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(54) **COMMUNICABLE DISEASE TRACKING**

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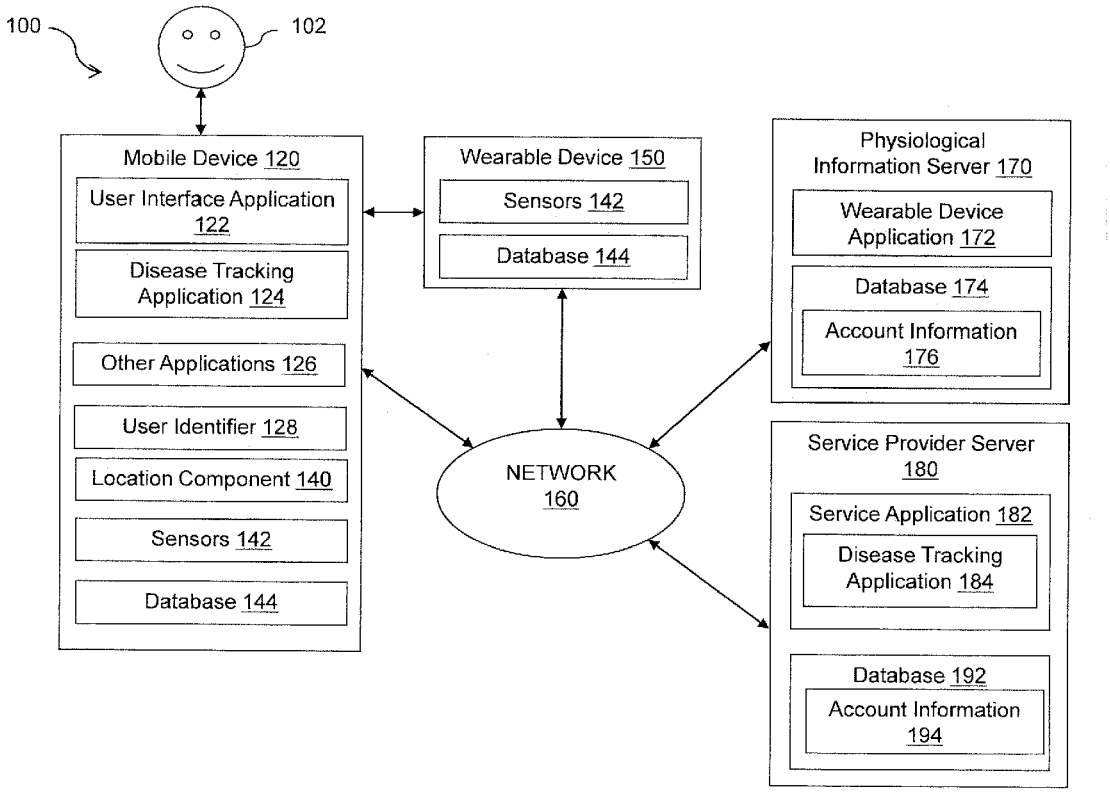
(57) **ABSTRACT**

Systems and methods for controlling the spread of a communicable disease are provided. A combination of physiological data and location data is used to estimate the likelihood that an individual is ill. Once an individual is determined to be ill, the individual's location history may be examined and individuals who were exposed to the individual identified. By tracking individuals who may be ill or who have reported themselves to be ill, and by identifying individuals with a possible exposure to those who may be ill, potential carriers of illness can be quarantined and their access to areas where communicable diseases pose a high risk limited.



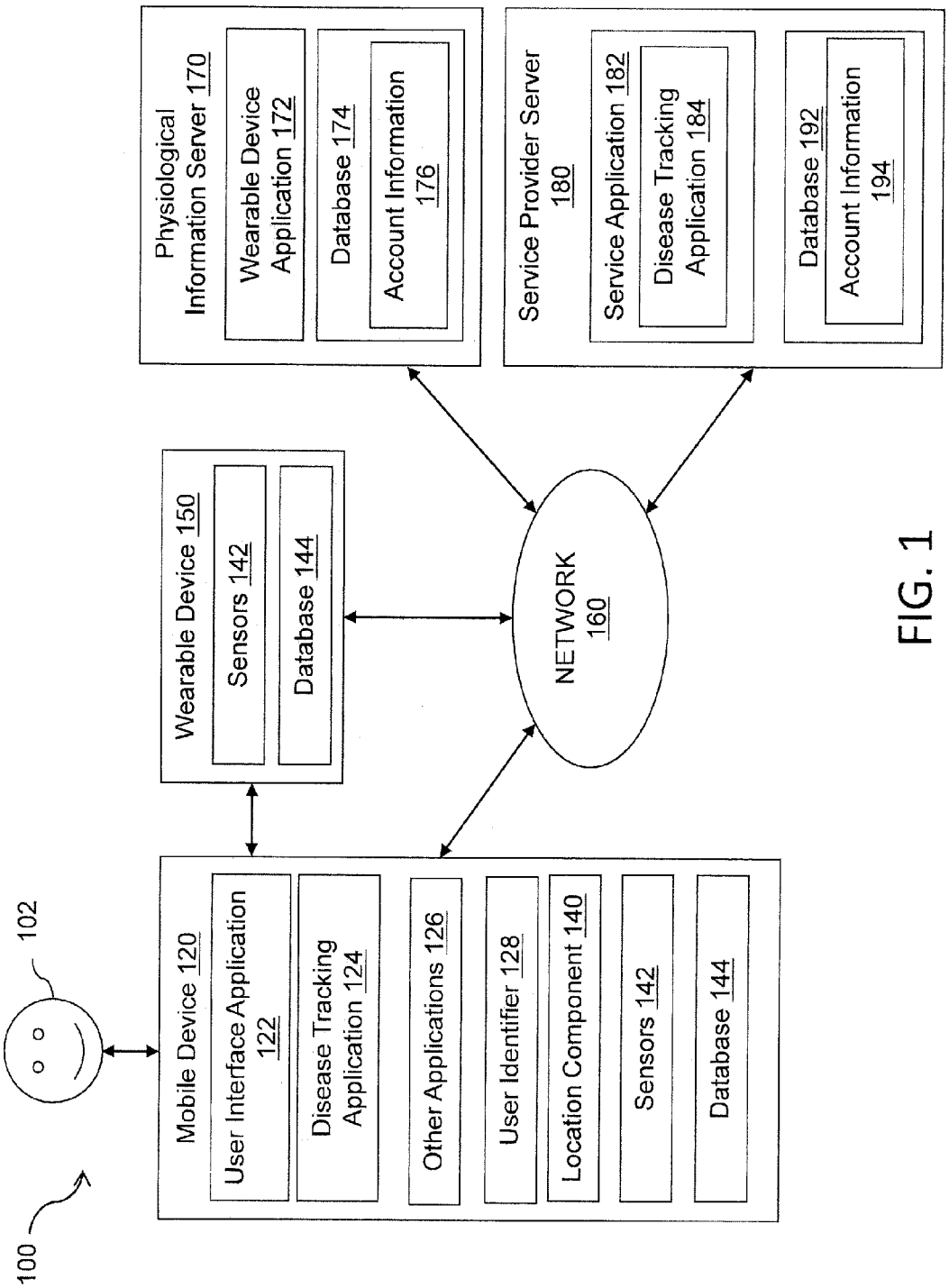

100
102
Mobile Device 120
User Interface Application 122
Disease Tracking Application 124
Other Applications 126
User Identifier 128
Location Component 140
Sensors 142
Database 144
Wearable Device 150
Sensors 142
Database 144
NETWORK 160
Physiological Information Server 170
Wearable Device Application 172
Database 174
Account Information 176
Service Provider Server 180
Service Application 182
Disease Tracking Application 184
Database 192
Account Information 194

FIG. 1

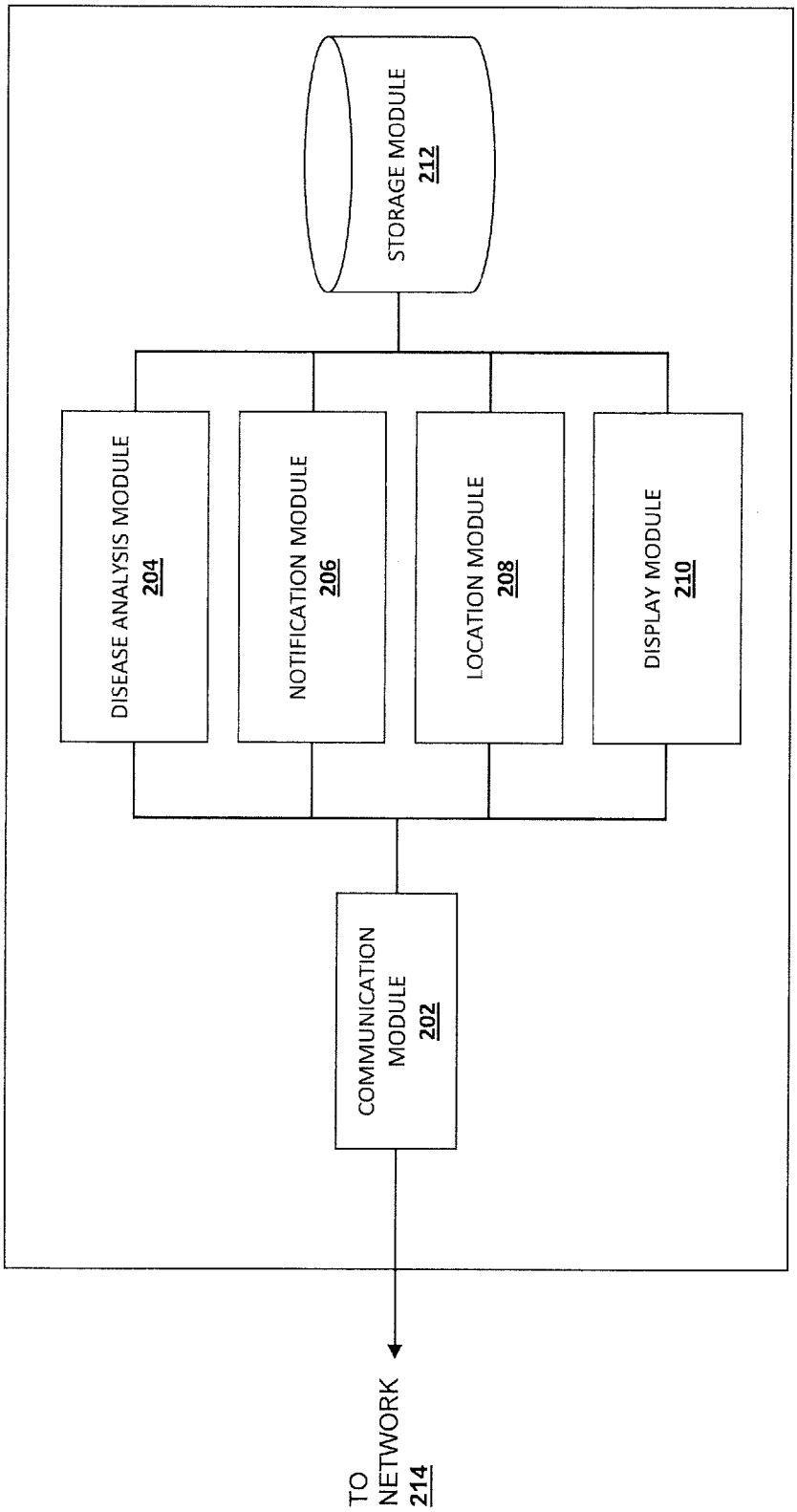

STORAGE MODULE
212
DISEASE ANALYSIS MODULE
204
NOTIFICATION MODULE
206
LOCATION MODULE
208
DISPLAY MODULE
210
COMMUNICATION MODULE
202
TO NETWORK
214

FIG. 2

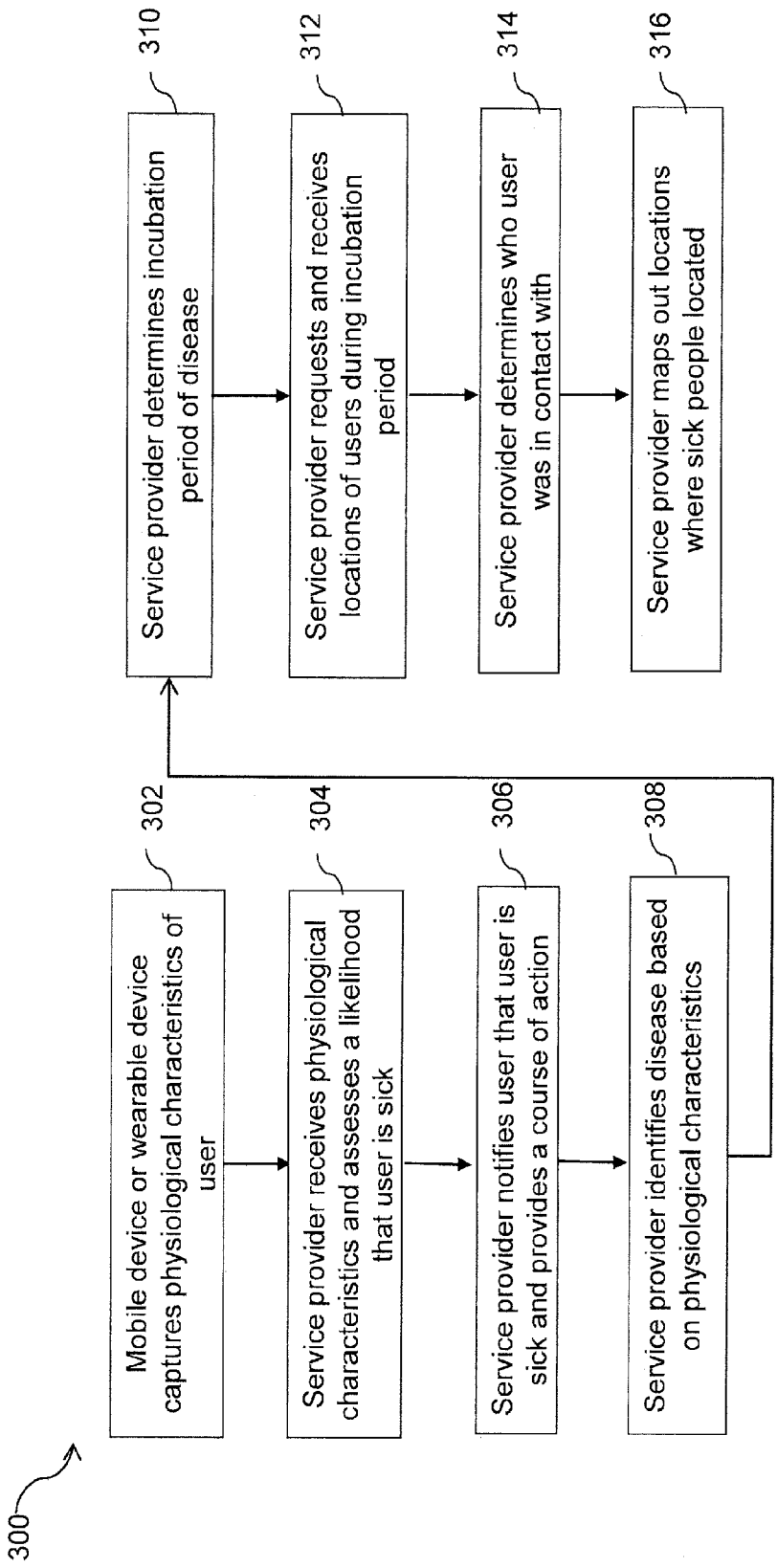

300
Mobile device or wearable device captures physiological characteristics of user
302
Service provider receives physiological characteristics and assesses a likelihood that user is sick
304
Service provider notifies user that user is sick and provides a course of action
306
Service provider identifies disease based on physiological characteristics
308
Service provider determines incubation period of disease
310
Service provider requests and receives locations of users during incubation period
312
Service provider determines who user was in contact with
314
Service provider maps out locations where sick people located
316

FIG. 3

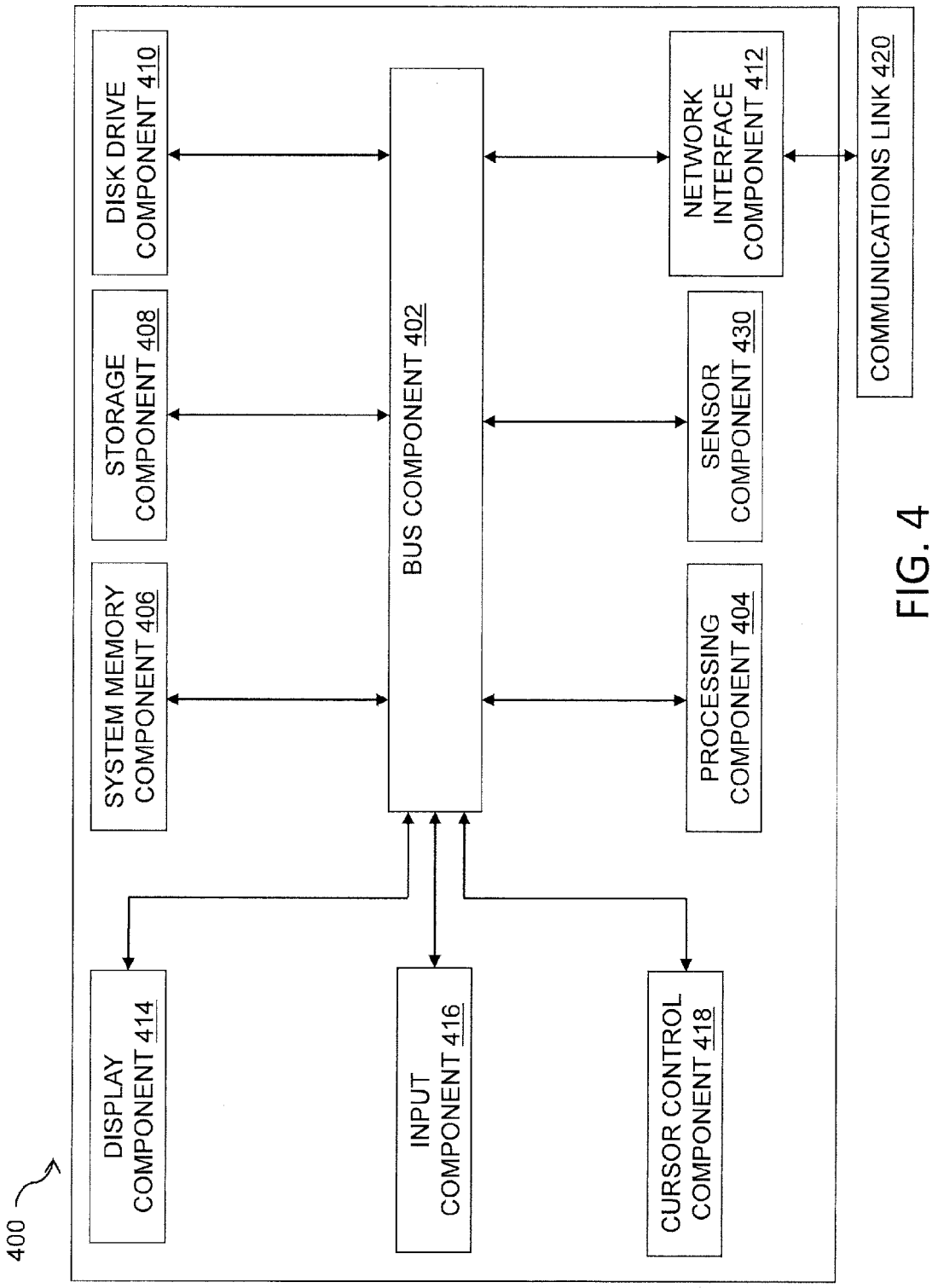

400
DISPLAY COMPONENT 414
INPUT COMPONENT 416
CURSOR CONTROL COMPONENT 418
SYSTEM MEMORY COMPONENT 406
STORAGE COMPONENT 408
DISK DRIVE COMPONENT 410
BUS COMPONENT 402
PROCESSING COMPONENT 404
SENSOR COMPONENT 430
NETWORK INTERFACE COMPONENT 412
COMMUNICATIONS LINK 420

FIG. 4

COMMUNICABLE DISEASE TRACKING

BACKGROUND

[0001] 1. Field of the Invention

[0002] The present invention generally relates to disease mapping and control, and particularly to controlling the spread of communicable diseases using location and physiological data.

[0003] 2. Related Art

[0004] Many countries and agencies desire to track the spread of disease throughout various locations. In many locations, there is difficulty in collecting and tracking disease information as well as quickly communicating the disease information to people to prevent or alleviate the spread of diseases.

[0005] In public health practice, the earliest detection of a disease outbreak offers the best opportunity to mitigate its effects. Consequently, one of the core functions of public health surveillance is to monitor public health status and recognize at the earliest possible time, the appearance of a disease or a change in its distribution or incidence. Early intervention allows for early recognition of affected individuals, initiation of treatment, and initiation of post-exposure mitigations among the exposed population. Surveillance technologies should offer the earliest reliable detection and characterization of outbreaks to afford the greatest opportunity to minimize casualties. A need still exists for systems and methods that provide faster detection and notification of the spread of disease.

BRIEF DESCRIPTION OF THE FIGURES

[0006] FIG. **1** is a block diagram illustrating a system for tracking the spread of a communicable disease according to an embodiment of the present disclosure;

[0007] FIG. **2** is a block diagram illustrating a service provider server according to an embodiment of the present disclosure;

[0008] FIG. **3** is a flowchart showing a method for tracking the spread of a communicable disease according to an embodiment of the present disclosure; and

[0009] FIG. **4** is a block diagram of a system for implementing one or more components in FIG. **1** according to an embodiment of the present disclosure.

[0010] Embodiments of the present disclosure and their advantages are best understood by referring to the detailed description that follows. It should be appreciated that like reference numerals are used to identify like elements illustrated in one or more of the figures, wherein showings therein are for purposes of illustrating embodiments of the present disclosure and not for purposes of limiting the same.

DETAILED DESCRIPTION

[0011] The present disclosure provides systems and methods for controlling the spread of a communicable disease. A "communicable disease" is an infectious disease that can be transmitted from an infected person to another person directly or indirectly. Examples of communicable diseases include the common cold, strep throat, pink eye, whooping cough, flu, malaria, and Ebola. A service provider collects physiological information, such as body temperature and blood pressure from one or more users via a device. Location data is also provided to the service provider. The service provider then analyzes this combination of data to track exposure to and risk of contracting a disease. In various embodiments, a user may report themselves as being ill or diagnosed with a specific disease.

[0012] The present disclosure facilitates the analysis of data and/or calculations, to produce an output that relates to disease control, such as the risk of contracting a disease or the risk of exposure to a disease. The analysis may produce a risk calculation, or may be configured so as to produce reporting, or any other communication, based upon collected data.

[0013] In some embodiments, the output may be shown in a visual representation, such as a map, which may indicate hot zones of infection or disease, location of infected persons, the location of persons at risk for infection or disease, and/or show the spread of infection or disease over time. Through a review of the visual representations, a user may learn of disease locations and the rate of spread of disease.

[0014] Advantageously, the present methods and systems may be used as a tool to curb disease before it spreads, and can further provide a way of calculating risk of disease to people. The methods and systems evaluate location, movement, and intersection of persons to identify a potentially infectious person, make a decision on whether to isolate a person, determine other persons exposed to the potentially infectious person, and/or identify the first infected person in a population.

[0015] FIG. **1** shows one embodiment of a block diagram of a network-based system **100** that is configured to control the spread of a communicable disease according to an embodiment of the present disclosure. As shown, system **100** may comprise or implement a plurality of servers and/or software components that operate to perform various methodologies in accordance with the described embodiments. Exemplary servers may include, for example, stand-alone and enterprise-class servers operating a server OS such as a MICROSOFT® OS, a UNIX® OS, a LINUX® OS, or other suitable server-based OS. It can be appreciated that the servers illustrated in FIG. **1** may be deployed in other ways and that the operations performed and/or the services provided by such servers may be combined or separated for a given implementation and may be performed by a greater number or fewer number of servers. One or more servers may be operated and/or maintained by the same or different entities.

[0016] As shown in FIG. **1**, system **100** includes mobile device **120** (e.g., a smartphone), a wearable device **150** (e.g., wristband activity tracker, smart watch, etc.), a physiological information server **170**, and at least one service provider server or device **180** (e.g., network server device) in communication over a network **160**. Network **160**, in one embodiment, may be implemented as a single network or a combination of multiple networks. For example, in various embodiments, network **160** may include the Internet and/or one or more intranets, landline networks, wireless networks, and/or other appropriate types of communication networks. In another example, network **160** may comprise a wireless telecommunications network (e.g., cellular phone network) adapted to communicate with other communication networks, such as the Internet. As such, in various embodiments, mobile device **120** and service provider server or device **180** may be associated with a particular link (e.g., a link, such as a URL (Uniform Resource Locator) to an IP (Internet Protocol) address).

[0017] Mobile device **120**, in one embodiment, is utilized by a user **102** to interact with service provider server **180** over network **160**. For example, user **102** may transmit physiological information to service provider server **180** via mobile

device **120**. Mobile device **120**, in various embodiments, may be implemented using any appropriate combination of hardware and/or software configured for wired and/or wireless communication over network **160**. In various implementations, mobile device **120** may include at least one of a smartphone, wireless cellular phone, satellite phone, tablet (e.g., iPad™ from Apple®), laptop computer, notebook computer, hybrid/convertible computer, personal computer (PC), and/or other types of mobile computing devices.

[0018] Mobile device **120**, in one embodiment, includes a user interface application **122**, which may be utilized by user **102** to access applications, view physiological information, receive notifications and/or transmit physiological information to service provider server **180** over network **160**. In one aspect, user **102** may login to an account related to user **102** via user interface, application **122**.

[0019] In one implementation, user interface application **122** comprises a software program, such as a graphical user interface (GUI), executable by a processor that is configured to interface and communicate with service provider server **180** via network **160**. In another implementation, user interface application **122** comprises a browser module that provides a network interface to browse information available over network **160**. For example, user interface application **122** may be implemented, in part, as a web browser to view information available over network **160**.

[0020] Mobile device **120**, in various embodiments, includes a disease tracking application **124**. Disease tracking application **124** may be developed by a service provider. Disease tracking application **124** may be downloaded to mobile device **120** from an app store and/or from a service provider website and installed on mobile device **120**. Disease tracking application **124** may receive assessments of whether user **102** is sick or ill from service provider server **180**, and present the assessments to user **102**. Disease tracking application **124**, in one embodiment, receives physiological information from user **102** via the mobile device **120** and provides the physiological information automatically to service provider server **180**.

[0021] Mobile device **120**, in various embodiments, may include other applications **126** as may be desired in one or more embodiments of the present disclosure to provide additional features available to user **102**. In one example, such other applications **126** may include security applications for implementing client-side security features, programmatic client applications for interfacing with appropriate application programming interfaces (APIs) over network **160**, and/or various other types of generally known programs and/or software applications. In still other examples, other applications **126** may interface with user interface application **122** for improved efficiency and convenience.

[0022] Mobile device **120**, in one embodiment, may include at least one user identifier **128**, which may be implemented, for example, as operating system registry entries, cookies associated with user interface application **122**, identifiers associated with hardware of mobile device **120**, or various other appropriate identifiers. User identifier **128** may include one or more attributes related to user **102**, such as personal information related to user **102** (e.g., one or more user names, passwords, photograph images, biometric IDs, addresses, phone numbers, social security number, etc.). In various implementations, user identifier **128** may be passed with a user login request to service provider server **180** via network **160**, and user identifier **128** may be used by service provider server **180** to associate user **102** with a particular user account maintained by service provider server **180**.

[0023] In various implementations, user **102** is able to input data and information into an input component (e.g., a touchscreen, a keyboard, a microphone, etc.) of mobile device **120** to provide physiological information and other user information. The user information may include user identification information.

[0024] Mobile device **120**, in various embodiments, includes a location component **140** configured to determine, track, monitor, and/or provide an instant geographical location of mobile device **120**. In one implementation, the geographical location may include GPS coordinates, zip-code information, area-code information, street address information, and/or various other generally known types of location information. In one example, the location information may be directly entered into mobile device **120** by user **102** via a user input component, such as a keyboard, touch display, and/or voice recognition microphone. In another example, the location information may be automatically obtained and/or provided by the mobile device **120** via an internal or external monitoring component that utilizes a global positioning system (GPS), which uses satellite-based positioning, and/or assisted GPS (A-GPS), which uses cell tower information to improve reliability and accuracy of GPS-based positioning. In other embodiments, the location information may be automatically obtained without the use of GPS. In some instances, cell signals or wireless signals are used. For example, location information may be obtained by checking in using mobile device **120** via a check-in device at a location, such as a beacon. This helps to save battery life and to allow for better indoor location where GPS typically does not work.

[0025] Wearable device **150**, in various embodiments, is utilized by user **102** to interact with mobile device **120** by local wireless communications, such as Bluetooth low energy (i.e., Bluetooth Smart®), wireless local area network (WLAN), Wi-Fi, near field communications (NFC), etc., or by wired communications, such as by a wired Universal Serial Bus (USB) connection. Wearable device **150** can transmit physiological information to mobile device **120**, for example, by wireless syncing via Bluetooth Smart®. Mobile device **120** can, in turn, transmit physiological information to physiological information server **170**. Wearable device **150** may communicate with physiological information server **170** and/or service provider server **180** over network **160** via mobile device **120**.

[0026] Wearable device **150**, in other embodiments, is configured to communicate wirelessly over network **160**. Wireless device **150** may be utilized by user **102** to interact with mobile device **120**, physiological information server **170**, and/or service provider server **180** over network **160**. For example, user **102** may transmit physiological information to mobile device **120**, physiological information server **170**, and/or service provider server **180** via wearable device **150**.

[0027] Wearable device **150**, in various embodiments, may be implemented using any appropriate combination of hardware and/or software configured for wired and/or wireless communication. In various implementations, the wearable device **150** includes at least one of an activity tracker (e.g., Flex™ from Fitbit®, UP24™ from Jawbone®, FuelBand™ by Nike®), which may also be called a fitness tracker and/or health tracker, smart watch (e.g., Galaxy Gear™ from Samsung®, Pebble Steel™ from Pebble®), eyeglasses with

appropriate computer hardware resources (e.g., Google Glass™ from Google®), and/or other types of wearable computing devices.

[0028] Mobile device **120** and/or wearable device **150**, in various embodiments, include one or more sensors **142**. Mobile device **120** and/or wearable device **150** may use sensors **142** to measure, which may include tracking, monitoring, detecting, quantifying, capturing, and/or otherwise measuring, one or more physiological characteristics. Mobile device **120** and/or wearable device **150** may receive data relating to the physiological characteristics, such as measurements and/or counts of the physiological characteristics, from sensors **142**. For example, mobile device **120** and/or wearable device **150** may receive the physiological data by accessing and/or communicating with sensors **142**. Mobile device **120** and/or wearable device **150** may process, analyze, infer from, and/or interpret physiological data, such as raw data of sensor measurements, to generate additional physiological information.

[0029] Sensors **142** may comprise an accelerometer, gyroscope, actimetry sensor, altimeter, pedometer, heart rate sensor, a time measuring device (e.g., a clock, a timer, or a stopwatch), blood pressure sensor, thermometer, an oximeter or other device capable of sensing and/or measuring the presence and/or concentration of oxygen, carbon dioxide, carbon monoxide, and/or the like in the blood, image sensor, thermal camera and/or microphone. The accelerometer that measures acceleration and the gyroscope that measures orientation may be used together to measure movement, such as an activity of user **102**. The accelerometer may be used to measure movement while user **102** is asleep to determine sleep patterns and/or circadian rhythms. The actimetry sensor, which includes an accelerometer and is specialized for measuring movement during sleep, may also be used to determine sleep patterns and circadian rhythms. The altimeter measures altitude and may be used to measure an incline of a path traveled by user **102**. The pedometer measures a number of steps taken by user **102**. The heart rate sensor, blood pressure sensor, and/or thermometer measure vital signs of user **102**.

[0030] In one aspect, when interfacing with mobile device **120** and/or wearable device **150**, user **102** may elect and/or consent to provide personal information, such as physiological information and/or location information, to physiological information server **170** and/or service provider server **180**. User **102** may set or configure the user settings/configuration menu of the mobile device **120** and/or wearable device **150**. Through the user settings/configuration menu, user **102** may provide consent to share personal information and specify the extent of the shared personal information. Mobile device **120** and/or wearable device **150** may transmit the physiological information dynamically by push synchronization, periodically, or each time disease tracking application **124** is opened by user **102**. In some embodiments, user **102** may be prompted for permission to release personal information. Accordingly, user **102** may have exclusive authority to allow transmission of physiological information and/or location information from the mobile device **120** and/or wearable device **150** to physiological information server **170** and/or service provider server **180**.

[0031] Mobile device **120** and/or wearable device **150**, in many embodiments, include a database **144**. Mobile device **120** and/or wearable device **150** may locally store physiological information in database **144**. The physiological information, which is based on the physiological characteristics measured by sensors **142**, may include physiological data, such as raw data of sensor measurements, the physiological data processed into information relating to physiological characteristics, physiological characteristic history and trends over time, etc.

[0032] The physiological information, in many embodiments, includes a variety of types of physiological information. The physiological information may include, for example, sleep-related information, vital sign-related information, activity information, etc. Each type of physiological information may be based on one or more physiological characteristics. One physiological characteristic can be used for more than one type of physiological information. For example, the physiological characteristic of heart rate may be used for sleep-related information, such as to determine whether user **102** is asleep, and also be used for activity information, such as to determine the number of calories burned.

[0033] Sleep-related information may include sleep patterns, circadian rhythms, number of hours slept, including number of hours in rapid eye movement (REM) sleep and deep sleep, and/or quality of sleep. Sleep-related information may also include trends and/or averages of each thereof. Sleep-related information may be based on measurements of movement, noise, temperature, heart rate, and/or location of user **102** (e.g., at home or hotel room) by sensors **142**.

[0034] Activity information may include a number of steps taken, distance traveled by walking, jogging, running, cycling, etc., length of time exercised, and/or calories burned. Activity information may be based on measurements of a step count, incline of path of travel, heart rate, and/or location tracking.

[0035] Vital sign-related information may include measured vital signs, measured changes in vital signs, trends and averages over time, and any other information related to vital signs. The vital signs include a heart rate, breathing/respiratory rate, temperature, and blood pressure. The changes in vital signs may be measured to determine whether user **102** is sick or ill.

[0036] Mobile device **120** and/or wearable device **150** may transmit physiological information to another user device (e.g., a PC or laptop), physiological information server **170**, and/or service provider server **180**. The other user device, wearable device **150**, physiological information server **170**, and/or the service provider server **180** may further process, analyze, infer from, and/or interpret physiological information to generate additional physiological information. The other user device, physiological information server **170**, and/or service provider server **180** can store a physiological history that includes long-term physiological information compiled over time, and physiological trends and averages based on the physiological history.

[0037] Mobile device **120**, wearable device **150**, physiological information server **170**, and/or service provider server **180**, in one embodiment, may take into account various non-physiological information, such as a time of day, location of user **102**, schedule of user **102**, calendar of user **102**, etc. when generating and/or processing physiological information. For example, a time of a day (e.g., night time), a location (e.g., at home, at a vacation location, or at a hotel), a day of the year, and/or a combination of information (e.g., at a store at 2 a.m. for the day after Thanksgiving shopping) may be used to determine and/or infer whether user **102** is sick or well.

[0038] Physiological information server **170**, in one embodiment, may be maintained by a business entity that

produces wearable device **150** (e.g., Fitbit®, Pebble®, Nike®, Samsung®, etc.), a partner of that business entity, and/or by an online service provider. Physiological information server **170** maintains one or more accounts in an account database **174**, each of which may include account information **176** associated with an individual users (e.g., user **102**) and/or an individual wearable device (e.g., wearable device **150**). For example, account information **194** may include physiological information, such as physiological characteristics measured by sensors **142** on wearable device **150**. Physiological information server **170** may communicate physiological information to mobile device **120**, wearable device **150**, and/or service provider server **180**.

[0039] Physiological information server **170**, in one embodiment, includes a wearable device application **172**. Wearable device application **172** provides an interface in which user **102** may view physiological information, track trends, and/or process information. For example, user **102** may be able to access wearable device application **172** through a website maintained by physiological information server **170**.

[0040] Service provider server **180**, in various embodiments, may be maintained by a service provider that provides online services and/or processing for information transactions. As such, service provider server **180** includes a service application **182**, which may be adapted to interact with the mobile device **120** over the network **160** to facilitate the receipt and analysis of physiological information from mobile device **120**, wearable device **150**, and/or physiological information server **170**. In one example, service provider server **180** may be provided by a service provider such as PayPal®, Inc. (an eBay® company) of San Jose, Calif., USA.

[0041] Service provider server **180**, in an embodiment, receives physiological information and/or location information from mobile device **120**, wearable device **150**, and/or physiological information server **170**. In certain embodiments, service provider **170** directly receives the physiological information from mobile device **120** and/or wearable device **150** over network **160**. In other embodiments, service provider **180** receives the physiological information via an intermediary such as physiological information server **170** because, for example, wearable device **150** does not have connectivity to network **160** and/or the wearable device company that produces wearable device **150** does not makes the data and/or information accessible to third parties. In some embodiments, service provider server **180** receives the physiological information by accessing and/or retrieving the physiological information on mobile device **120**, wearable device **150**, and/or physiological information server **170**.

[0042] Service provider server **180**, in one embodiment, may be configured to maintain one or more user accounts in database **192**, each of which may include account information **194** associated with one or more individual users (e.g., user **102**). Account information **194** may include physiological information and/or location information. In various aspects, the methods and systems described herein may be modified to accommodate users that may or may not be associated with at least one existing user account.

[0043] Service application **182**, in one embodiment, utilizes a disease tracking application **184** to determine whether a user is sick with a communicable disease based on physiological information. For example, if user **102**'s body temperature is elevated without accompanying measurements indicating physical activity or other explanation, disease tracking application **184** can infer that user **102** is sick. In one implementation, disease tracking application **184** calculates the risk that a user is ill and should be quarantined or at least be limited to exposure with others. The risk calculation may be a combination of multiple risk sub-assessments that may be applied to produce a total risk calculation. For example, besides physiological information of user **102**, disease tracking application **184** may further analyze location information, a time of day, schedule of user **102**, calendar of user **102**, etc. By analyzing location history and finding anomalies (such as user **102** being home or at the doctor's office when they are usually at work), and combining this with physiological data, disease tracking application **184** can infer with high certainty that user **102** is ill. The location information allows disease tracking application **184** to track areas where user **102** visited and who user **102** may have infected or been in contact with, along with where user **102** may be planning to go. Location data can also be used for research purposes to determine onset of symptoms and track diseases throughout populations, including identification of the first infected person within a population, as well as notifying others at locations where user **102** may be planning to go.

[0044] The result of the calculation is an indicator that marks the risk that the user is sick with a communicable disease. The indicator may be present in many forms, such as an overall score, a percentile, or it may further be translated to a standardized indicator, such as high, medium, or low. Based on the indicator, the disease tracking application **184** can notify user **102** that he or she is sick, as well as provide recommendations and other actionable information on how to prevent the further spread of disease. For example, establishments that care for individuals with weaker immune systems (such as hospitals or nursing homes) can use this data to prohibit access to those who are known to be ill or may have been exposed to a communicable disease. This can also be applied to areas where healthy individuals are required, such as the donation of blood or plasma. The service provider, such as through the disease tracking application **184**, can also notify others that were at locations with user **102**, are currently at a location with user **102**, or may be at a location user **102** may be going to (e.g., by accessing schedule and/or calendar of user **102**), which enables these other users to take desired actions, such as getting a checkup or avoiding a location user **102** may be at in the future.

[0045] In one implementation, user **102** may have identity attributes stored with service provider server **180**, and user **102** may have credentials to authenticate or verify identity with service provider server **180**. User attributes may include personal information and/or physiological information. In various aspects, the user attributes may be passed to service provider server **180** as part of a login, search, and/or selection, and the user attributes may be utilized by service provider server **180** to associate user **102** with one or more particular user accounts maintained by the service provider server **180**.

[0046] FIG. **2** illustrates an embodiment of a service provider server **180**. The server **180** includes several components or modules, such as a communication module **202**, disease analysis module **204**, notification module **206**, location module **208**, display module **210**, and storage module **212**.

[0047] The server **180** includes a communication module **202** that is coupled to the network **214** and to any or all of disease analysis module **204**, notification module **206**, location module **208**, and display module **210**, any of which may be coupled to a storage module **212**. Any or all of the modules

202-210 may be implemented as a subsystem of the server **180** including for example, a circuit, a hardware component, a hardware subcomponent, and/or a variety of other subsystems known in the art. Furthermore, any or all of the modules **202-210** may be preconfigured to perform their disclosed functionality, or may be configured by a processing system "on-the-fly" or as needed to perform their disclosed functionality. As such, any or all of the modules **202-210** may include pre-configured and dedicated circuits and/or hardware components of the service provider server **180**, or may be circuits and/or hardware components that are configured as needed.

[0048] For example, any or all of the modules **202-210** may be provided via one or more circuits that include resistors, inductors, capacitors, voltage sources, current sources, switches, logic gates, registers, and/or a variety of other circuit elements known in the art. One or more of the circuit elements in a circuit may be configured to provide the circuit (s) that cause the modules **202-210** to perform the functions described above. As such, in some embodiments, preconfigured and dedicated circuits may be implemented to perform the functions of the modules **202-210**. In other embodiments, a processing system may execute instructions on a non-transitory, computer-readable medium to configure one or more circuits as needed to perform the functions of the modules **202-210**.

[0049] The communication module **202** may be included as a separate module provided in the server **180**, or may be provided using instructions stored on a computer-readable medium that, when executed by a processing system in the server **180**, configure the communication module **202** to send and receive information over the network **214**, as well as provide any of the other functionality that is discussed above. The disease analysis module **204** may be included as a separate module provided in the server **180**, or may be provided using instructions stored on a computer-readable medium that, when executed by a processing system in the server **180**, configure the disease analysis module **204** to receive physiological characteristics from sensors **142**, calculate the likelihood that a user is sick, identify a communicable sickness or disease, monitor the status of a user, and query devices for physiological information, as well as provide any of the other functionality that is discussed above. The notification module **206** may be included as a separate module provided in the server **180**, or may be provided using instructions stored on a computer-readable medium that, when executed by a processing system in the server **180**, configure the notification module **206** to notify users that they are sick and provide suggestions to users to prevent the further spread of disease, as well as provide any of the other functionality that is discussed above. The location module **208** may be included as a separate module provided in the server **180**, or may be provided using instructions stored on a computer-readable medium that, when executed by a processing system in the server **180**, configure the location module **208** to receive location information from mobile device **120** and/or wearable device **150**, as well as provide any of the other functionality that is discussed above. The display module **210** may be included as a separate module provided in the server **180**, or may be provided using instructions stored on a computer-readable medium that, when executed by a processing system in the server **180**, configure the display module **210** to display a map or other visual representation of locations where infected persons have visited or are located, as well as provide any of the other functionality that is discussed above. While the storage module **212** has been illustrated as located in the server **180**, one of ordinary skill in the art will recognize that it may include multiple storage modules and may be connected to the modules **204-210** through the network **214** without departing from the scope of the present disclosure.

[0050] Referring now to FIG. **3**, a flowchart of a method **300** for controlling the spread of a communicable disease is illustrated according to an embodiment of the present disclosure. At step **302**, mobile device **120** or wearable device **150** measures, which may include tracking, monitoring, detecting, quantifying, capturing, and/or otherwise measuring, one or more physiological characteristics of the user **102**. The physiological characteristics can include, for example, physiological data (e.g., vital sign and physical activity data), such as blood pressure, pulse, respiration rate, body temperature, hydration level, physical activity, oxygen consumption, carbon dioxide levels, and glucose or blood sugar level. Physical activities that may be measured include, but are not limited to, walking, running, and swimming.

[0051] At step **304**, disease analysis module **204** receives the one or more physiological characteristics of user **102** and assesses a likelihood or probability that the user **102** is sick based on the received characteristics. In an embodiment, disease analysis module **204** receives the physiological characteristics from mobile device **120**, wearable device **150**, and/or physiological information server **170**. The extent of physiological information that is received by disease analysis module **204** may depend on user consent and/or election. Disease analysis module **204** may store the physiological information on database **192**, and may further process the physiological information.

[0052] To assess the likelihood that user **102** is sick, disease analysis module **204** evaluates the one or more physiological characteristics. For example, if user **102** has a higher than normal temperature, increased pulse, increased heart rate, disturbed sleep pattern and low physical activity level, the disease analysis module **204** can infer that user **102** is not well. In various embodiments, disease analysis module **204** inputs the values of the physiological characteristics (e.g., numerical values for body temperature, pulse rate, heart rate, etc.) into a probabilistic model or algorithm to determine a likelihood that user **102** is sick. The probabilistic model may be built using previously collected physiological data. The probabilistic model may output an indicator or score. If the indicator or score exceeds a certain predetermined threshold, then user **102** may be determined to be sick. For example, if the predetermined threshold is set at 50% and the calculated score is 70%, user **102** is determined to be sick. On the other hand, if the calculated score is only 30%, user **102** is determined not to be sick.

[0053] In several exemplary embodiments, physiological information may be coupled or combined with non-physiological information such as location of user **102**, time of day, and calendar or schedule of user **102** to determine the likelihood that user **102** is sick with a communicable disease. In one implementation, disease analysis module **204** accesses user **102**'s location and calendar to determine whether user **102** is sick with a communicable disease. For example, disease analysis module **204** may learn that user **102** is at home when he or she is scheduled to be in the office at a meeting. The non-physiological information can increase or decrease the likelihood that user **102** is sick. For example, in the above case, the fact that user **102** is at home rather than in the office

increases the likelihood that user **102** is sick. In various embodiments, the non-physiological information may be input into the probabilistic model or algorithm to output a revised score that indicates a revised likelihood that user **102** is sick.

[0054] The physiological information may be transmitted to disease analysis module **204** dynamically by automatic synchronization or periodically every predetermined time period (e.g., every 3 hours). For example, mobile device **120** and/or wearable device **150** may measure the physiological characteristics of user **102** and directly transmit the physiological information to service provider server **180**. In another example, mobile device **120** and/or wearable device **150** may transmit the physiological information to physiological information server **170**, which stores and maintains the physiological information of user **102**. Disease analysis module **204** may in turn receive the physiological information from physiological information server **170**.

[0055] In one embodiment, when user **102** is determined to be sick, further analysis determines whether the sickness is communicable. For example, indications of a headache likely due to causes not communicable through touch or air may result in different actions performed by the system **100**. For example, the notification module **206** would not warn user **102** to stay away from others and public places, or warn others who were exposed to user **102**. The notification module **206** may still provide suggestions or recommendations to user **102** such as seeing a doctor or getting rest. In some embodiments, disease analysis module **204** may attempt to identify the non-communicable disease by matching the symptoms and signs exhibited by user **102** with known non-communicable diseases.

[0056] At step **306**, when user **102** is determined to be sick with a communicable disease, notification module **206** notifies user **102** that he or she is sick and provides a course of action to prevent the further spread of the communicable disease. For example, notification module **206** can suggest that user **102** stay home, stay away from certain areas (nursing homes, hospitals, etc.), and/or schedule an appointment to see his or her doctor. In some embodiments, notification module **206** also notifies user **102**'s doctor to let the doctor know that user **102** is sick so that the doctor can check up on user **102**. The one or more courses of action generally include a strategy to control the spread of the communicable disease. The strategy to control the spread of the disease can include one or more of household quarantine, individual quarantine, geographic quarantine, social distancing, hospitalization, school closure, work place closure, travel restrictions, public transit closure, therapeutic treatment or intervention, prophylactic treatment or intervention, vaccination, provision of protective clothing, provision of masks, warning or notification of others, and additional point-of-care testing.

[0057] In some embodiments, physiological information of user **102** is periodically monitored to determine how long user **102** is sick or remains contagious. Once the risk level of infection goes down, notification module **206** can notify user **102** that he or she is allowed to go outside and/or back to work.

[0058] At step **308**, disease analysis module **204** identifies user **102**'s communicable sickness or disease based on the one or more physiological characteristics. In other words, disease analysis module **204** diagnoses the communicable disease based on the symptoms or signs exhibited by user **102**. In the above example, user **102** is experiencing a fever, increased pulse, and increased heart rate, which are signs of the flu. Disease analysis module **204** may examine all the different diseases that have these signs to come up with the best match. For example, disease analysis module **204** may analyze the primary symptoms or signs of a disease to determine a match or eliminate possible diseases, and then use secondary symptoms or signs to narrow down a list of possible diseases.

[0059] Once the communicable disease is identified, disease analysis module **204** at step **310** determines the incubation period of the disease. For example, disease analysis module **204** may access a database and search for the specific incubation period. The incubation period is the period between exposure to a pathogenic organism or virus that causes the disease and when symptoms or signs are first apparent. For example, the incubation period for the flu is typically between 24 hours and 4 days, with the average being 2 days. A person can be contagious during the incubation period.

[0060] In various embodiments, user **102** reports to the disease analysis module **204** that he or she is sick and identifies the communicable sickness or disease. In these embodiments, there is no need for disease analysis module **204** to analyze physiological information. In certain embodiments, disease analysis module **204** receives both physiological information from a device and information from user **102**. For example, disease analysis module **204** may receive blood pressure, heart rate, and respiratory rate data from the device and also data regarding headaches, stomachaches, and fatigue from user **102**.

[0061] At step **312**, location module **208** transmits a request to mobile device **120** regarding locations visited by the user **102** during the incubation period and receives locations visited by user **102**. For example, assuming user **102** has the flu, location module **208** queries mobile device **120** regarding the locations visited by user **102** in the last 4 days.

[0062] At step **314**, location module **208** takes the locations visited by the user **102** during the incubation period and identifies who user **102** was in contact with. For example, location module **208** can take the different locations of user **102** and compare these locations with the locations of other users at the time using GPS. If the locations are within a predetermined distance (e.g., within 1-3 feet) of each other, location module **208** can conclude that the other users were exposed to user **102**. In another example, location module **208** determines if two user devices were close enough to communicate or exchange data (such as through Bluetooth technology). If the two users were close enough to exchange information, location module **208** determines that the users were close enough to infect each other.

[0063] Once the location module **208** knows who user **102** was in contact with, disease analysis module **204** can query the user devices of those who were contacted or exposed to user **102** for physiological information and determine if those users are sick. If they are sick, the above-described steps can be repeated to determine their locations and who they were in contact with. In certain embodiments, location module **208** can determine the source of the sickness. In various embodiments, notification module **206** notifies those users who are or were in contact with user **102** that they are sick or were in contact with someone who is sick. In certain embodiments, notification module **206** notifies those who may be at a location that user **102** may be visiting of the possible threat. Notification module **206** can also provide a course of action to

these users, such as getting a checkup, avoiding certain locations, and/or wearing protective clothing.

[0064] At step **316**, the display module **210** graphs or maps out all the locations where sick or exposed persons (e.g., user **102** and those exposed or infected by user **102**) have visited or are located so that the results are shown visually. The map can be sent out to hospitals, clinics, doctors, and/or users who frequent or live in the area to notify them of the spread of the disease, that they may be in contact with the disease and/or so they can avoid the area.

[0065] Referring now to FIG. **4**, a block diagram of a system **400** is illustrated suitable for implementing embodiments of the present disclosure, including mobile device **120**, wearable device **150**, physiological information server or device **170**, and service provider server or device **180**. System **400**, such as part of a cell phone, a tablet, a personal computer and/or a network server, includes a bus **402** or other communication mechanism for communicating information, which interconnects subsystems and components, including one or more of a processing component **404** (e.g., processor, microcontroller, digital signal processor (DSP), etc.), a system memory component **406** (e.g., RAM), a static storage component **408** (e.g., ROM), a network interface component **412**, a display component **414** (or alternatively, an interface to an external display), an input component **416** (e.g., keypad or keyboard), a cursor control component **418** (e.g., a mouse pad), and a sensor component **430** (e.g., gyroscope, accelerometer, camera, pedometer, heart rate monitor, etc.).

[0066] In accordance with embodiments of the present disclosure, system **400** performs specific operations by processor **404** executing one or more sequences of one or more instructions contained in system memory component **406**. Such instructions may be read into system memory component **406** from another computer readable medium, such as static storage component **408**. These may include instructions to receive physiological information, identify diseases, monitor physiological information, receive location information, provide notifications and courses of action to users, etc. In other embodiments, hard-wired circuitry may be used in place of or in combination with software instructions for implementation of one or more embodiments of the disclosure.

[0067] Logic may be encoded in a computer readable medium, which may refer to any medium that participates in providing instructions to processor **404** for execution. Such a medium may take many forms, including but not limited to, non-volatile media, volatile media, and transmission media. In various implementations, volatile media includes dynamic memory, such as system memory component **406**, and transmission media includes coaxial cables, copper wire, and fiber optics, including wires that comprise bus **402**. Memory may be used to store visual representations of the different options for searching, auto-synchronizing, storing access control information, making payments, or conducting financial transactions. In one example, transmission media may take the form of acoustic or light waves, such as those generated during radio wave and infrared data communications. Some common forms of computer readable media include, for example, RAM, PROM, EPROM, FLASH-EPROM, any other memory chip or cartridge, carrier wave, or any other medium from which a computer is adapted to read.

[0068] In various embodiments of the disclosure, execution of instruction sequences to practice the disclosure may be performed by system **400**. In various other embodiments, a plurality of systems **400** coupled by communication link **420** (e.g., network **160** of FIG. **1**, LAN, WLAN, PTSN, or various other wired or wireless networks) may perform instruction sequences to practice the disclosure in coordination with one another. Computer system **400** may transmit and receive messages, data, information and instructions, including one or more programs (i.e., application code) through communication link **420** and communication interface **412**. Received program code may be executed by processor **404** as received and/or stored in disk drive component **410** or some other non-volatile storage component for execution.

[0069] In view of the present disclosure, it will be appreciated that various methods and systems have been described according to one or more embodiments for controlling the spread of a communicable disease.

[0070] Although various components and steps have been described herein as being associated with mobile device **120**, one or more merchant servers or devices **130**, wearable device **150**, personal metric information server or device **170**, and service provider server or device **180** of FIG. **1**, it is contemplated that the various aspects of such servers illustrated in FIG. **1** may be distributed among a plurality of servers, devices, and/or other entities.

[0071] Where applicable, various embodiments provided by the present disclosure may be implemented using hardware, software, or combinations of hardware and software. Also where applicable, the various hardware components and/or software components set forth herein may be combined into composite components comprising software, hardware, and/or both without departing from the spirit of the present disclosure. Where applicable, the various hardware components and/or software components set forth herein may be separated into sub-components comprising software, hardware, or both without departing from the spirit of the present disclosure. In addition, where applicable, it is contemplated that software components may be implemented as hardware components, and vice-versa.

[0072] Software in accordance with the present disclosure, such as program code and/or data, may be stored on one or more computer readable mediums. It is also contemplated that software identified herein may be implemented using one or more specific purpose computers and/or computer systems, networked and/or otherwise. Where applicable, the ordering of various steps described herein may be changed, combined into composite steps, and/or separated into substeps to provide features described herein.

[0073] The various features and steps described herein may be implemented as systems comprising one or more memories storing various information described herein and one or more processors coupled to the one or more memories and a network, wherein the one or more processors are operable to perform steps as described herein, as non-transitory machine-readable medium comprising a plurality of machine-readable instructions which, when executed by one or more processors, are adapted to cause the one or more processors to perform a method comprising steps described herein, and methods performed by one or more devices, such as a hardware processor, mobile device, server, and other devices described herein.

What is claimed is:

1. A system, comprising:

a disease analysis module that receives physiological information of a user or a report from a user of a communicable disease, combines the physiological information

or report with location information of the user to track the user and identify individuals who were exposed to the user, and queries user devices of the identified individuals for physiological information of the identified individuals;

a location module that requests and receives the location information from a user device of the user; and

a notification module that provides at least one course of action to the user and identified individuals.

2. The system of claim **1**, wherein the physiological information comprises one or more of blood pressure, pulse, respiration rate, body temperature, hydration level, physical activity, oxygen consumption, carbon dioxide levels, and glucose or blood sugar level.

3. The system of claim **1**, wherein the at least one course of action comprises one or more of household quarantine, individual quarantine, geographic quarantine, social distancing, hospitalization, therapeutic treatment or intervention, prophylactic treatment or intervention, vaccination, use of protective clothing or masks, and additional testing.

4. The system of claim **1**, wherein the disease analysis module further receives physiological information of the identified individuals and determines that the identified individuals are ill.

5. The system of claim **4**, wherein the notification module further alerts the identified individuals that they are ill.

6. The system of claim **1**, wherein the disease analysis module further monitors the physiological information of the user for a period of time.

7. The system of claim **6**, wherein the notification module further alerts the user when the user is no longer contagious.

8. The system of claim **1**, further comprising a display module that presents a visual representation of one or more zones of locations of infected persons, location of persons at risk for infection, a spread of infection over time, or any combination thereof.

9. The system of claim **1**, wherein the disease analysis module further identifies individuals who are currently at a location with the user, at a location the user is expected to visit, or both.

10. The system of claim **9**, wherein the notification module further alerts the identified individuals who are currently at a location with a user, at a location the user is expected to visit, or both, of a risk of infection.

11. A method for controlling the spread of a communicable disease, comprising:

receiving, by a disease analysis module of a service provider from sensors on a user device, physiological information of a user;

receiving, by a location module of the service provider from the user device, location information of the user;

determining, by the disease analysis module, that the user is ill with a communicable disease based on the physiological information and the location information;

alerting, by a notification module of the service provider, the user that the user is ill;

identifying, by the disease analysis module, the communicable disease based on the physiological information; and

evaluating, by the disease analysis module, the location information, movement of the user, and intersection of the user with other individuals to identify individuals exposed to the communicable disease.

12. The method of claim **11**, further comprising receiving, by the disease analysis module, calendar or schedule information of the user.

13. The method of claim **12**, further comprising combining, by the disease analysis module, the calendar or schedule information with the physiological information and location information to determine that the user is ill.

14. The method of claim **11**, further comprising determining, by the disease analysis module, an incubation period of the identified communicable disease.

15. The method of claim **14**, further comprising requesting, by the location module to the user device, locations visited by the user during the incubation period.

16. The method of claim **15**, further comprising identifying, by the location module, the intersection of the user with other individuals.

17. A non-transitory computer-readable medium comprising executable modules which, in response to execution by a computer system, cause the computer system to perform a method comprising:

receiving, by a disease analysis module of a service provider from sensors on a user device, physiological information of a user;

receiving, by a location module of the service provider from the user device, location information of the user;

calculating, by the disease analysis module, a likelihood that the user is ill with a communicable disease based on the physiological information and the location information;

alerting, by the notification module of the service provider, the user that the user is ill;

providing, by the notification module, a course of action to the user;

identifying, by the location module, individuals who the user was in contact with; and

presenting, by a display module of the service provider, a visual representation of one or more zones of locations of infected persons, location of persons at risk for infection, a spread of infection over time, or any combination thereof.

18. The non-transitory machine-readable medium of claim **17**, wherein calculating the likelihood that the user is ill comprises inputting the physiological information and location information into a probabilistic model.

19. The non-transitory machine-readable medium of claim **18**, wherein calculating the likelihood that the user is ill further comprises inputting time of day, calendar information, schedule information, or a combination thereof into the probabilistic model.

20. The non-transitory machine-readable medium of claim **17**, wherein the method further comprises requesting, by the disease analysis module, physiological information of the individuals who the user was in contact with.

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