile controller device.

8. The diabetes management system of claim 5, wherein the mobile controller device, when presenting the status information of the continuous glucose monitor or the insulin delivery device, is further operable to: remaining battery life, a time period until a component of needs maintenance, a status of a direct or an indirect communication connection with either the continuous glucose monitor or the insulin delivery device, a length of time during which either the continuous glucose monitor or the insulin delivery device has been used, a remaining supply of medicine or other consumable materials used by the insulin delivery device components.

9. The diabetes management system of claim 1, wherein the insulin delivery device further comprises: an insulin pump device to administer insulin dosages to the user; a data storage device to store a unique identifier for the patient; and a controller operable to control delivery of insulin from the insulin pump device to the patient based, at least in part, on the blood glucose levels received through the one or more sensor interfaces.

10. The diabetes management system of claim 1, wherein the insulin delivery device further comprises: an insulin pump device to administer insulin dosages to the user; a data storage device to store a unique identifier for the patient; and a controller operable to pair with and securely communicate with the mobile controller device.

11. The diabetes management system of claim 6, wherein the controller of the insulin delivery device is further operable to: broadcast secure wireless signals including health-related information of the user.

12. The diabetes management system of claim 1, wherein the mobile controller device is further operable to: present, in a maintenance field of the user interface, a status indication that system maintenance tasks are up to date.

13. The diabetes management system of claim 1, wherein the insulin delivery device further comprises: a disposable component including a pump device coupled to a fluid cartridge, wherein the pump device is operable to deliver insulin from the fluid cartridge to a user; and a reusable component including a controller that provides electronics and a user interface that is operable to control the pump device.

14. The diabetes management system of claim 10, wherein the controller of the insulin delivery device is operable to: create a wired or wireless connection with the mobile controller device via the electronics of the controller.

15. The diabetes management system of claim 1, wherein the controller of the insulin delivery device is operable to: receive data from the continuous glucose monitor; and transfer the received data to the mobile controller device.

16. The diabetes management system of claim 1, wherein the mobile controller device is further operable to: receive maintenance information from one or more of a blood glucose meter, a monitoring device, an infusion set, an insulin pump, or insulin pen.

17. The diabetes management system of claim 16, wherein the mobile controller device further comprises: a maintenance database operable to store the received maintenance information.

18. The diabetes management system of claim 1, wherein the mobile controller device is further operable to: monitor maintenance activities and corresponding deadlines based on the maintenance information stored in the maintenance database.

19. The diabetes management system of claim 18, wherein the mobile controller device is further operable to: in response to a corresponding deadline for a monitored maintenance activity enters a first threshold time period for the monitored maintenance activity, begin actively monitoring a user's location; and determine whether the user is in an optimal location and/or context to receive a

maintenance reminder.

20. The diabetes management system of claim 19, wherein an optimal location is a location where a user has conducted a maintenance activity.