US 20190139391A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2019/0139391 A1**

LEE et al. (43) **Pub. Date: May 9, 2019**

(54) **SAFETY STATUS SENSING SYSTEM AND SAFETY STATUS SENSING METHOD THEREOF**

(71) Applicant: **Institute For Information Industry**, Taipei (TW)

(72) Inventors: **Jia-Ru LEE**, Kaohsiung City (TW); **Hung-Sheng CHIU**, Taipei City (TW); **Chih-Hao HSU**, Taipei City (TW); **Hsiu-Fen LEE**, Nantou County (TW); **Hsiao-Chen CHANG**, Taipei City (TW)

(21) Appl. No.: **15/936,352**

(22) Filed: **Mar. 26, 2018**

(30) **Foreign Application Priority Data**

Nov. 3, 2017 (TW) 106138149

Publication Classification

(51) **Int. Cl.**

G08B 21/04 (2006.01)

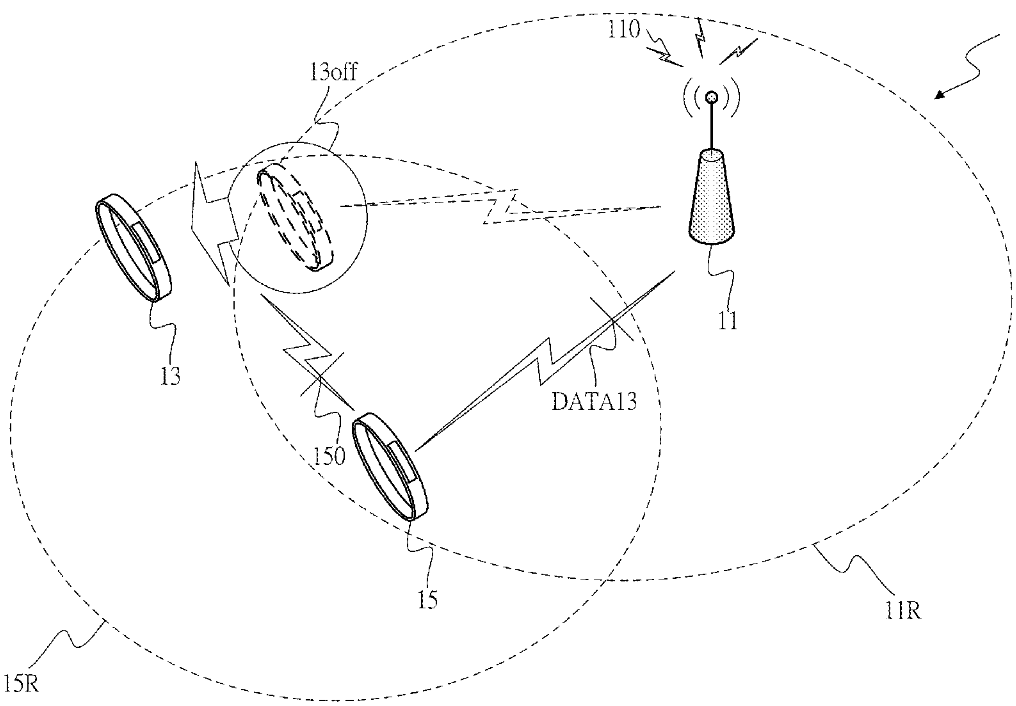
A61B 5/00 (2006.01)

(52) **U.S. Cl.**

CPC ***G08B 21/0453*** (2013.01); *A61B 5/024* (2013.01); ***A61B 5/0022*** (2013.01); ***A61B 5/746*** (2013.01)

(57) **ABSTRACT**

A safety status sensing system and a safety status sensing method thereof are provided. A first wearable sensing device periodically transmits a first safety status message to the LoRa host. After determining no message received from the first wearable sensing device within a first time period, the LoRa host issues a first alarm message and determines an off-line location of the first wearable sensing device according to the first device information of the first wearable sensing device. The LoRa host determines that the off-line location is within a communication coverage of the second wearable sensing device, and transmits the first device information to the second wearable sensing device. The second wearable sensing device transmits a point-to-point communication signal to the first wearable sensing device according to the first device information.



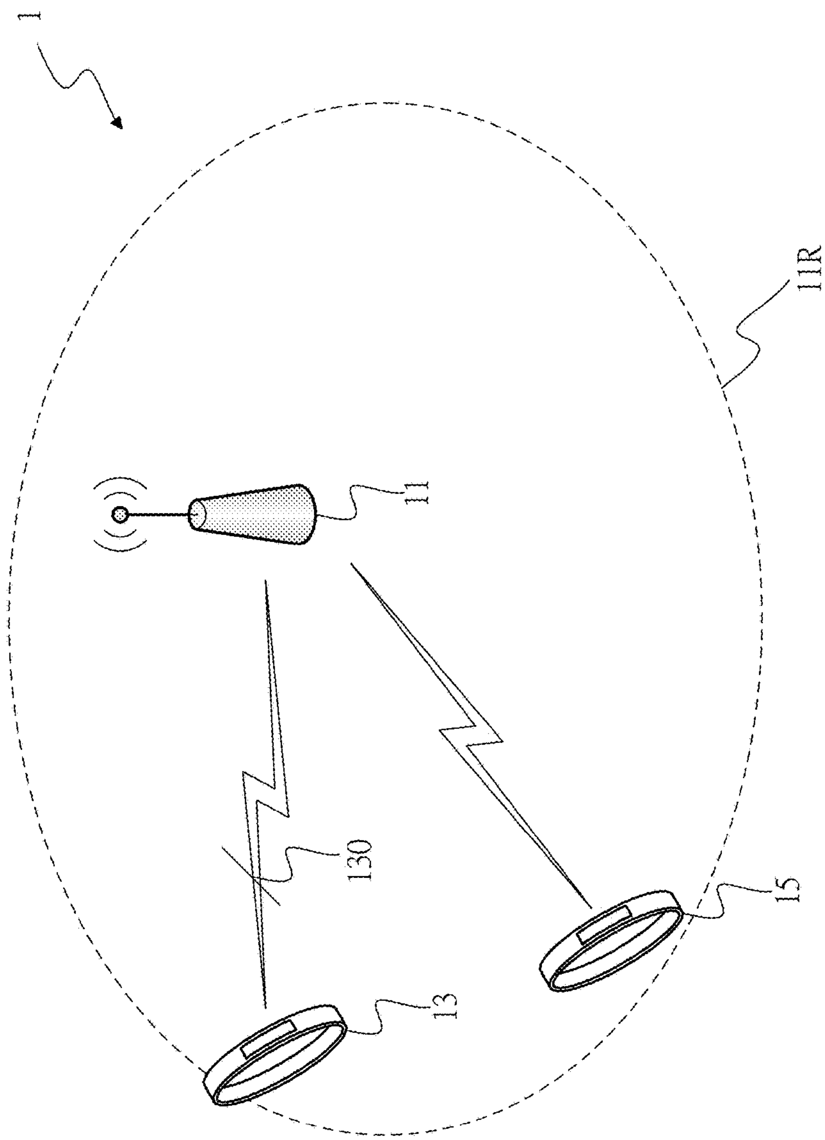


FIG. 1A

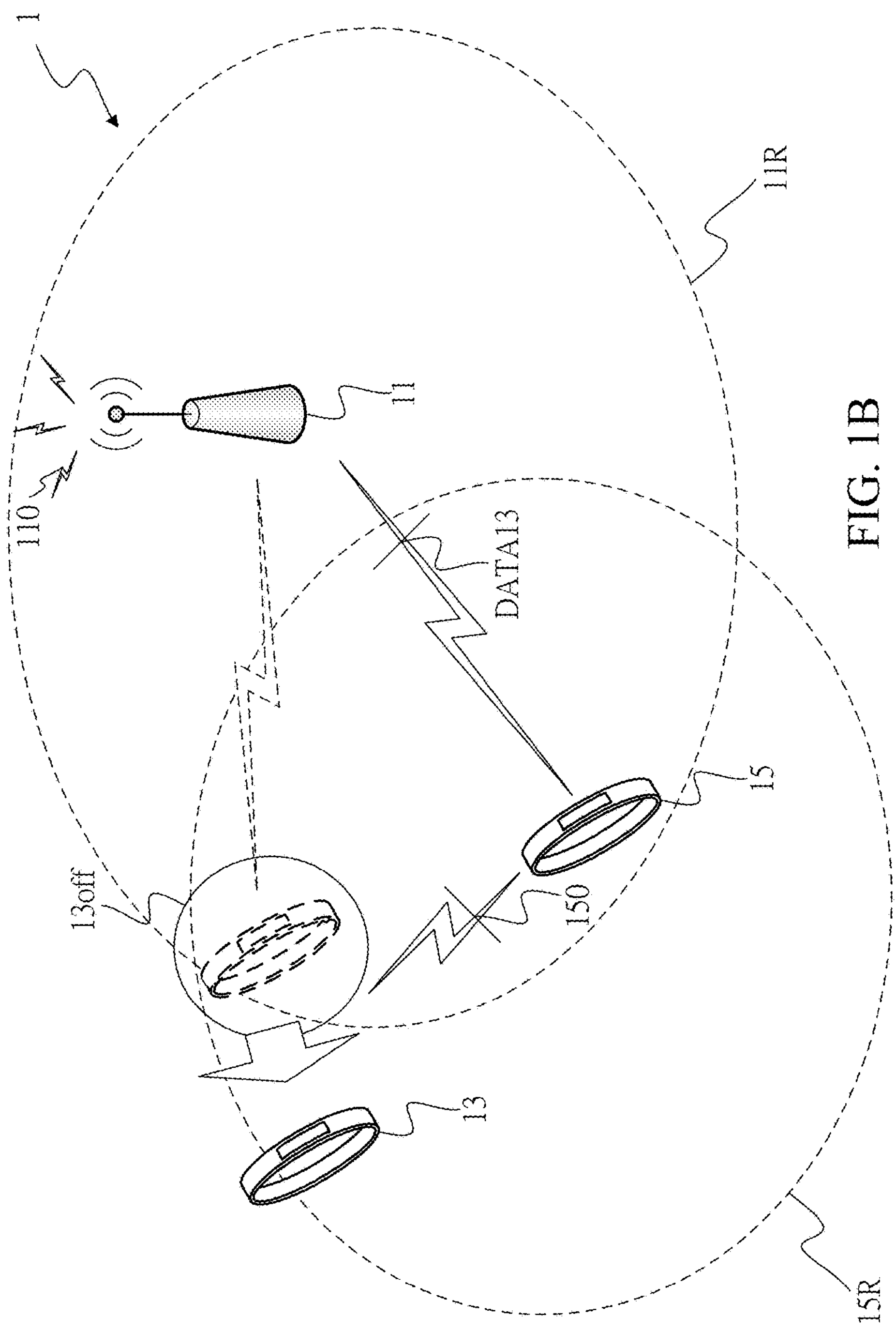


FIG. 1B

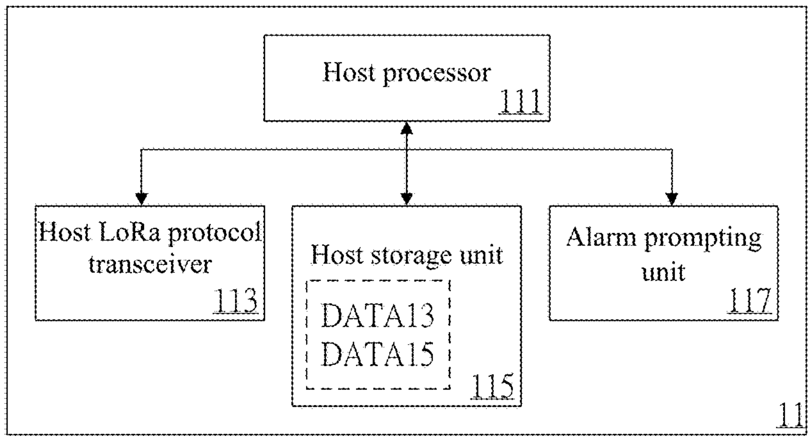


FIG. 1C

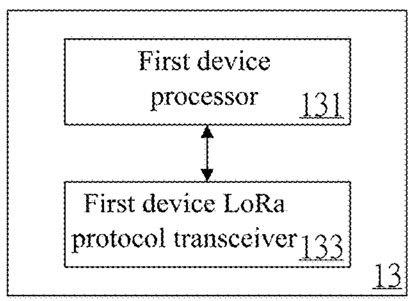


FIG. 1D

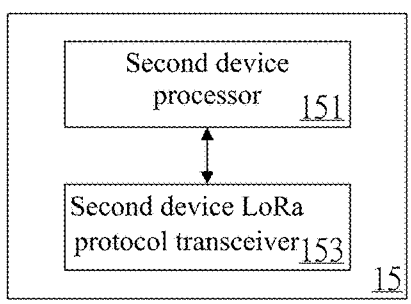


FIG. 1E

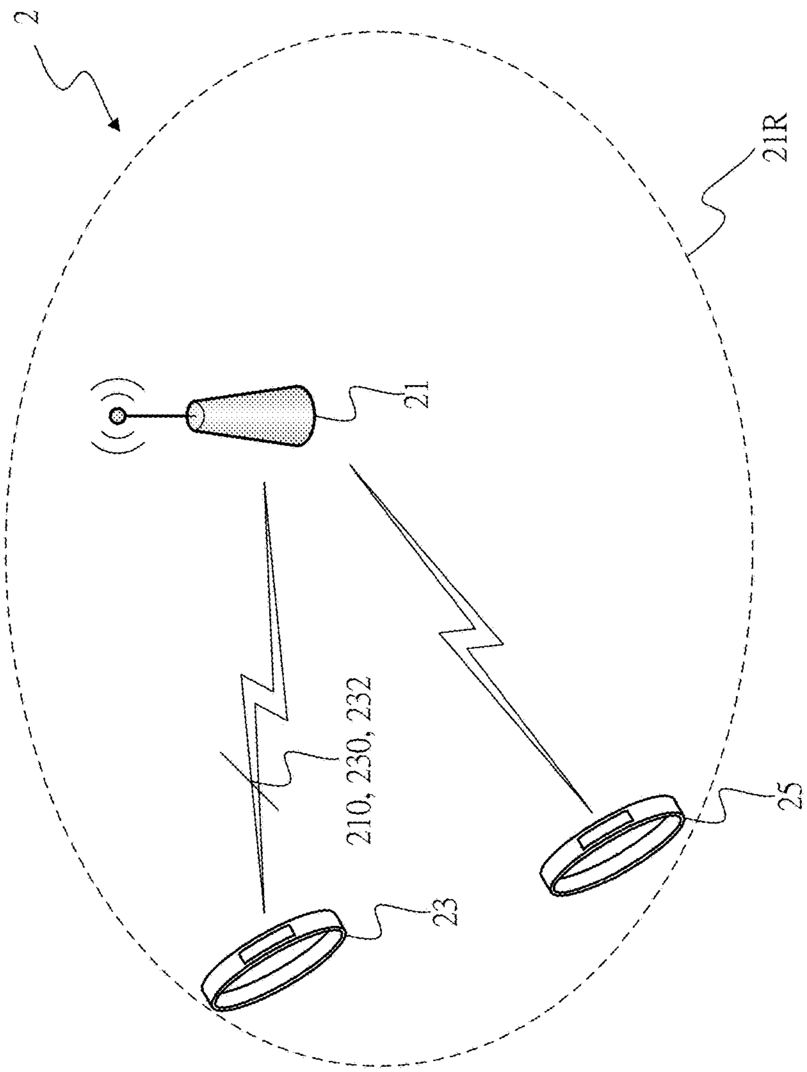


FIG. 2A

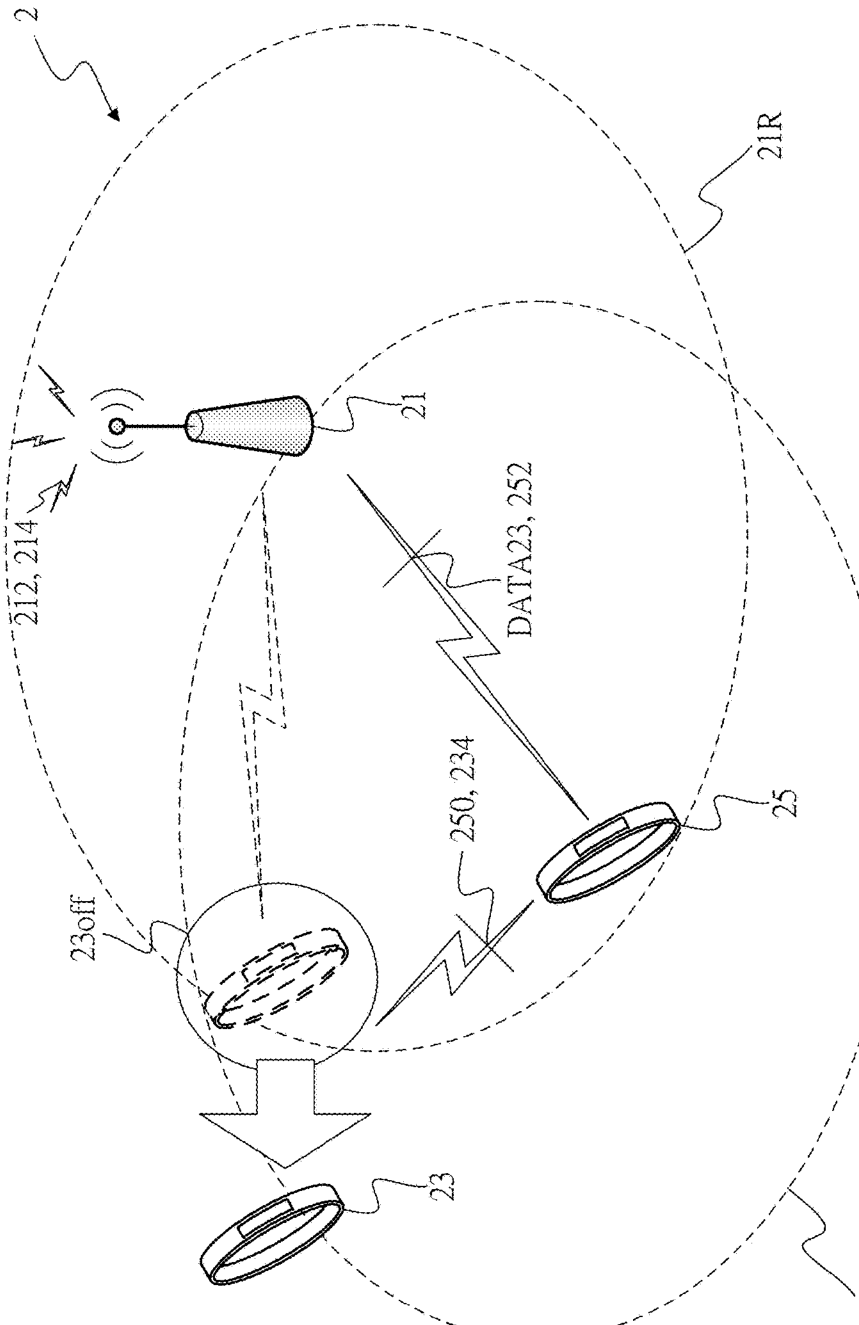


FIG. 2B

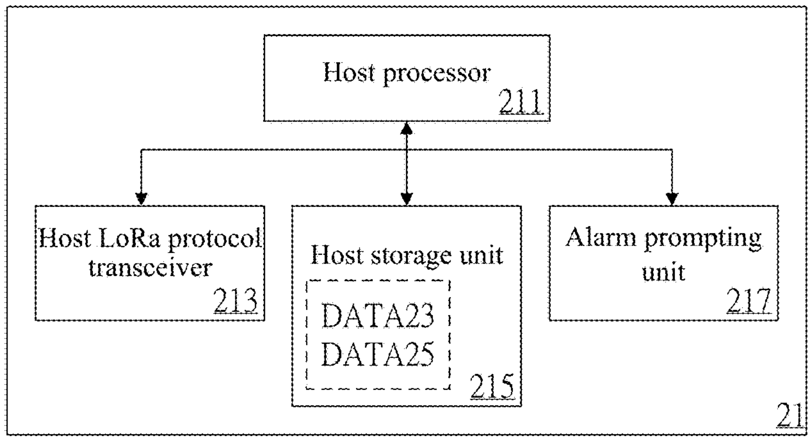


FIG. 2C

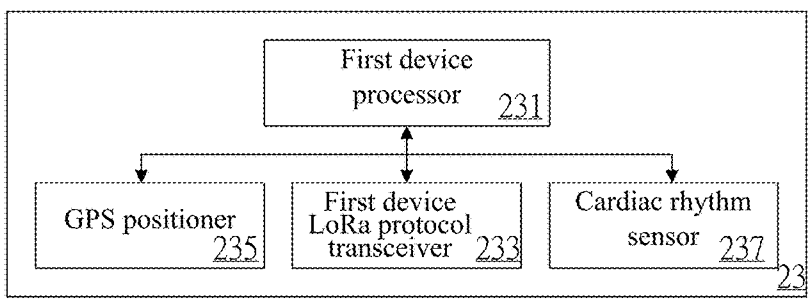


FIG. 2D

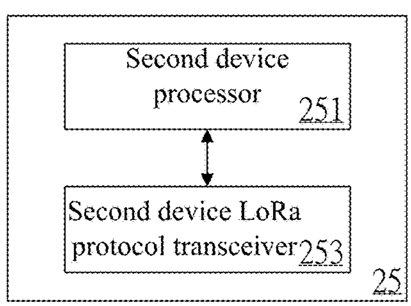


FIG. 2E

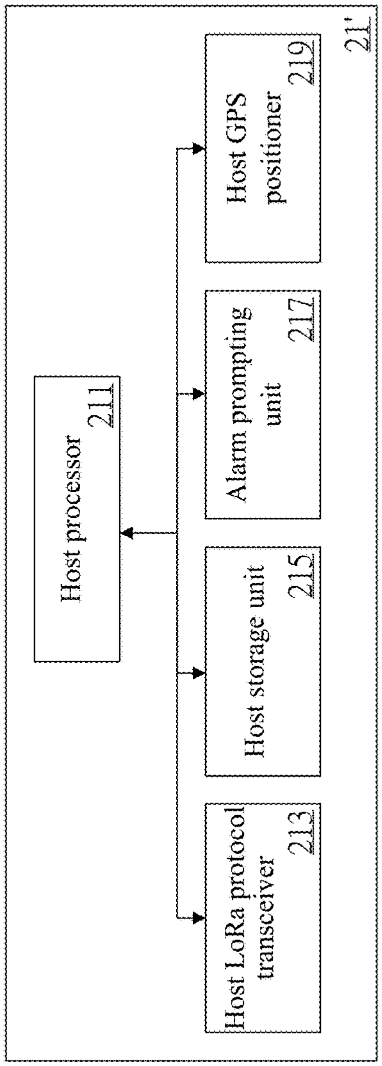

Host processor
211
Host LoRa protocol transceiver
213
Host storage unit
215
Alarm prompting unit
217
Host GPS positioner
219
21'

FIG. 2F

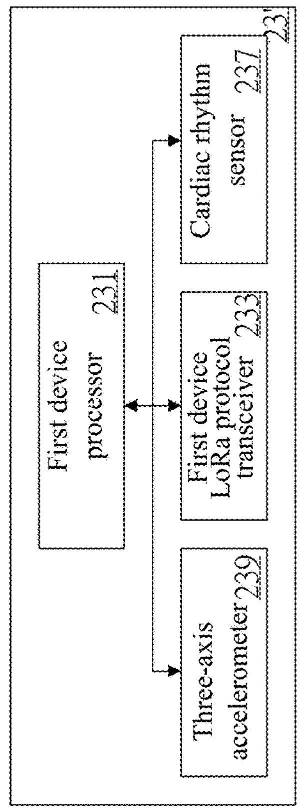

First device processor
231
Three-axis accelerometer
239
First device LoRa protocol transceiver
233
Cardiac rhythm sensor
237
23'

FIG. 2G

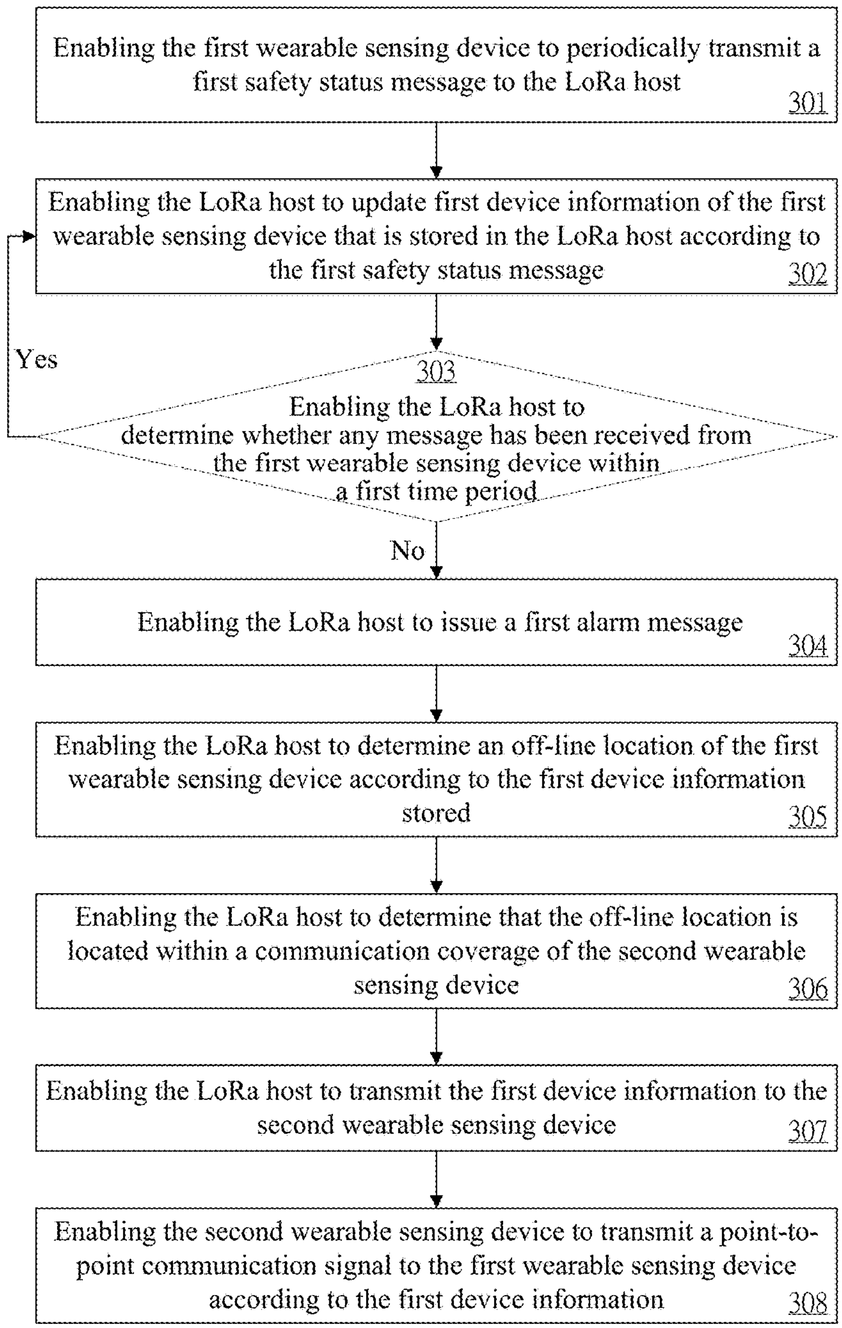

Enabling the first wearable sensing device to periodically transmit a first safety status message to the LoRa host
301
Enabling the LoRa host to update first device information of the first wearable sensing device that is stored in the LoRa host according to the first safety status message
302
Yes
303
Enabling the LoRa host to determine whether any message has been received from the first wearable sensing device within a first time period
No
Enabling the LoRa host to issue a first alarm message
304
Enabling the LoRa host to determine an off-line location of the first wearable sensing device according to the first device information stored
305
Enabling the LoRa host to determine that the off-line location is located within a communication coverage of the second wearable sensing device
306
Enabling the LoRa host to transmit the first device information to the second wearable sensing device
307
Enabling the second wearable sensing device to transmit a point-to-point communication signal to the first wearable sensing device according to the first device information
308

FIG. 3

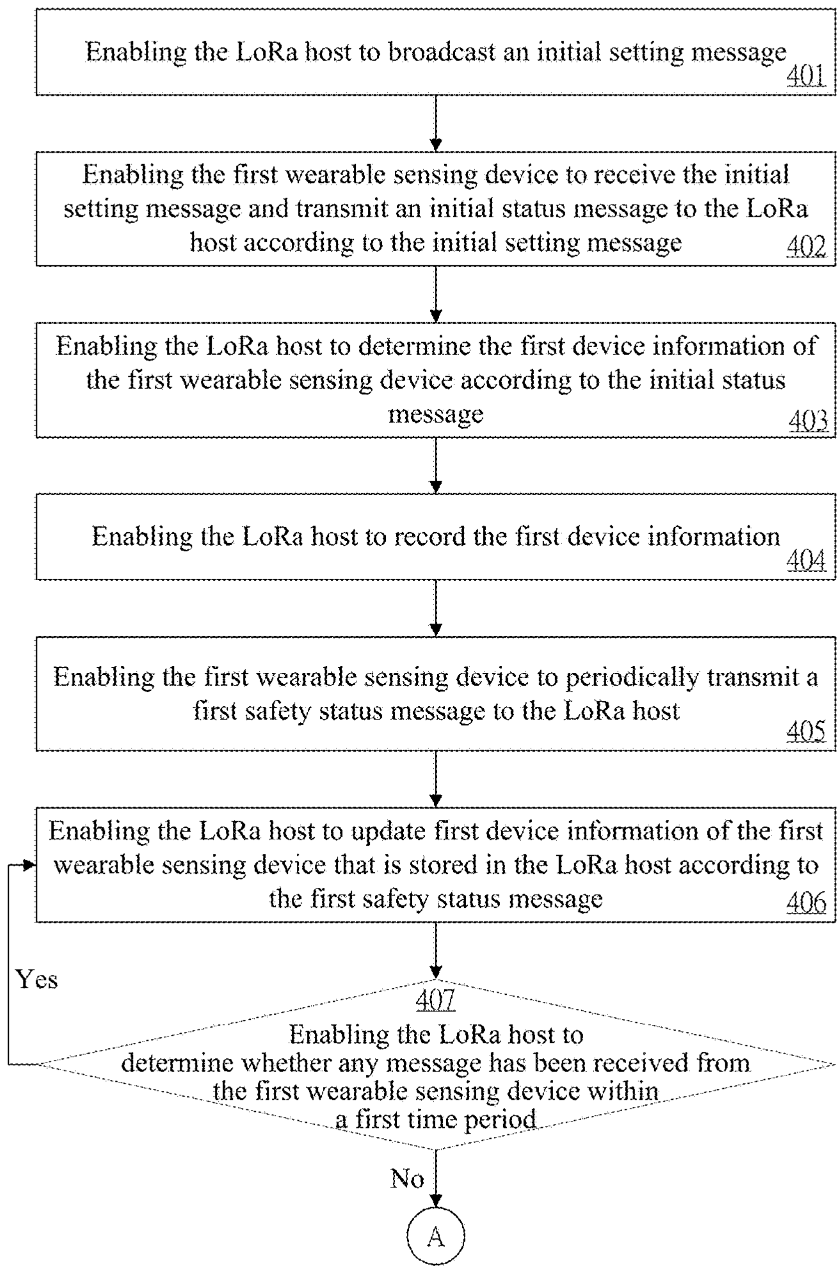

Enabling the LoRa host to broadcast an initial setting message
401
Enabling the first wearable sensing device to receive the initial setting message and transmit an initial status message to the LoRa host according to the initial setting message
402
Enabling the LoRa host to determine the first device information of the first wearable sensing device according to the initial status message
403
Enabling the LoRa host to record the first device information
404
Enabling the first wearable sensing device to periodically transmit a first safety status message to the LoRa host
405
Enabling the LoRa host to update first device information of the first wearable sensing device that is stored in the LoRa host according to the first safety status message
406
Yes
407
Enabling the LoRa host to determine whether any message has been received from the first wearable sensing device within a first time period
No
A

FIG. 4A

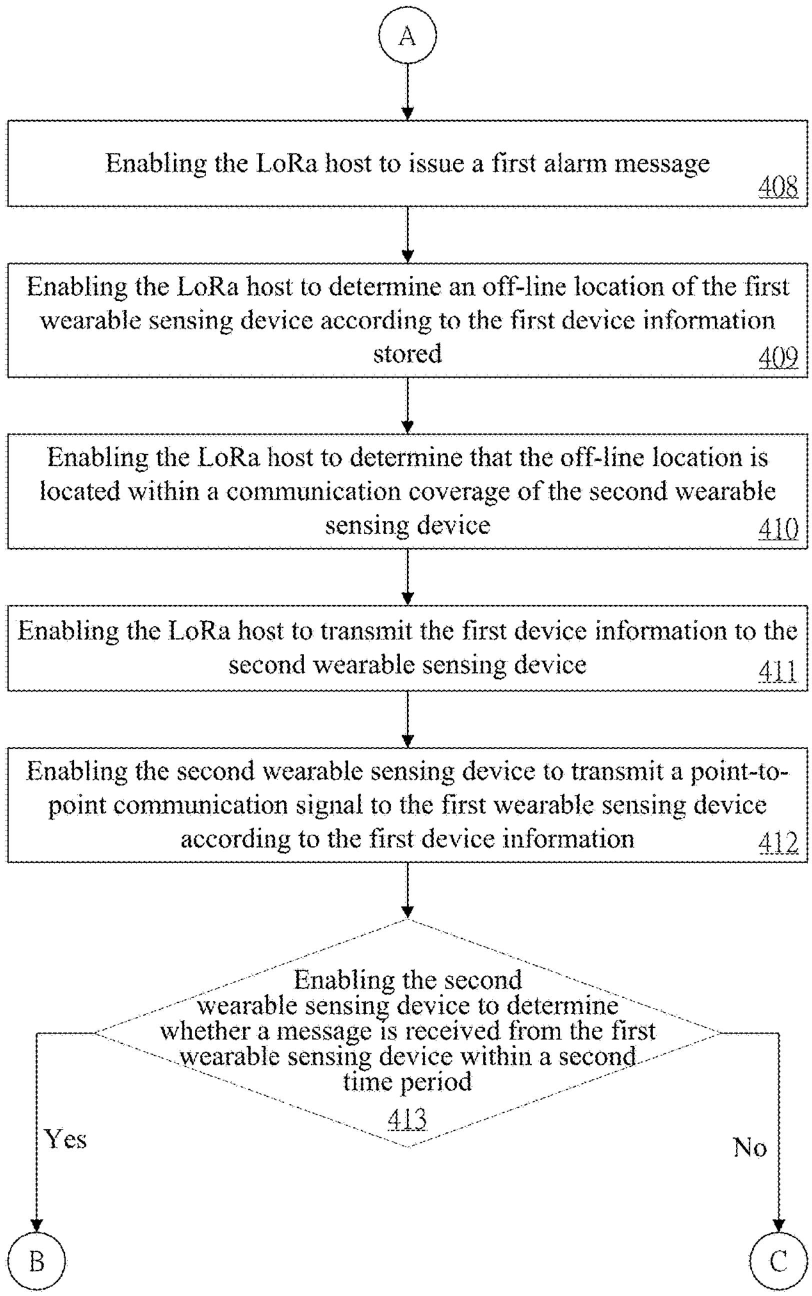

A
Enabling the LoRa host to issue a first alarm message
408
Enabling the LoRa host to determine an off-line location of the first wearable sensing device according to the first device information stored
409
Enabling the LoRa host to determine that the off-line location is located within a communication coverage of the second wearable sensing device
410
Enabling the LoRa host to transmit the first device information to the second wearable sensing device
411
Enabling the second wearable sensing device to transmit a point-to-point communication signal to the first wearable sensing device according to the first device information
412
Enabling the second wearable sensing device to determine whether a message is received from the first wearable sensing device within a second time period
413
Yes
No
B
C

FIG. 4B

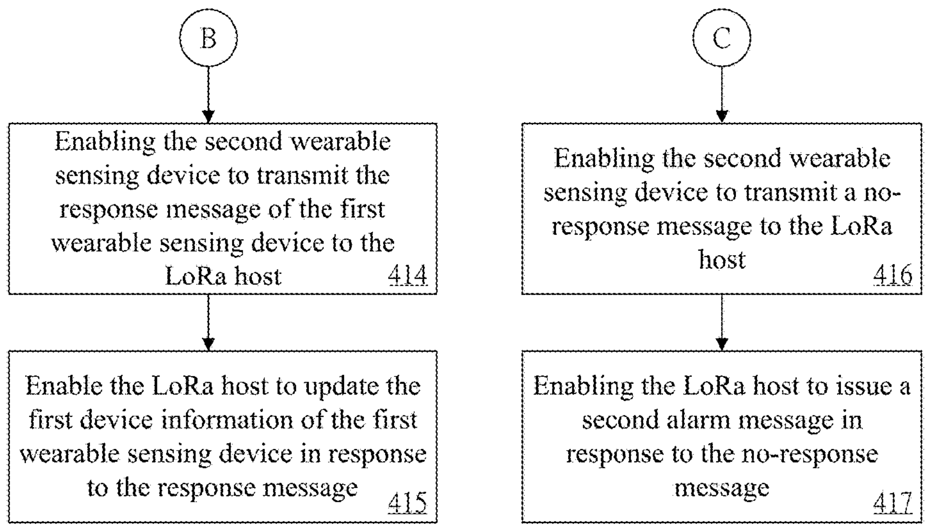

B
C
Enabling the second wearable sensing device to transmit the response message of the first wearable sensing device to the LoRa host
414
Enable the LoRa host to update the first device information of the first wearable sensing device in response to the response message
415
Enabling the second wearable sensing device to transmit a no-response message to the LoRa host
416
Enabling the LoRa host to issue a second alarm message in response to the no-response message
417

FIG. 4C

SAFETY STATUS SENSING SYSTEM AND SAFETY STATUS SENSING METHOD THEREOF

PRIORITY

[0001] This application claims priority to Taiwan Patent Application No. 106138149 filed on Nov. 3, 2017, which are hereby incorporated by reference in its entirety.

FIELD

[0002] The present invention relates to a safety status sensing system and a safety status sensing method thereof. More particularly, the present invention relates to a safety status sensing system and a safety status sensing method thereof that feature an easy deployment, a low power and a high flexibility in safety status reporting.

BACKGROUND

[0003] In the prior art, wearable electronic devices have been widely used in various fields. One primary application of the wearable electronic devices is to sense a physiological status of a human body and report the information measured to a base station or a backhaul host for recording and analysis. In this way, it can be confirmed whether the body of the user is healthy and whether any abnormal status occurs can be determined instantly.

[0004] However, for the aforesaid wearable electronic devices and the systems thereof for detecting the safety status of the user, the network environment and the system hardware thereof usually need to be constructed in advance, and the coverage thereof in which the user can be detected is mainly based on the number of base stations in the network.

[0005] Accordingly, when a large-scale activity (e.g., a road running activity, a mountain climbing activity) is held and the aforesaid wearable electronic devices and the safety status sensing system thereof are to be used for enhancing the security of the activity, constructing the network environment and the system hardware in advance is hard to be implemented and the hardware cost required by a larger communication coverage also increases remarkably.

[0006] According to the above descriptions, an urgent need exists in the art to improve the aforesaid problem, thereby improving the flexibility and convenience in network construction of the wearable electronic devices and the safety status sensing system thereof and meanwhile reducing the construction cost.

SUMMARY

[0007] The disclosure includes a safety status sensing method for a safety status sensing system. The safety status sensing system can comprise a LoRa host, a first wearable sensing device and a second wearable sensing device. The LoRa host communicates with the first wearable sensing device and the second wearable sensing device according to a LoRa protocol. The safety status sensing method comprises: (a) enabling the first wearable sensing device to periodically transmit a first safety status message to the LoRa host; (b) enabling the LoRa host to update first device information of the first wearable sensing device that is stored in the LoRa host according to the first safety status message; (c) enabling the LoRa host to issue a first alarm message after the LoRa host determines that no message has been received from the first wearable sensing device within a first time period; (d) enabling the LoRa host to determine an off-line location of the first wearable sensing device according to the first device information stored after the step (c); (e) enabling the LoRa host to determine that the off-line location is located within a communication coverage of the second wearable sensing device according to second device information of the second wearable sensing device, wherein the second device information is stored in the LoRa host; (f) enabling the LoRa host to transmit the first device information to the second wearable sensing device; and (g) enabling the second wearable sensing device to transmit a point-to-point communication signal to the first wearable sensing device according to the first device information.

[0008] The disclosure also includes a safety status sensing system, which comprises a LoRa host, a first wearable sensing device and a second wearable sensing device. The LoRa host can comprise a host processor, a host LoRa protocol transceiver, a host storage unit and an alarm prompting unit. The first wearable sensing device comprises a first device processor and a first device LoRa protocol transceiver. The second wearable sensing device comprises a second device processor and a second device LoRa protocol transceiver. The first wearable sensing device is configured to use the first device processor to periodically transmit a first safety status message to the LoRa host via the first device LoRa protocol transceiver. Thereafter, the LoRa host is configured to use the host LoRa protocol transceiver to receive the first safety status message from the first wearable sensing device; use the host processor to update first device information of the first wearable sensing device that is stored in the host storage unit according to the first safety status message; use the host processor to issue a first alarm message via the alarm prompting unit after the host processor determines that no message has been received by the host LoRa protocol transceiver from the first wearable sensing device within a first time period; use the host processor to determine an off-line location of the first wearable sensing device according to the first device information; use the host processor to determine that the off-line location is located within a communication coverage of the second wearable sensing device according to second device information of the second wearable sensing device, wherein the second device information is stored in the host storage unit; and use the host processor to transmit the first device information to the second wearable sensing device via the host LoRa protocol transceiver. The second wearable sensing device is configured to use the second device LoRa protocol transceiver to receive the first device information; and use the second device processor to transmit a point-to-point communication signal to the first wearable sensing device according to the first device information via the second device LoRa protocol transceiver.

[0009] The detailed technology and preferred embodiments implemented for the subject invention are described in the following paragraphs accompanying the appended drawings for people skilled in this field to well appreciate the features of the claimed invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1**A to FIG. **1**B are schematic views illustrating the operation of a safety status sensing system according to a first embodiment of the present invention;

[0011] FIG. **1**C is a block diagram of a LoRa host according to the first embodiment of the present invention;

[0012] FIG. **1**D is a block diagram of a first wearable sensing device according to the first embodiment of the present invention;

[0013] FIG. **1**E is a block diagram of a second wearable sensing device according to the first embodiment of the present invention;

[0014] FIG. **2**A to FIG. **2**B are schematic views illustrating the operation of a safety status sensing system according to a second embodiment of the present invention;

[0015] FIG. **2**C is a block diagram of a LoRa host according to the second embodiment of the present invention;

[0016] FIG. **2**D is a block diagram of a first wearable sensing device according to the second embodiment of the present invention;

[0017] FIG. **2**E is a block diagram of a second wearable sensing device according to the second embodiment of the present invention;

[0018] FIG. **2**F is a block diagram of another implementation of the LoRa host according to the second embodiment of the present invention;

[0019] FIG. **2**G is a block diagram of another implementation of the first wearable sensing device according to the second embodiment of the present invention;

[0020] FIG. **3** is a flowchart diagram of a safety status sensing method according to a third embodiment of the present invention; and

[0021] FIG. **4**A to FIG. **4**C are flowchart diagrams of a safety status sensing method according to a fourth embodiment of the present invention.

DETAILED DESCRIPTION

[0022] In the following description, the present invention will be explained with reference to certain example embodiments thereof. However, these example embodiments are not intended to limit the present invention to any specific examples, embodiments, environment, applications or implementations described in these example embodiments. Therefore, description of these example embodiments is only for purpose of illustration rather than to limit the present invention.

[0023] In the following embodiments and the attached drawings, elements unrelated to the present invention are omitted from depiction; and dimensional relationships among individual elements in the attached drawings are illustrated only for ease of understanding, but not to limit the actual scale.

[0024] Please refer to FIG. **1**A to FIG. **1**E. FIG. **1**A to FIG. **1**B are schematic views illustrating the operation of a safety status sensing system **1** according to a first embodiment of the present invention. The safety status sensing system **1** comprises a LoRa host **11**, a first wearable sensing device **13** and a second wearable sensing device **15**. FIG. **1**C is a block diagram of the LoRa host **11** according to the first embodiment of the present invention, and the LoRa host **11** comprises a host processor **111**, a host LoRa protocol transceiver **113**, a host storage unit **115** and an alarm prompting unit **117**.

[0025] FIG. **1**D is a block diagram of the first wearable sensing device **13** according to the first embodiment of the present invention, and the first wearable sensing device comprises a first device processor **131** and a first device LoRa protocol transceiver **133**. FIG. **1**E is a block diagram of the second wearable sensing device **15** according to the first embodiment of the present invention, and the second wearable sensing device comprises a second device processor **151** and a second device LoRa protocol transceiver **153**. Elements of each of the devices are electrically connected with each other, and the devices communicate with each other via the LoRa communication protocol. Interactions among the devices will be further described hereinafter.

[0026] First referring to FIG. **1**A, in the first embodiment, the first wearable sensing device **13** and the second wearable sensing device **15** are respectively worn by different users and periodically report information relevant to user safety to the LoRa host **11**. Specifically, taking the first wearable sensing device **13** as an example, the first wearable sensing device **13** is mainly configured to periodically transmit a first safety status message **130** relevant to the user safety status to the LoRa host **11** via the first device LoRa protocol transceiver **133**.

[0027] On the other hand, when the first wearable sensing device **13** is still within a communication coverage **11**R of the LoRa host **11**, the host LoRa protocol transceiver **113** of the LoRa host **11** can receive the first safety status message **130** from the first wearable sensing device **13**, and the host processor **111** updates first device information DATA**13** relevant to the first wearable sensing device **13** that is stored in the host storage unit **115** according to the first safety status message **130** so as to master safety information relevant to the user of the first wearable sensing device **13** instantly. Similarly, the host storage unit **115** stores second device information DATA**15** of the second wearable sensing device **15** (in other embodiments, it may further comprise device information of other wearable sensing devices).

[0028] Then referring to FIG. **1**B, when the user of the first wearable sensing device **13** moves so that the first wearable sensing device **13** is not within the communication coverage **11**R of the LoRa host **11**, the LoRa host **11** cannot receive any safety status message from the first wearable sensing device **13**, so the LoRa host **11** cannot monitor the safety status of the user of the first wearable sensing device **13**.

[0029] In other words, if the host processor **111** of the LoRa host **11** determines that no message has been received from the first wearable sensing device **13** by the host LoRa protocol transceiver **113** within a first time period (not shown), then it means that concerns have been raised over the safety detection of the user. Thus, the host processor **111** of the LoRa host **11** first issues a first alarm message **110** via the alarm prompting unit **117**.

[0030] Thereafter, the host processor **111** of the LoRa host **11** first determines an off-line location **13**off of the first wearable sensing device **13** according to the first device information DATA**13** that is updated latest and stored in the host storage unit **115**. Next, the LoRa host **11** searches for other wearable sensing devices that are around the off-line location **13**off of the first wearable sensing device **13** and within the communication coverage **11**R of the LoRa host **11** according to the off-line location **13**off and the second device information DATA**15** (in other implementations, other device information is further comprised) stored in the host storage unit **115**, in order to attempt to connect with the first wearable sensing device **13** via the other wearable sensing devices.

[0031] In the first embodiment, the host processor **111** of the LoRa host **11** determines that the off-line location **13**off is located within a communication coverage **15**R of the second wearable sensing device **15** according to the second device information DATA**15** of the second wearable sensing device **15** that is stored in the host storage unit **115**. Accordingly, the host processor **111** transmits the first device information DATA**13** to the second wearable sensing device **15** via the host LoRa protocol transceiver **113** so that the second wearable sensing device **15** attempts to connect with the first wearable sensing device **13**.

[0032] On the other hand, after the second device LoRa protocol transceiver **153** of the second wearable sensing device **15** receives the first device information DATA**13**, the second device processor **151** transmits a point-to-point communication signal **150** to the first wearable sensing device **13** via the second device LoRa protocol transceiver **153** according to the first device information DATA**13**, thereby attempting to contact with the first wearable sensing device **13**.

[0033] Please refer to FIG. **2**A to FIG. **2**E. FIG. **2**A to FIG. **2**B are schematic views illustrating the operation of a safety status sensing system **2** according to a second embodiment of the present invention. The safety status sensing system **2** comprises a LoRa host **21**, a first wearable sensing device **23** and a second wearable sensing device **25**. FIG. **2**C is a block diagram of a LoRa host **21** according to the second embodiment of the present invention, and the LoRa host **21** comprises a host processor **211**, a host LoRa protocol transceiver **213**, a host storage unit **215** and an alarm prompting unit **217**.

[0034] FIG. **2**D is a block diagram of a first wearable sensing device according to the second embodiment of the present invention, and the first wearable sensing device comprises a first device processor **231**, a first device LoRa protocol transceiver **233**, a first GPS positioner **235** and a first cardiac rhythm sensor **237**. FIG. **2**E is a block diagram of the second wearable sensing device **25** according to the second embodiment of the present invention, and the second wearable sensing device comprises a second device processor **251** and a second device LoRa protocol transceiver **253**.

[0035] Similarly, elements of each of the devices in the aforesaid second embodiment are electrically connected with each other, and the devices communicate with each other via the LoRa communication protocol. The second embodiment mainly further illustrates operation details and subsequent detection statuses of the safety status sensing system of the present invention. It shall be particularly appreciated that, because the second wearable sensing device **25** of the second embodiment is mainly used as a relay device when the first wearable sensing device **23** is disconnected from the LoRa host **21**, only the main elements (the second device processor **251** and the second device LoRa transceiver **253**) are illustrated and the positioning or heart beat sensing elements thereof are not particularly described. However, this is not intended to limit the implementation of the second wearable sensing device **25**.

[0036] First referring to FIG. **2**A, in the second embodiment, during the deployment of the safety status sensing system **2**, the host LoRa protocol transceiver **213** of the LoRa host **21** broadcasts an initial setting message **210** to notify wearable sensing devices in the network environment to report information, thereby initializing network environment parameters. On the other hand, after receiving the initial setting message **210**, the first device LoRa protocol transceiver **233** of the first wearable sensing device **21** can report to the LoRa host **21**.

[0037] In detail, the first device processor **231** of the first wearable sensing device **23** reports an initial status message **230** to the LoRa host **21** via the first device LoRa protocol transceiver **233** according to the initial setting message **210** so as to inform the LoRa host **21** of the status of the first wearable sensing device **23**. After the host LoRa protocol transceiver **213** of the LoRa host **21** receives the initial status message **230**, the host processor **211** accordingly decides first device information DATA**23** of the first wearable sensing device **23** and records the first device information DATA**23** into the host storage unit **215**. Similarly, the host processor **211** records second device information DATA**25** of the second wearable sensing device **25** into the host storage unit **215** (in other implementations, the host storage unit **215** may further comprise device information of other wearable sensing devices).

[0038] Next, in the second embodiment, the first wearable sensing device **23** and the second wearable sensing device **25** are respectively worn by different users and periodically report information relevant to user safety to the LoRa host **21**. Specifically, taking the first wearable sensing device **23** as an example, the first wearable sensing device **23** is mainly configured to periodically transmit a first safety status message **232** relevant to the user safety status to the LoRa host **21** via the first device LoRa protocol transceiver **233**.

[0039] On the other hand, when the first wearable sensing device **23** is still within a communication coverage **21**R of the LoRa host **21**, the host LoRa protocol transceiver **213** of the LoRa host **21** can receive the first safety status message **230** from the first wearable sensing device **23**, and the host processor **211** updates the first device information DATA**23** relevant to the first wearable sensing device **23** that is stored in the host storage unit **215** so as to master safety information relevant to the user of the first wearable sensing device **23** instantly.

[0040] It shall be particularly appreciated that, in the second embodiment, the first wearable sensing device **23** has a first device identification (not shown), and the first safety status message **232** reported to the LoRa host **21** periodically by the first wearable sensing device **23** comprises the first device identification (ID), a first heart beat rate detected by the first cardiac rhythm sensor **237**, a first time and a first location detected by the first GPS positioner **235**. Accordingly, the first device information DATA**23** is mainly configured to periodically record and update the first device ID, the first heart beat rate, the first time and the first location associated with the first wearable sensing device **23**.

[0041] Then referring to FIG. **2**B, when the user of the first wearable sensing device **23** moves so that the first wearable sensing device **23** is not within the communication coverage **21**R of the LoRa host **21**, the LoRa host **21** cannot receive any safety status message from the first wearable sensing device **23**, so the LoRa host **21** cannot monitor the safety status of the user of the first wearable sensing device **23**.

[0042] In other words, if the host processor **211** of the LoRa host **21** determines that no message has been received from the first wearable sensing device **23** by the host LoRa protocol transceiver **213** within a first time period (not shown), then it means that concerns have been raised over the safety detection of the user. Thus, the host processor **211** of the LoRa host **21** first issues a first alarm message **212** via the alarm prompting unit **217**.

[0043] Thereafter, the host processor **211** of the LoRa host **21** first determines an off-line location **23**off of the first wearable sensing device **23** according to the first device information DATA**23** that is updated latest and stored in the host storage unit **215**. Next, the LoRa host **21** searches for other wearable sensing devices that are around the off-line location of the first wearable sensing device **23** and within the communication coverage **21**R of the LoRa host **21** according to the off-line location **23**off and the second device information DATA**25** stored in the host storage unit **215**, in order to attempt to connect with the first wearable sensing device **23** via the other wearable sensing devices.

[0044] In the second embodiment, the host processor **211** of the LoRa host **21** determines the location and the communication coverage of the second wearable sensing device **25** according to the second device information DATA**25** of the second wearable sensing device **25** that is stored in the host storage unit **215**, and thus it may further determine that the off-line location **23**off is located within a communication coverage **25**R of the second wearable sensing device **25**. Accordingly, the host processor **211** transmits the first device information DATA**23** to the second wearable sensing device **25** via the host LoRa protocol transceiver **213** so that the second wearable sensing device **25** attempts to connect with the first wearable sensing device **23**.

[0045] On the other hand, after the second device LoRa protocol transceiver **253** of the second wearable sensing device **25** receives the first device information DATA**23**, the second device processor **251** transmit a point-to-point communication signal **250** to the first wearable sensing device **23** via the second device LoRa protocol transceiver **253** according to the first device information DATA**23**, thereby attempting to contact with the first wearable sensing device **23**.

[0046] More particularly, in the second embodiment, the second device processor **251** of the second wearable sensing device **25** determines via the second device LoRa protocol transceiver **253** whether any response message corresponding to the point-to-point communication signal **250** is received from the first wearable sensing device **23** within a second time period (not shown) after the point-to-point communication signal **250** is transmitted.

[0047] If the second device processor **251** of the second wearable sensing device **25** determines that no response message is received from the first wearable sensing device **23** within the second time period, then the concern that the user of the first wearable sensing device **23** is in an unsafe status is remarkably increased. Thus, the second device LoRa protocol transceiver **253** of the second wearable sensing device **25** transmits a no-response message **252** to the LoRa host **21**. After the host LoRa protocol transceiver **213** receives the no-response message **252**, the host processor **211** of the LoRa host **21** issues a second alarm message **214** via the alarm prompting unit **217**.

[0048] On the other hand, if the second device processor **251** of the second wearable sensing device **25** determines that a response message **234** corresponding to the point-to-point communication signal **250** is received from the first wearable sensing device **23** within the second time period, then the second device processor **251** transmits via the second device LoRa protocol transceiver **253** the response message **234** to the LoRa host **21**. The response message **234** comprises information relevant to the safety of the first wearable sensing device **23**, so the host processor **211** of the LoRa host **21** can accordingly update the first device information DATA**23** stored in the LoRa host storage unit **215** for subsequent tracing of the user safety information after the host LoRa protocol transceiver **213** receives the response message **234**.

[0049] It shall be additionally appreciated that, in other implementations, the location of the wearable sensing device may be decided via other hardware. Specifically, please refer to FIG. **2**F and FIG. **2**G. FIG. **2**F is a block diagram of another implementation of a LoRa host **21'** according to the second embodiment of the present invention, and the LoRa host **21'** comprises a host processor **211**, a host LoRa protocol transceiver **213**, a host storage unit **215**, an alarm prompting unit **217** and a host GPS positioner **219**. FIG. **2**G is a block diagram of another implementation of a first wearable sensing device **23'** according to the second embodiment of the present invention, and the first wearable sensing device **23'** comprises the first device processor **231**, the first device LoRa protocol transceiver **233**, a three-axis accelerometer **239** and a first cardiac rhythm sensor **237**.

[0050] Further speaking, in other implementations, during the deployment of the safety status sensing system **2**, the GPS positioner **219** of the LoRa host **21** may first generate a host GPS location (not shown) and transmit the host GPS location to the first wearable sensing device **23** via the host LoRa protocol transceiver **213**. Accordingly, when the first wearable sensing device **23** knows the initial location of the LoRa host **21** and starts to move away from the LoRa host **21**, the three-axis accelerometer **239** of the first wearable sensing device **23** starts to generate displacement information (not shown). In this case, the first device processor **231** can calculate the first location based on the initial location (i.e., the host GPS location) and the displacement information, and update the first location at any moment according to the displacement information generated by the three-axis accelerometer **239**. In this way, the location of the wearable sensing device can be estimated and updated even without the GPS positioner.

[0051] A third embodiment of the present invention is a safety status sensing method, and a flowchart diagram thereof is as shown in FIG. **3**. The method of the third embodiment is for use in a safety status sensing system (e.g., the safety status sensing system of the aforesaid embodiments). The safety status sensing system comprises a LoRa host, a first wearable sensing device and a second wearable sensing device. The LoRa host communicates with the first wearable sensing device and the second wearable sensing device according to a LoRa protocol. Detailed steps of the third embodiment are as follows.

[0052] First, step **301** is executed to enable the first wearable sensing device to periodically transmit a first safety status message to the LoRa host. Step **302** is executed to enable the LoRa host to update first device information of the first wearable sensing device that is stored in the LoRa host according to the first safety status message. Step **303** is executed to enable the LoRa host to determine whether any message has been received from the first wearable sensing device within a first time period. If the determination result is yes, then the step **302** is executed again.

[0053] On the other hand, if the determination result is no, then step **304** is executed to enable the LoRa host to issue a first alarm message. Next, step **305** is executed to enable the LoRa host to determine an off-line location of the first wearable sensing device according to the first device information stored. Step **306** is executed to enable the LoRa host to determine that the off-line location is located within a communication coverage of the second wearable sensing device according to second device information of the second wearable sensing device. The second device information is stored in the LoRa host.

[0054] Thereafter, step **307** is executed to enable the LoRa host to transmit the first device information to the second wearable sensing device. Step **308** is executed to enable the second wearable sensing device to transmit a point-to-point communication signal to the first wearable sensing device according to the first device information so as to attempt to contact with the first wearable sensing device.

[0055] A fourth embodiment of the present invention is a safety status sensing method, and flowchart diagrams thereof are as shown in FIG. **4**A to FIG. **4**C. The method of the fourth embodiment is for use in a safety status sensing system (e.g., the safety status sensing system of the aforesaid embodiments). The safety status sensing system comprises a LoRa host, a first wearable sensing device and a second wearable sensing device. The LoRa host communicates with the first wearable sensing device and the second wearable sensing device according to a LoRa protocol. Detailed steps of the fourth embodiment are as follows.

[0056] First, step **401** is executed to enable the LoRa host to broadcast an initial setting message. Step **402** is executed to enable the first wearable sensing device to receive the initial setting message and transmit an initial status message to the LoRa host according to the initial setting message. Step **403** is executed to enable the LoRa host to determine the first device information of the first wearable sensing device according to the initial status message. Step **404** is executed to enable the LoRa host to record the first device information.

[0057] Next, step **405** is executed to enable the first wearable sensing device to periodically transmit a first safety status message to the LoRa host. Step **406** is executed to enable the LoRa host to update first device information of the first wearable sensing device that is stored in the LoRa host according to the first safety status message. Step **407** is executed to enable the LoRa host to determine whether any message has been received from the first wearable sensing device within a first time period. If the determination result is yes, then the step **406** is executed again.

[0058] On the other hand, if the determination result is no, then step **408** is executed to enable the LoRa host to issue a first alarm message. Next, step **409** is executed to enable the LoRa host to determine an off-line location of the first wearable sensing device according to the first device information stored. Step **410** is executed to enable the LoRa host to determine that the off-line location is located within a communication coverage of the second wearable sensing device according to second device information of the second wearable sensing device. The second device information is stored in the LoRa host.

[0059] Thereafter, step **411** is executed to enable the LoRa host to transmit the first device information to the second wearable sensing device. Step **412** is executed to enable the second wearable sensing device to transmit a point-to-point communication signal to the first wearable sensing device according to the first device information so as to attempt to contact with the first wearable sensing device. Step **413** is executed to enable the second wearable sensing device to determine whether a response message corresponding to the point-to-point communication signal is received from the first wearable sensing device within a second time period.

[0060] If the determination result is yes, then step **414** is executed to enable the second wearable sensing device to transmit the response message of the first wearable sensing device to the LoRa host. Step **415** is executed to enable the LoRa host to update the first device information of the first wearable sensing device in response to the response message. If the determination result is no, then step **416** is executed to enable the second wearable sensing device to transmit a no-response message to the LoRa host. Step **417** is executed to enable the LoRa host to issue a second alarm message in response to the no-response message.

[0061] According to the above descriptions, the safety status sensing system and the safety status sensing method of the present invention deploy the host and the wearable devices in the network environment mainly through the LoRa communication protocol of a low power, and utilize the relay characteristic of nodes in the LoRa protocol specification to extend the communication coverage for safety reporting of the nodes. In this way, the flexibility and convenience in network construction of the wearable electronic devices can be improved remarkably, and the construction cost can also be reduced effectively.

[0062] The above disclosure is related to the detailed technical contents and inventive features thereof. People skilled in this field may proceed with a variety of modifications and replacements based on the disclosures and suggestions of the invention as described without departing from the characteristics thereof. Nevertheless, although such modifications and replacements are not fully disclosed in the above descriptions, they have substantially been covered in the following claims as appended.

1. A safety status sensing method for a safety status sensing system, the safety status sensing system comprising a LoRa host, a first wearable sensing device and a second wearable sensing device, and the LoRa host communicating with the first wearable sensing device and the second wearable sensing device according to a LoRa protocol, the safety status sensing method comprising:

(a) the first wearable sensing device periodically transmitting a first safety status message to the LoRa host;

(b) the LoRa host updating a first device information of the first wearable sensing device that is stored in the LoRa host according to the first safety status message;

(c) the LoRa host issuing a first alarm message after the LoRa host determines that no message has been received from the first wearable sensing device within a first time period;

(d) the LoRa host determining an off-line location of the first wearable sensing device according to the first device information stored after the step (c);

(e) the LoRa host determining that the off-line location is located within a communication coverage of the second wearable sensing device according to second device information of the second wearable sensing device, wherein the second device information is stored in the LoRa host;

(f) the LoRa host transmitting the first device information to the second wearable sensing device; and

(g) the second wearable sensing device transmitting a point-to-point communication signal to the first wearable sensing device according to the first device information.

2. The safety status sensing method of claim **1**, further comprising the following steps before the step (a):

(a1) the LoRa host broadcasting an initial setting message;

(a2) the first wearable sensing device receiving the initial setting message and transmitting an initial status message to the LoRa host according to the initial setting message;

(a3) the LoRa host determining the first device information of the first wearable sensing device according to the initial status message; and

(a4) the LoRa host to recording the first device information.

3. The safety status sensing method of claim **1**, further comprising:

(h) the second wearable sensing device determining, after the step (g), that no response message corresponding to the point-to-point communication signal is received from the first wearable sensing device within a second time period;

(i) the second wearable sensing device transmitting a no-response message to the LoRa host according to the result of the step (h); and

(j) the LoRa host issuing a second alarm message in response to the no-response message.

4. The safety status sensing method of claim **1**, further comprising:

(h) the second wearable sensing device determining, after the step (g), that a response message corresponding to the point-to-point communication signal is received from the first wearable sensing device within a second time period;

(i) the second wearable sensing device transmitting the response message to the LoRa host according to the result of the step (h); and

(j) the LoRa host updating the first device information of the first wearable sensing device in response to the response message.

5. The safety status sensing method of claim **1**, wherein the first safety status message and the first device information respectively comprise a first device identification (ID), a first heart beat rate, a first time and a first location associated with the first wearable sensing device.

6. A safety status sensing system, comprising:

a LoRa host, comprising a host processor, a host LoRa protocol transceiver, a host storage unit and an alarm prompting unit;

a first wearable sensing device, comprising a first device processor and a first device LoRa protocol transceiver; and

a second wearable sensing device, comprising a second device processor and a second device LoRa protocol transceiver;

wherein the first wearable sensing device is configured to use the first device processor to periodically transmit a first safety status message to the LoRa host via the first device LoRa protocol transceiver;

wherein the LoRa host is configured to use the host LoRa protocol transceiver to receive the first safety status message from the first wearable sensing device; use the host processor to update first device information of the first wearable sensing device that is stored in the host storage unit according to the first safety status message; use the host processor to issue a first alarm message via the alarm prompting unit after the host processor determines that no message has been received by the host LoRa protocol transceiver from the first wearable sensing device within a first time period; use the host processor to determine an off-line location of the first wearable sensing device according to the first device information; use the host processor to determine that the off-line location is located within a communication coverage of the second wearable sensing device according to second device information of the second wearable sensing device, wherein the second device information is stored in the host storage unit; and use the host processor to transmit the first device information to the second wearable sensing device via the host LoRa protocol transceiver; and

wherein the second wearable sensing device is further configured to use the second device LoRa protocol transceiver to receive the first device information; and use the second device processor to transmit a point-to-point communication signal to the first wearable sensing device according to the first device information via the second device LoRa protocol transceiver.

7. The safety status sensing system of claim **6**, wherein the LoRa host is further configured to use the host LoRa protocol transceiver to broadcast an initial setting message;

wherein the first wearable sensing device is further configured to use the first device processor to receive the initial setting message and transmit an initial status message to the LoRa host according to the initial setting message via the first device LoRa protocol transceiver; and

wherein the LoRa host is further configured to use the host LoRa protocol transceiver to receive the initial status message; use the host processor to determine the first device information of the first wearable sensing device according to the initial status message; and use the LoRa host storage unit to record the first device information.

8. The safety status sensing system of claim **6**, wherein the second wearable sensing device is further configured to use the second device processor to determine that no response message corresponding to the point-to-point communication signal is received by the second device LoRa protocol transceiver from the first wearable sensing device within a second time period; and use the second device LoRa protocol transceiver to transmit a no-response message to the LoRa host; and

wherein the LoRa host is further configured to use the host LoRa protocol transceiver to receive the no-response message; and use the host processor to issue a second alarm message via the alarm prompting unit in response to the no-response message.

9. The safety status sensing system of claim **6**, wherein the second wearable sensing device is further configured to use the second device processor to determine that a response message corresponding to the point-to-point communication signal is received by the second device LoRa protocol transceiver from the first wearable sensing device within a second time period; and use the second device LoRa protocol transceiver to transmit the response message to the LoRa host; and

wherein the LoRa host is further configured to use the host LoRa protocol transceiver to receive the response message; and use the host processor to update the first device information of the first wearable sensing device that is stored in the LoRa host storage unit in response to the response message.

10. The safety status sensing system of claim **6**, wherein the first wearable sensing device has a first device ID and further comprises:

a GPS positioner, being configured to determine a first location; and

a cardiac rhythm sensor, being configured to detect a first heart beat rate of a user;

wherein the first safety status message and the first device information respectively comprise the first device ID, the first heart beat rate, a first time and the first location.

11. The safety status sensing system of claim **6**, wherein the LoRa host further comprises a GPS positioner configured to generate a host GPS location and transmit the host GPS location to the first wearable sensing device via the host LoRa protocol transceiver, and the first wearable sensing device has a first device ID and further comprises:

a three-axis accelerometer, being configured to generate displacement information; and

a cardiac rhythm sensor, being configured to detect a first heart beat rate of a user;

wherein the first device processor generates a first location according to the host GPS location and the displacement information, and the first safety status message and the first device information respectively comprise the first device ID, the first heart beat rate, a first time and the first location.

12. A first wearable sensing device, comprising:

a first device processor; and

a first device LoRa protocol transceiver;

wherein the first device processor periodically transmits a safety status message to a LoRa host via the first device LoRa protocol transceiver, the first device LoRa protocol transceiver is further configured to receive a point-to-point communication signal from a second wearable sensing device, and the first device processor is further configured to transmit a response message to the second wearable sensing device via the first device LoRa protocol transceiver according to the point-to-point communication signal.

13. The first wearable sensing device of claim **12**, wherein the first device processor further receives an initial setting message of the LoRa host and transmits an initial status message to the LoRa host according to the initial setting message via the first device LoRa protocol transceiver.

14. The first wearable sensing device of claim **12**, wherein the first wearable sensing device has a first device ID and further comprises:

a GPS positioner, being configured to determine a first location; and

a cardiac rhythm sensor, being configured to detect a first heart beat rate of a user;

wherein the first safety status message and the first device information respectively comprise the first device ID, the first heart beat rate, a first time and the first location.

15. The first wearable sensing device of claim **12**, wherein the first wearable sensing device has a first device ID, and the first device LoRa protocol transceiver is further configured to receive a host GPS location from the LoRa host, the first wearable sensing device further comprising:

a three-axis accelerometer, being configured to generate displacement information; and

a cardiac rhythm sensor, being configured to detect a first heart beat rate of a user;

wherein the first device processor generates a first location according to the host GPS location and the displacement information, and the first safety status message and the first device information respectively comprise the first device ID, the first heart beat rate, a first time and the first location.

* * * * *