## ENVIRONMENT-INTEGRATED SMART RING CHARGER

## Abstract

A charging system can include a housing. The housing can include a controller. The housing also can include a power source configured to power the controller. The charging system also can include a wireless charger configured to transfer energy to the power source. The wireless charger can include a first indicator. The first indicator can be configured to provide a first non-flashing visual output at a first brightness level and indicative of a first charging status of the power source. The first indicator also can be configured to provide a second non-flashing visual output at a second brightness level indicative of a second charging status of the power source. Other embodiments are disclosed.

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## Background/Summary

CROSS-REFERENCES TO RELATED APPLICATIONS [0001] This application is a continuation of U.S. Non-Provisional patent application Ser. No. 18/975,246, filed on Dec. 10, 2024, which is a continuation of U.S. Non-Provisional patent application Ser. No. 18/234,180, filed on Aug. 15, 2023, which is a continuation of U.S. Non-Provisional patent application Ser. No. 17/937,576, filed Oct. 3, 2022, which is a continuation of U.S. Non-Provisional application Ser. No. 16/929,641, filed Jul. 15, 2020, which claims the benefit of U.S. Provisional Patent Application No. 62/877,391, filed on Jul. 23, 2019, and U.S. Provisional Patent Application No. 62/990,123, filed Mar. 16, 2020, all of which are incorporated by reference herein in their entirety for all purposes.

FIELD OF THE DISCLOSURE
[0002] The present disclosure generally relates to smart ring wearable devices and, more specifically, to systems for charging smart ring devices with chargers integrated into objects in the environment for enabling charging when a user holds an object with an integrated charger while wearing the smart ring.
BACKGROUND
[0003] To the extent that smart ring technology has been adopted, it has a number of challenges. For example, a number of problems exist with wearable devices generally, including: they often need to be removed for charging; they often have poor fit; they often provide relatively little user interactivity; and they often provide limited functionality.
BRIEF SUMMARY
[0004] A smart ring charging system may be configured to transfer energy between a charging source outside of the ring housing and the power source of the smart ring disposed at the ring housing. The charging source may be disposed at an object that a user can grasp or hold. The charging may be initiated when the user holds the object with the charging source. A user interface of the charging system may include one or more indicators configured to indicate the charging rate of the power source disposed at the smart ring, at the object with the integrated charging source, or at another suitable location. The indicators may provide audio, visual, or haptic output indicative of the charging system operation. The energy transfer between the charging source and the power source may be wireless and may use inductive coupling. To that end, the smart ring may include a receiving induction coil configured to generate a voltage in response to a change in magnetic flux through the coil, the magnetic flux associated with one or more transmitting coils electrically connected to the charging source.
[0005] In one aspect, a smart ring charging system comprises a charging source integrated into an object, the object configured to be held by a user wearing a smart ring. The system further

comprises the smart ring including: (i) a ring-shaped housing; (ii) a power source, disposed within or at the ring-shaped housing and configured to receive energy from the charging source while the user is wearing the smart ring and holding the object with the charging source; (iii) a controller, disposed within or at the ring-shaped housing and configured to estimate a charging rate at which the power source receives energy from the charging source; and (iv) one or more input/output (I/O) components, including a user interface disposed within or at the ring-shaped housing and configured to indicate when the charging rate is above a threshold.

[0006] In another aspect, a method for charging a smart ring comprises: integrating a charging source into an object, the object configured to be held by a user wearing a smart ring; transmitting, by the charging source, energy for charging a power source disposed within the smart ring; and receiving, by the power source disposed within the smart ring, the energy transmitted by the charging source while the user is wearing the smart ring and holding the object with the integrated charging source. The method further comprises: detecting, by a controller, that a charging rate at which the power source is receiving the energy from the charging source is above a threshold; and indicating, by a user interface, the charging rate in response to detecting that the charging rate is above the threshold.

[0007] Still, in another aspect, a smart ring charging system comprises a charging source integrated into an object, the object configured to be held by a user wearing a smart ring. The charging system also comprises the smart ring including: (i) a ring-shaped housing; (ii) a power source, disposed within or at the ring-shaped housing and configured to receive energy from the charging source while the user is wearing the smart ring and holding the object with the charging source; (iii) a controller, disposed within or at the ring-shaped housing and configured to estimate a charging rate at which the power source receives energy from the charging source; and (iv) one or more input/output (I/O) components, including a transmitter disposed within or at the ring-shaped housing and configured to transmit a signal indicative of the estimated charging rate. Furthermore, the system comprises one or more indicators disposed outside of the smart ring and configured to indicate the charging rate in response to the transmitted signal.

[0008] In yet another aspect, a smart ring charging system comprises a charging source integrated into an object, the object configured to be held by a user wearing a smart ring; a controller, disposed within or at the object with the charging source and configured to estimate a charging rate at which the power source receives energy from the charging source; and one or more indicators disposed within or at the object with the charging source and configured to indicate the charging rate. The system further comprises the smart ring including: (i) a ring-shaped housing; and (ii) a power source, disposed within or at the ring-shaped housing and configured to receive energy from the charging source while the user is wearing the smart ring and holding the object with the charging source.

[0009] In another embodiment, a ring includes a controller. The ring can also include a power source configured to power the controller. The ring further can include a charging unit. The charging unit can be configured to convert a first form of energy into a second form of energy. The charging unit also can be coupled to the power source to provide the second form of energy to the power source. The controller can execute instructions to control operation of a user interface.

[0010] In another embodiment, a method for charging a ring can include providing, by a power source, energy to a controller. The method for charging a ring also can include converting, by a charging unit, a first form of energy into a second form of energy. The charging unit can be coupled to the power source. The method for charging a ring also can include providing, by the charging unit, the second form of energy to the power source. The method for charging a ring also can include controlling, by the controller, operation of a user interface.

[0011] In another embodiment, a method of providing a ring can include providing a controller. The method of providing a ring also can include providing a power source configured to power the controller. The method of providing a ring further can include providing a charging unit configured

to convert a first form of energy into a second form of energy. The charging can be coupled to the power source to provide the second form of energy to the power source. The controller can execute instructions to control operation of a user interface.

[0012] In another embodiment, a charging system can include a housing. The housing can include a controller. The housing also can include a power source configured to power the controller. The charging system also can include a wireless charger configured to transfer energy to the power source. The wireless charger can include a first indicator. The first indicator can be configured to provide a first non-flashing visual output at a first brightness level and indicative of a first charging status of the power source. The first indicator also can be configured to provide a second non-flashing visual output at a second brightness level indicative of a second charging status of the power source.

[0013] In another embodiment, a method for charging a housing can include providing the housing. Providing the housing can include providing a controller. Providing the housing also can include providing a power source configured to power the controller. The method for charging a housing further can include providing a wireless charger configured to transfer energy to the power source. Providing the wireless charger can include providing a first indicator. Providing the first indicator can include providing a first non-flashing visual output at a first brightness level and indicative of a first charging status of the power source. Providing the first indicator also can include providing a second non-flashing visual output at a second brightness level indicative of a second charging status of the power source.

[0014] In another embodiment, a charging system can include a housing. The housing can include a controller and at least one sensor. The housing also can include a power source configured to power the controller. The charging system also can include a wireless charger configured to transfer energy to the power source. The wireless charger can include a first indicator. The first indicator can be configured to provide a first non-flashing visual output at a first brightness level and indicative of a first charging status of the power source. The first indicator also can be configured to provide a second non-flashing visual output at a second brightness level indicative of a second charging status of the power source.

[0015] Depending upon the embodiment, one or more benefits may be achieved. These benefits and various additional objects, features and advantages of the present disclosure can be fully appreciated with reference to the detailed description and accompanying drawings that follow.

## Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. **1** illustrates a system comprising a smart ring and a block diagram of smart ring components according to some embodiments.

[0017] FIG. **2** illustrates a number of different form factor types of a smart ring according to some embodiments.

[0018] FIG. **3** illustrates examples of different smart ring form factors.

[0019] FIG. **4** illustrates an environment within which a smart ring may operate according to some embodiments.

[0020] FIG. **5**A, FIG. **5**B, and FIG. **5**C are schematic diagrams of example implementations of a charging system with an environment-integrated charging source for a smart ring.

DETAILED DESCRIPTION

[0021] Smart ring wearable technology can enable a wide range of applications including security, safety, health and wellness, and convenient interfacing between a user and a variety of technologies based at least in part upon integrating a variety of sensor, input/output devices, and computing capabilities in a compact form factor. One of the challenges in increasing smart ring capabilities is

reliably powering the needed components, particularly considering the limited space for a power source in the compact form factor. An ability to conveniently charge a power source of a smart ring without removing the smart ring from a finger would contribute to the adoption of smart ring technology.

[0022] One way to charge a smart ring without removing the smart ring from the finger may include using a charger disposed in the environment of the smart ring. For example, the charger may be integrated into an object that a user may hold or grasp while a wearing a smart ring in a manner that allows a power source of the smart ring to charge. For the purposes of charging, the charger may connect to the smart ring worn by the user by a cable or via a socket. Additionally or alternatively, the smart ring and the charger may be configured for wireless energy transfer. Some wireless energy transfer techniques may rely on generated variable electromagnetic fields at a charging source that may couple a portion of the generated energy to the power source of the smart ring. To that end, the charging source and the smart ring may include inductively coupled coils—a transmitting coil at the charging source and a receiving coil at the ring.

[0023] Various techniques, systems, and methods for charging a power source of a smart ring using charging sources integrated into objects in the environment of the smart ring are discussed below with reference to FIG. **1**, FIG. **2**, FIG. **3**, FIG. **4**, FIG. **5**A, FIG. **5**B, and FIG. **5**C. In section I, a smart ring and environment-integrated charging system is described with reference to FIG. **1**. In section II, example smart ring form factor types and configurations to facilitate connections to an integrated charging source are discussed with reference to FIG. **2** and FIG. **3**. In section III, an example operating environment in which a smart ring and the charging system may operate is described with reference to FIG. **4**. In section IV, example schematics for a charging system with an environment-integrated charging source are described with reference to FIG. **5**A, FIG. **5**B, and FIG. **5**C. In section V, other considerations are described.

I. Examples of Smart Ring and Smart Ring Components

[0024] FIG. **1** illustrates a system **100** comprising a smart ring **101** that may be charged via a charging system according to one or more of the techniques described herein. FIG. **1** also shows one or more devices or systems that may be electrically, mechanically, or communicatively connected to the smart ring **101**. As shown, the smart ring **101** may include a set of components **102**, which may have various power needs and may impact the frequency with which the smart ring **101** needs recharging. Some of the components **102** may interact, as described below, with the components of the charging system disposed outside of the smart ring. Furthermore, in implementations where the charging system uses wireless transfer of electromagnetic energy between the charging source and the smart ring, the components **102** may be configured to be compatible with the electromagnetic fields to which the components **102** may be exposed during charging.

[0025] The system **100** may comprise any one or more of: a charger **103** for the smart ring **101**, a user device **104**, a network **105**, a mobile device **106**, or a server **107**. The charger **103** may provide energy to the smart ring **101** by way of a direct electrical, a wireless, or an optical connection. The smart ring **101** may be in a direct communicative connection with the user device **104**, the mobile device **106**, or the server **107** by way of the network **105**. Interactions between the smart ring **101** and other components of the system **100** are discussed in more detail in the context of FIG. **4**.

[0026] The smart ring **101** may sense a variety of signals indicative of activities of a user wearing the ring **101**, biometric signals, a physiological state of the user, or signals indicative of the user's environment. The smart ring **101** may analyze the sensed signals using built-in computing capabilities or in cooperation with other computing devices (e.g., user device **104**, mobile device **106**, server **107**) and provide feedback to the user or about the user via the smart ring **101** or other devices (e.g., user device **104**, mobile device **106**, server **107**). Additionally or alternatively, the smart ring **101** may provide the user with notifications sent by other devices, enable secure access to locations or information, or a variety of other applications pertaining to health, wellness,

productivity, or entertainment.

[0027] The smart ring **101**, which may be referred to herein as the ring **101**, may comprise a variety of mechanical, electrical, optical, or any other suitable subsystems, devices, components, or parts disposed within, at, throughout, or in mechanical connection to a housing **110** (which may be ring shaped and generally configured to be worn on a finger). Additionally, a set of interface components **112***a* and **112***b* may be disposed at the housing, and, in particular, through the surface of the housing. The interface components **112***a* and **112***b* may provide a physical access (e.g., electrical, fluidic, mechanical, or optical) to the components disposed within the housing. The interface components **112***a* and **112***b* may exemplify surface elements disposed at the housing. As discussed below, some of the surface elements of the housing may also be parts of the smart ring components.

[0028] As shown in FIG. **1**, the components **102** of the smart ring **101** may be distributed within, throughout, or on the housing **110**. As discussed in the contexts of FIG. **2** and FIG. **3** below, the housing **110** may be configured in a variety of ways and include multiple parts. The smart ring components **102** may, for example, be distributed among the different parts of the housing **110**, as described below, and may include surface elements of the housing **110**. The housing **110** may include mechanical, electrical, optical, or any other suitable subsystems, devices, components, or parts disposed within or in mechanical connection to the housing **110**, including a battery **120** as a power source, a charging unit **130**, a controller **140**, a sensor system **150** comprising one or more sensors, a communications unit **160**, a one or more user input devices **170**, or a one or more output devices **190**. Each of the components **120**, **130**, **140**, **150**, **160**, **170**, and/or **190** may include one or more associated circuits, as well as packaging elements. The components **120**, **130**, **140**, **150**, **160**, **170**, and/or **190** may be electrically or communicatively connected with each other (e.g., via one or more busses or links, power lines, etc.), and may cooperate to enable "smart" functionality described within this disclosure.

[0029] The battery **120** may supply energy or power to the controller **140**, the sensors **150**, the communications unit **160**, the user input devices **170**, or the output devices **190**. In some scenarios or implementations, the battery **120** may supply energy or power to the charging unit **130**. The charging unit **130**, may supply energy or power to the battery **120**. In some implementations, the charging unit **130** may supply (e.g., from the charger **103**, or harvested from other sources) energy or power to the controller **140**, the sensors **150**, the communications unit **160**, the user input devices **170**, or the output devices **190**. In a charging mode of operation of the smart ring **101**, the average power supplied by the charging unit **130** to the battery **120** may exceed the average power supplied by the battery **120** to the charging unit **130**, resulting in a net transfer of energy from the charging unit **130** to the battery **120**. In a non-charging mode of operation, the charging unit **130** may, on average, draw energy from the battery **120**.

[0030] The battery **120** may include one or more cells that convert chemical, thermal, nuclear or another suitable form of energy into electrical energy to power other components or subsystems **140**, **150**, **160**, **170**, and/or **190** of the smart ring **101**. The battery **120** may include one or more alkaline, lithium, lithium-ion and or other suitable cells. The battery **120** may include two terminals that, in operation, maintain a substantially fixed voltage of 1.5, 3, 4.5, 6, 9, 12 V or any other suitable terminal voltage between them. When fully charged, the battery **120** may be capable of delivering to power-sinking components an amount of charge, referred to herein as "full charge," without recharging. The full charge of the battery may be 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000, 5000 mAh or any other suitable charge that can be delivered to one or more power-consuming loads as electrical current.

[0031] The battery **120** may include a charge-storage device, such as, for example a capacitor or a super-capacitor. In some implementations discussed below, the battery **120** may be entirely composed of one or more capacitive or charge-storage elements. The charge storage device may be capable of delivering higher currents than the energy-conversion cells included in the battery **120**.

Furthermore, the charge storage device may maintain voltage available to the components or subsystems **130**, **140**, **150**, **160**, **170**, and/or **190** when one or more cells of the battery **120** are removed to be subsequently replaced by other cells.

[0032] The charging unit **130** may be configured to replenish the charge supplied by the battery **120** to power-sinking components or subsystems (e.g., one or more of subsystems **130**, **140**, **150**, **160**, **170**, and/or **190**) or, more specifically, by their associated circuits. To replenish the battery charge, the charging unit **130** may convert one form of electrical energy into another form of electrical energy. More specifically, the charging unit **130** may convert alternating current (AC) to direct current (DC), may perform frequency conversions of current or voltage waveforms, or may convert energy stored in static electric fields or static magnetic fields into direct current. Additionally or alternatively, the charging unit **130** may harvest energy from radiating or evanescent electromagnetic fields (including optical radiation) and convert it into the charge stored in the battery **120**. Furthermore, the charging unit **130** may convert non-electrical energy into electrical energy. For example, the charging unit **130** may harvest energy from motion, or from thermal gradients.

[0033] The controller **140** may include a processor unit **142** and a memory unit **144**. The processor unit **142** may include one or more processors, such as a microprocessor (uP), a digital signal processor (DSP), a central processing unit (CPU), a graphical processing unit (GPU), a field-programmable gate array (FPGA), an application-specific integrated circuit (ASIC), or any other suitable electronic processing components. Additionally or alternatively, the processor unit **142** may include photonic processing components.

[0034] The memory unit **144** may include one or more computer memory devices or components, such as one or more registers, RAM, ROM, EEPROM, or on-board flash memory. The memory unit **144** may use magnetic, optical, electronic, spintronic, or any other suitable storage technology. In some implementations, at least some of the functionality the memory unit **144** may be integrated in an ASIC or and FPGA. Furthermore, the memory unit **144** may be integrated into the same chip as the processor unit **142** and the chip, in some implementations, may be an ASIC or an FPGA.

[0035] The memory unit **144** may store a smart ring (SR) routine **146** with a set of instructions, that, when executed by the processor **142** may enable the operation and the functionality described in more detail below. Furthermore, the memory unit **144** may store smart ring (SR) data **148**, which may include (i) input data used by one or more of the components **102** (e.g., by the controller when implementing the SR routine **146**) or (ii) output data generated by one or more of the components **102** (e.g., the controller **140**, the sensor unit **150**, the communication unit **160**, or the user input unit **170**). In some implementations, other units, components, or devices may generate data (e.g., diagnostic data) for storing in the memory unit **144**.

[0036] The processing unit **142** may draw power from the battery **120** (or directly from the charging unit **130**) to read from the memory unit **144** and to execute instructions contained in the smart ring routine **146**. Likewise, the memory unit **144** may draw power from the battery **120** (or directly from the charging unit **130**) to maintain the stored data or to enable reading or writing data into the memory unit **144**. The processor unit **142**, the memory unit **144**, or the controller **140** as a whole may be capable of operating in one or more low-power mode. One such low power mode may maintain the machine state of the controller **140** when less than a threshold power is available from the battery **120** or during a charging operation in which one or more battery cells are exchanged.

[0037] The controller **140** may receive and process data from the sensors **150**, the communications unit **160**, or the user input devices **170**. The controller **140** may perform computations to generate new data, signals, or information. The controller **140** may send data from the memory unit **144** or the generated data to the communication unit **160** or the output devices **190**. The electrical signals or waveforms generated by the controller **140** may include digital or analog signals or waveforms. The controller **140** may include electrical or electronic circuits for detecting, transforming (e.g.,

linearly or non-linearly filtering, amplifying, attenuating), or converting (e.g., digital to analog, analog to digital, rectifying, changing frequency) of analog or digital electrical signals or waveforms.

[0038] The sensor unit **150** may include one or more sensors disposed within or throughout the housing **110** of the ring **101**. Each of the one or more sensors may transduce one or more of: light, sound, acceleration, translational or rotational movement, strain, temperature, chemical composition, surface conductivity or other suitable signals into electrical or electronic sensors or signals. A sensor may be acoustic, photonic, micro-electro-mechanical systems (MEMS) sensors, chemical, micro-fluidic (e.g., flow sensor), capacitive or any other suitable type of sensor. The sensor unit **150** may include, for example, an inertial motion unit (IMU) for detecting orientation and movement of the ring **101**. Additionally or alternatively, the sensor unit **150** may include one or more sensors for measuring proximity or pressure.

[0039] The communication unit **160** may facilitate wired or wireless communication between the ring **101** and one or more other devices. The communication unit **160** may include, for example, a network adaptor to connect to a computer network, and, via the network, to network-connected devices. The computer network may be the Internet or another type of suitable network (e.g., a personal area network (PAN), a local area network (LAN), a metropolitan area network (MAN), a wide area network (WAN), a mobile, a wired or wireless network, a private network, a virtual private network, etc.). The communication unit **160** may use one or more wireless protocols, standards, or technologies for communication, such as Wi-Fi, near field communication (NFC), Bluetooth, or Bluetooth low energy (BLE). Additionally or alternatively, the communication unit **160** may enable free-space optical or acoustic links. In some implementations, the communication unit **160** may include one or more ports for a wired communication connections. The wired connections used by the wireless communication module **160** may include electrical or optical connections (e.g., fiber-optic, twisted-pair, coaxial cable).

[0040] User input unit **170** may collect information from a person wearing the ring **101** or another user, capable of interacting with the ring **101**. In some implementations, one or more of the sensors in the sensor unit **150** may act as user input devices within the user input unit **170**. User input devices may transduce tactile, acoustic, video, gesture, or any other suitable user input into digital or analog electrical signal, and send these electrical signals to the controller **140**.

[0041] The output unit **190** may include one or more devices to output information to a user of the ring **101**. The one or more output devices may include acoustic devices (e.g., speaker, ultrasonic); haptic (thermal, electrical, mechanical) devices; electronic displays for optical output, such as an organic light emitting device (OLED) display, a laser unit, a high-power light-emitting device (LED), etc.; or any other suitable types of devices. For example, the output unit **190** may include a projector that projects an image onto a suitable surface. In some implementations, the sensor unit **150**, the user input unit **170**, and the output unit **190** may cooperate to create a user interface with capabilities (e.g., a keyboard) of much larger computer systems, as described in more detail below.

[0042] The components **120**, **130**, **140**, **150**, **160**, **170**, and/or **190** may be interconnected by a bus **195**, which may be implemented using one or more circuit board traces, wires, or other electrical, optoelectronic, or optical connections. The bus **195** may be a collection of electrical power or communicative interconnections. The communicative interconnections may be configured to carry signals that conform to any one or more of a variety of protocols, such as I2C, SPI, or other logic to enable cooperation of the various components.

II. Example Smart Ring Form Factor Types

[0043] FIG. **2** includes block diagrams of a number of different example form factor types or configurations **205a**, **205b**, **205c**, **205d**, **205e**, and/or **205f** of a smart ring (e.g., the smart ring **101**). In a charging system, the variety of configurations of the ring-shaped housing may influence, or, conversely, depend on the technique of energy transfer between a charging source and a power source of the smart ring. Furthermore, the configurations **205a**, **205b**, **205c**, **205d**, **205e**, and/or

**205***f* may depend on or determine the types of indicators or communication components disposed at the ring.

[0044] The configurations **205***a,* **205***b,* **205***c,* **205***d,* **205***e,* and/or **205***f* (which may also be referred to as the smart rings **205***a,* **205***b,* **205***c,* **205***d,* **205***e,* and/or **205***f*) may each represent an implementation of the smart ring **101**, and each may include any one or more of the components **102** (or components similar to the components **102**). In some embodiments, one or more of the components **102** may not be included in the configurations **205***a,* **205***b,* **205***c,* **205***d,* **205***e,* and/or **205***f.* The configurations **205***a,* **205***b,* **205***c,* **205***d,* **205***e,* and/or **205***f* include housings **210***a-f,* which may be similar to the housing **110** shown in FIG. **1**.

[0045] The configuration **205***a* may be referred to as a band-only configuration comprising a housing **210***a.* In the configuration **205***b,* a band may include two or more removably connected parts, such as the housing parts **210***b* and **210***c.* The two housing parts **210***b* and **210***c* may each house at least some of the components **102**, distributed between the housing parks **210***b* and **210***c* in any suitable manner.

[0046] The configuration **205***c* may be referred to as a band-and-platform configuration comprising (i) a housing component **210***d* and (ii) a housing component **210***e* (sometimes called the "platform **210***e*"), which may be in a fixed or removable mechanical connection with the housing **210***d.* The platform **210***e* may function as a mount for a "jewel" or for any other suitable attachment. The housing component **210***d* and the platform **210***e* may each house at least one or more of the components **102** (or similar components).

[0047] In some instances, the term "smart ring" may refer to a partial ring that houses one or more components (e.g., components **102**) that enable the smart ring functionality described herein. The configurations **205***d* and **205***e* may be characterized as "partial" smart rings, and may be configured for attachment to a second ring. The second ring may be a conventional ring without smart functionality, or may be second smart ring, wherein some smart functionality of the first or second rings may be enhanced by the attachment.

[0048] The configuration **205***d,* for example, may include a housing **210***f* with a groove to enable clipping onto a conventional ring. The grooved clip-on housing **210***f* may house the smart ring components described above. The configuration **205***e* may clip onto a conventional ring using a substantially flat clip **210***g* part of the housing and contain the smart ring components in a platform **210***h* part of the housing.

[0049] The configuration **205***f,* on the other hand, may be configured to be capable of being mounted onto a finger of a user without additional support (e.g., another ring). To that end, the housing **210***i* of the configuration **205***f* may be substantially of a partial annular shape subtending between 180 and 360 degrees of a full circumference. When implemented as a partial annular shape, the housing **210***i* may be more adaptable to fingers of different sizes that a fully annular band (360 degrees), and may be elastic. A restorative force produced by a deformation of the housing **210***i* may ensure a suitable physical contact with the finger.

[0050] The configuration **205***g* may be configured to have two rings, a first ring **205***g***1** capable of and adapted to be mounted onto a finger of a user, and a second ring **205***g***2** capable of and adapted to be directly mounted onto the first ring **205***g***1**, as depicted in FIG. **2**. Said another way, the first ring **205***g***1** and the second ring **205***g***2** are arranged in a concentric circle arrangement, such that the second ring **205***g***2** does not contact a user's finger when the smart ring **205***g* is worn. Rather, only the first ring **205***g***1** contacts the user's finger. Additional suitable combinations of configurations (not illustrated) may combine at least some of the housing features discussed above.

[0051] FIG. **3** includes perspective views of example configurations **305***a,* **305***b,* **305***c,* **305***d,* **305***e,* and/or **305***f* of a smart ring (e.g., the smart ring **101**) in which a number of surface elements are included. In a charging system, the variety of configurations of the smart ring may influence, or, conversely, depend on the technique of energy transfer between a charging source and a power source of the smart ring. Additionally, some of the surface elements may be configured to indicate

when a charging rate of the smart ring rises above or falls below a threshold, the charge remaining at the power source, etc.

[0052] Configuration **305***a* is an example band configuration **205***a* of a smart ring (e.g., smart ring **101**). Some of the surface elements of the housing may include interfaces **312***a,* **312***b* that may be electrically connected to, for example, the charging unit **130** or the communications unit **160**. On the outside of the configuration **305***a,* the interfaces **312***a,* **312***b* may be electrically or optically connected with a charger to transfer energy from the charger to a battery (e.g., the battery **120**), or with another device to transfer data to or from the ring **305***a*. The outer surface of the configuration **305***a* may include a display **390***a,* while the inner surface may include a biometric sensor **350***a*.

[0053] The configurations **305***b* and **305***c* are examples of configurations of a smart ring with multiple housing parts (e.g., configuration **205***b* in FIG. **2**). Two (or more) parts may be separate axially (configuration **305***b*), azimuthally (configuration **305***c*), or radially (nested rings, not shown). The parts may be connected mechanically, electrically, or optically via, for example, interfaces analogous to interfaces **312***a,* **312***b* in configuration **305***a*. Each part of a smart ring housing may have one or more surface elements, such as, for example, sensors **350***b,* **350***c* or output elements **390***b,* **390***c*. The latter may be LEDs (e.g., output element **390***b*) or haptic feedback devices (e.g., output element **390***c*), among other suitable sensor or output devices. Additionally or alternatively, at least some of the surface elements (e.g., microphones, touch sensors) may belong to the user input unit **170**.

[0054] Configuration **305***d* may be an example of a band and platform configuration (e.g., configuration **205***c*), while configurations **305***e* and **305***f* may be examples of the partial ring configurations **205***d* and **205***e,* respectively. Output devices **390***d,* **390***e,* **390***f* on the corresponding configurations **305***d-f* may be LCD display, OLED displays, e-ink displays, one or more LED pixels, speakers, or any other suitable output devices that may be a part of a suite of outputs represented by an output unit (e.g., output unit **190**). Other surface elements, such as an interface component **312***c* may be disposed within, at, or through the housing. It should be appreciated that a variety of suitable surface elements may be disposed at the illustrated configurations **305***a,* **305***b,* **305***c,* **305***d,* **305***e,* and/or **305***f* at largely interchangeable locations. For example, the output elements **390***d,* **390***e,* **390***f* may be replaced with sensors (e.g., UV sensor, ambient light or noise sensors, etc.), user input devices (e.g., buttons, microphones, etc.), interfaces (e.g., including patch antennas or optoelectronic components communicatively connected to communications units), or other suitable surface elements.

III. Example Operating Environment for a Smart Ring

[0055] FIG. **4** illustrates an example environment **400** within which a smart ring **405** may be configured to operate. The environment **400** includes examples of objects at which a charging source may be advantageously disposed in the charging systems discussed in this disclosure. In an embodiment, the smart ring **405** may be the smart ring **101**. In some embodiments, the smart ring **405** may be any suitable smart ring capable of providing at least some of the functionality described herein. Depending on the embodiment, the smart ring **405** may be configured in a manner similar or equivalent to any of the configurations **205***a,* **205***b,* **205***c,* **205***d,* **205***e,* and/or **205***f* or **305***a,* **305***b,* **305***c,* **305***d,* **305***e,* and/or **305***f* shown in FIG. **2** and FIG. **3**.

[0056] The smart ring **405** may interact (e.g., by sensing, sending data, receiving data, receiving energy) with a variety of devices, such as bracelet **420** or another suitable wearable device, a mobile device **422** (e.g., a smart phone, a tablet, etc.) that may be, for example, the user device **104**, another ring **424** (e.g., another smart ring, a charger for the smart ring **405**, etc.), a secure access panel **432**, a golf club **434** (or another recreational accessory), a smart ring **436** worn by another user, or a steering wheel **438** (or another vehicle interface). Additionally or alternatively, the smart ring **405** may be communicatively connected to a network **440** (e.g., WiFi, 5G cellular), and by way of the network **440** (e.g., network **105** in FIG. **1**) to a server **442** (e.g., server **107** in FIG. **1**) or a personal computer **444** (e.g., mobile device **106**). Additionally or alternatively, the ring **405** may

be configured to sense or harvest energy from natural environment, such as the sun **450**.

[0057] The ring **405** may exchange data with other devices by communicatively connecting to the other devices using, for example, the communication unit **160**. The communicative connection to other device may be initiated by the ring **405** in response to user input via the user input unit **170**, in response to detecting trigger conditions using the sensor unit **150**, or may be initiated by the other devices. The communicative connection may be wireless, wired electrical connection, or optical. In some implementation, establishing a communicative link may include establishing a mechanical connection.

[0058] The ring **405** may connect to other devices (e.g., a device with the charger **103** built in) to charge the battery **120**. The connection to other devices for charging may enable the ring **405** to be recharged without the need for removing the ring **405** from the finger. For example, the bracelet **420** may include an energy source that may transfer the energy from the energy source to battery **120** of the ring **405** via the charging unit **430**. To that end, an electrical (or optical) cable may extend from the bracelet **420** to an interface (e.g., interfaces **112***a,* **112***b,* **312***a,* **312***b*) disposed at the housing (e.g., housings **110**, **210***a-i*) of the ring **405**. Other wearable charging devices may transfer charge to the ring **405** by any suitable means. In some implementations, a user may wear a glove with a built-in charging device configured to charge the ring **405**. The mobile device **422**, the ring **424**, the golf club **434**, the steering wheel **438** may also include energy source configured as chargers (e.g., the charger **103**) for the ring **405**. The chargers for may transfer energy to the ring **405** via a wired or wireless (e.g., inductive coupling) connection with the charging unit **130** of the ring **405**.

IV. Examples of Charging Systems for a Smart Ring

[0059] FIG. **5**A, FIG. **5**B, and FIG. **5**C are schematic diagrams of example charging systems **500***a,* **500***b,* **500***c* for corresponding smart rings **501***a,* **501***b,* **501***c*. The smart rings **501***a,* **501***b,* **501***c* may exemplify the smart ring **101** of FIG. **1** or the smart ring **405** of FIG. **4** operating within the environment **400**. As discussed below, the smart rings **501***a,* **501***b,* **501***c* may be configured for charging from charging sources integrated in some objects (e.g., golf club **434**, steering wheel **438**) disposed in the environment **400**. Thus, a user of the smart ring **405** may advantageously charge the smart ring **405** in the course of the user's activities and without removing the ring **405** from the finger.

[0060] In FIG. **5**A, for example, a ring-shaped housing **510** includes a power source **520** (e.g., battery **120**) configured to receive energy from a charging source **522**. The charging source **522** may be integrated into an object **524** (e.g., golf club **434**, steering wheel **438**, or another suitable object configured to be held by a user), so as to facilitate charging the power source **520** while the user is wearing the smart ring **501***a* and holding the object **524**. The charging source **522** may be integrated into the object during a manufacturing step for the object **524**. Alternatively, the charging source **522** may be a separate article of manufacture disposed at the object **524** as an addition, installed, for example, by the user of the object **524**. If the charging source **522** disposed at the object **524** does not substantially impede the original use of the object **524**, while facilitating the charging as described herein, the charging source **522** may be considered, in a sense, to be installed at the object **524**. Besides the examples illustrated in the environment **400**, the object **524** may be, for example, a handlebar of a motorcycle or a bicycle. Alternatively, the object **524** may be a hand-held object such as a cane, a tennis racket, an umbrella, etc. In some implementations, the object **524** may include an energy harvesting circuit configured to harvest kinetic, solar, thermal, or ambient radio energy and to supply the harvested energy to the charging source for subsequent transfer to the smart ring **501***a*.

[0061] A controller **540** (e.g., the controller **140**) and one or more input/output (I/O) components **560** may be disposed within the ring-shaped housing **510**. Both the controller **540** and the I/O components **560** may be electrically connected to and draw energy from the power source **520**. Furthermore, the controller **540** may be communicatively connected to the power source **520** and to

the I/O components **560**. The I/O components **560** may implement, for example, the communication unit **160**, the user input unit **170**, or the output unit **190** of the smart ring **101**. The I/O components **560** may include a user interface (UI) **562**. The user interface **562** may include one or more visual indicators (e.g., light emitting diodes (LEDs), a display, etc.), one or more audio indicators (e.g., a speaker, a buzzer, etc.), or one or more haptic indicators (e.g., a haptic motor, a piezoelectric actuator, a voice coil, a micro-heater, etc.).

[0062] The controller **540** may be configured to estimate a charging rate at which the power source **520** receives energy from the charging source **522**. To that end, the controller **540** may include a circuit that monitors voltage across the terminals of the power source **520**. Additionally or alternatively, the controller **540** may include a circuit for monitoring current flowing into the power source **520**. In some implementations, voltage or current monitoring circuits may be integrated into the power source **520** and the power source **520** may send signals indicative of the monitored voltage or current to the controller **540**. In any case, the controller **540** may estimate a charging rate at which the power source **520** receives energy from the charging source **522** based at least in part upon the monitored current or voltage. The controller **540** may use a single sample or multiple samples of monitored current to estimate the charging rate. Additionally or alternatively, the controller **540** may use multiple samples of the monitored voltage at the power source as well as the time between the samples to estimate the charging rate. In some implementations, the controller **540** may estimate the charging rate averaged over a suitable time interval that may be 1, 2, 5, 10, 20, 50, 100 sec or any other suitable interval.

[0063] The controller **540** may compare the estimated charging rate to a threshold. The threshold charging rate may be, for example, 0.01 mAh/min, 0.1 mAh/min, 1 mAh/min, 10 mAh/min, etc. corresponding to currents of 0.6 mA, 6 mA, 60 mA, or 600 mA, etc. In response to detecting that the charging rate is above the threshold, the controller **540** may cause the I/O components to indicate that the power source **520** is charging using the user interface **562**. In some implementations, when the charging rate is below the threshold for a pre-determined duration, the charging system **500***a* may cause the charging source **522** to switch off, as described in more detail below.

[0064] In some implementations, the controller **540** may cause an LED disposed at the ring-shaped housing **510** to turn on and remain turned on or to flash periodically to indicate that charging is in progress. Brightness, flashing rate, or flashing pattern of the LED may indicate the charging rate in some applications. In some implementations, the controller **540** may cause an organic LED (OLED), a liquid-crystal, or an e-ink display disposed at the ring-shaped housing **110** to display one or more symbols or characters indicative of the charging rate.

[0065] Additionally or alternatively, the controller **540** may cause an audio indicator of the user interface **562** (e.g., a buzzer, a speak, etc.) disposed at the ring-shaped housing **510** to produce a tone, a buzz, or any suitable sound to indicate that the power source **520** is charging. The tone, the buzz or any other sound may vary to indicate the charging rate of the power source **520**.

[0066] Still additionally or alternatively, the user interface **562** may include a haptic indicator (e.g., a vibration motor, a voice coil, a piezo actuator, etc.) to provide the user with haptic feedback indicative of the charging rate, for example. For example, the controller **540** may cause the haptic indicator to produce a vibration or a sequence of taps of intensity, frequency, duration, and/or pattern indicative of the charging rate.

[0067] The charging system **500***a* may include a wired connection between the charging source **522** and the power source **520**. In some implementations, the power source **520** may complete a circuit with the charging source **522** to thereby initiate charging. In other implementations, the charging source may include a switch and one or more sensors, with the switch configured to enable charging based at least in part upon the one or more sensors. In some implementations, the sensors at the charging source **522** may be configured to sense the load impedance to identify the power source **520** before initiating charging. Additionally or alternatively, the sensors at the charging

source **522** may be configured to sense the voltage level at the power source **520** to determine whether the power source **520** is in need of charging, for example, and activate charging based at least in part upon the sensor output.

[0068] To facilitate charging via a wired connection of the power source **520** by the charging source **522**, the charging source **522** and the power source **520** may include mating connectors. Furthermore, the object **524** into which the charging source is integrated may include one or more registration structures that aid in aligning the smart ring with the charging source **522** at the object **524** to facilitate the mating of the connectors. Furthermore, the one or more registration structures may give tactile feedback to the user indicative that the smart ring **501***a* is in position or, in some implementations, nearly in position for charging.

[0069] In some implementations, the power source **520** is configured to receive power from the charging source **522** by way of a wireless connection. For example, the wireless connection for power transfer may be implemented using inductive coupling. Specifically, the charging source **522** may include an oscillator (possibly followed by one or more amplifiers) supplying alternating current (AC) to a transmitting coil also disposed at the charging source **522**. The power source **520** of the smart ring may receive energy from the charging source **522** via a charging unit (e.g., the charging unit **130** in FIG. **1**) that includes a receiving coil and rectifying components. When the active transmitting coil is in suitable proximity to the receiving coil, magnetic flux generated by the current in the transmitting coil induces an AC voltage across terminals of the receiving coil. The rectifying components (e.g., suitably arranged diodes and capacitors) may rectify and smooth (i.e., convert to direct current (DC) waveform suitable for charging the power source **520**) the AC waveform. Thus, the power source **520** may receive, via the receiving coil, the electrical energy transmitted by the charging source **522** via the transmitting coil.

[0070] Wireless power transfer via inductive coupling may rely on one or both of two general techniques. In the first, the transmitting and receiving coils are disposed in close proximity and coaxial alignment so that the magnetic flux through one coil largely goes through the other coil. Thus, the coils are closely-coupled. The degree to which the magnetic flux is shared between the two coils can be quantified as a coupling coefficient, which may be 0.05, 0.1, 0.2, 0.4, 0.6, 0.8 or another suitable value. Power transfer efficiency may be largely dependent on and marginally smaller than the coupling coefficient.

[0071] The second inductive coupling technique uses resonant inductive coupling. In this technique, the transmitting and receiving coil may have a substantially smaller coupling coefficient. On the other hand, the transmitting and receiving inductive coils may be connected to corresponding capacitive elements to form corresponding resonant circuits that, when properly tuned, ensure efficient power transfer despite a reduced coupling coefficient. The frequency of the oscillator may be tuned to match the resonance frequency of the circuits. The resonant inductive power transfer may transfer power with greater separation between the transmitting and receiving coils, though power transfer efficiency may be smaller (e.g., efficiency of 1, 2, 5, 10%) than when using closely-coupled coils.

[0072] With either closely-coupled coils or resonant inductive coupling, the rate of wireless transmission of energy may vary substantially in response to the relative position between transmitting and the receiving coils. Thus, the indicators in the user interface **562**, such as the ones described above, may prompt the user to adjust the position of a hand (with the smart ring) holding the object **524** so as to achieve a higher charging rate. Additionally or alternatively, it may be advantageous to dispose indicators outside of the smart ring. For example, in some implementation or situations, the indicators disposed at the ring may not be easily noticeable by a user. Also, disposing indicators outside of the ring-shaped housing **510** may reduce the power consumption for the power source **520**.

[0073] FIG. **5**B schematically illustrates the charging system **500***b* in which the ring-shaped housing **510** includes a set of I/O components **564** that include a transmitter **566** (that may be

referred to, more generally, as a communication component and may be a part of a transceiver) configured to transmit communication signals to a communication device external to the ring-shaped housing **510**. The communication signal transmitted by the transmitter **566** may be indicative of the charging rate. One or more indicators, including indicator **570** may be disposed outside of the smart ring **501***b* and configured to indicate the charging rate in response to the signal transmitted by the transmitter **566**. To that end, the indicator **570** may be in communicative connection with a receiver configured for receiving the signals transmitted by the transmitter **566**. For example, the transmitter **566** and the corresponding receiver may be configured to communicate over radio waves using a WiFi, a Bluetooth, a Bluetooth Low Energy (BLE), or any other suitable protocol. In some implementations, the transmitter **566** and a corresponding receiver may implement an infrared link between the smart ring and the indicator **570**.

[0074] The indicator **570** may be a visual indicator, an audio indicator, or a haptic indicator and may be disposed at any convenient location. For example, in implementations where the object **524** with the charging source **522** is a steering wheel of a vehicle or a handlebar of a motorcycle, the indicator **570** may be disposed at a corresponding head unit of the vehicle or the motorcycle. The indicator **570** may also be an audio indicator disposed within the audio system of the vehicle or the motorcycle.

[0075] In some implementations, the indicator **570** may be disposed at the object **524**. For example, when the object is a golf club or a tennis racket, the indicator may be an LED, or a haptic motor disposed at a corresponding handle of the object **524**. In some implementations, the indicator **570** may be integrated with the charging source **522** disposed at the object **524**, as discussed in more detail below.

[0076] In other implementations, the indicator **570** may be integrated into a mobile device (e.g., a smart phone, a smart watch, or another suitable device other than the smart ring) of the user. For example, a smart ring application running on a smart phone of the user may generate, based at least in part upon the signal received from the transmitter **566**, notifications indicative of the charging rate of the smart ring and use any of the output device of the smart phone as the indicator **570**.

[0077] Multiple indicators **570** may be used to indicate the charging rate of the smart ring power source **520** to the user. The indicators may be disposed at multiple locations and may be configured to receive the one or more signals indicative of the charging rate of the power source from the transmitter **566**. In an alternative implementation, the user mobile device may receive the signal from the transmitter **566**, and may in turn cause multiple indicators **570**, disposed at or communicatively connected to the mobile device, to indicate the charging rate.

[0078] FIG. **5**C schematically illustrates the charging system **500***c* in which estimating the charging rate at which the power source **520** receives energy from the charging source **522** and indicating the charging rate (e.g., when the charging rate is above a threshold) is implemented by components disposed at the object **524** with the charging source **522**. To that end, a controller **580** and a user interface **590**, including one or more indicators, are disposed at the object **524**. The controller **580** may be communicatively connected to the charging source **522** and to the user interface **590**. The controller **580** may estimate the charging rate using a technique suitable for the implemented method of charging. For example, when the charging source **522** is configured to transmit power to the power source **520** via a wired connection, the controller **580** may estimate the charging rate using a circuit indicative of current supplied by the charging source **522**. This approach may work well for a wired connection in which charging efficiency is substantially stable. When the charging source **522** is configured to transmit power to the power source **520** via a wireless connection, on the other hand, the controller **580** may rely on additional techniques to estimate the charging rate. For example, the controller **580** may include or be electrically connected to a circuit configured for measuring a reflection coefficient at the output or another suitable stage of the charging source **522**. The reflection coefficient may be indicative of the coupling efficiency between the wireless power transfer elements (e.g., coils, as described above) of the charging source **522** and the power source

**520**, and, consequently, of the charging rate.

[0079] Additionally or alternatively, the power source **520** of the charging system **500***c* may be communicatively connected to a controller (e.g., controller **540**) disposed in the ring-shaped housing **510**. The controller of the smart ring may be configured to communicate with the controller **580** connected to the charging source **522** via corresponding communication components (e.g., at the smart ring-communication unit **160** or transmitter **566** and a suitable counterpart at the object **524**). For example, the controller **540** connected to the power source **520** may estimate the charging rate of the power source **520** using one of the techniques described above and send a signal, indicative of the charging rate, via the communication component at the smart ring. The controller **580** may receive, via the communication unit at the object **524**, the signal indicative of the charging rate and cause the user interface **590** to indicate the whether there is charging, whether the charging rate is above a threshold, etc. In some implementations, a component configured for the wireless charging may be integrated in the same chip with the communication components that exchange signals indicative of the charging.

[0080] In the charging systems **500***a,* **500***b,* **500***c* described above, the charging source **522** may be configured to activate, conditionally, in response to detecting a connection to or proximity of the power source **520**. In the case of a wired power transfer connection, the conditional activation of the charging source **522** may prevent the charging source **522** from transferring power to an incompatible device or to a spurious load, such as an accidental short circuit. In the case of the wireless power transfer connection, the conditional activation of the charging source **522** may prevent wasting power. Conditional activation of the charging source **522** may prevent, for example, activation the transmitting coil of an inductive coupling system when the receiving coil is not in the condition to receive the power.

[0081] To detect proximity of the smart ring to the charging source **522**, the object **524** may include one or more sensors. The one or more sensors may include optical, capacitive, radio frequency identification (RFID), ultrasonic, pressure or any other suitable sensors capable of detecting a hand of a user or the smart ring directly. The charging source **522** may be configured to activate (i.e., start transmitting energy) in response to the detection. Furthermore, the charging source **522** may be configured to subsequently deactivate (i.e., stop transmitting energy) after a delay and upon determining that the estimated charging rate is below a threshold.

[0082] Additionally or alternatively, a user interface, disposed at the object **524** (e.g., in the charging system **500***c*), at the ring-shaped housing **510** (e.g., in the charging system **500***a*), or elsewhere (e.g., in the charging system **500***b*) may be configured to indicate proximity of the smart ring to the charging source **522**. In some implementations, the indication of proximity may allow the user to adjust the position of the smart ring with respect to the charging source **522** to facilitate charging. For example, a user interface may indicate proximity of the smart ring to the charging source and a low charging rate. In response, the user may then adjust a grip on the object (e.g., a steering wheel) to increase the charging rate. In an implementation, a grip on the steering wheel that substantially maximizes the charging rate may be associated with the recommended hand position from the consideration of safety.

[0083] In general, the charging systems **500***a,* **500***b,* **500***c* may include sensors, communication components, and indicators disposed at the corresponding smart rings **501***a,* **501***b,* **501***c,* at the object **524**, or elsewhere in the environment. These sensors, communication components, and indicators may cooperate, as described above, with each other and with the controllers **540**, **580** to facilitate the transfer of energy from the charging source **524** to the power source **520** in an efficient manner. The efficiency may be improved by a user responding to the indicators to actively facilitate or terminate the charging operation, or by the controllers **540**, **580** responding to sensors and automatically initiating, adjusting, or terminating the charging operation.

V. Examples of Other Considerations

[0084] When implemented in software, any of the applications, services, and engines described

herein may be stored in any tangible, non-transitory computer readable memory such as on a magnetic disk, a laser disk, solid state memory device, molecular memory storage device, or other storage medium, in a RAM or ROM of a computer or processor, etc. Although the example systems disclosed herein are disclosed as including, among other components, software or firmware executed on hardware, it should be noted that such systems are merely illustrative and should not be considered as limiting. For example, it is contemplated that any or all of these hardware, software, and firmware components could be embodied exclusively in hardware, exclusively in software, or in any combination of hardware and software. Accordingly, while the example systems described herein are described as being implemented in software executed on a processor of one or more computer devices, persons of ordinary skill in the art will readily appreciate that the examples provided are not the only way to implement such systems.

[0085] The described functions may be implemented, in whole or in part, by the devices, circuits, or routines of the system **100** shown in FIG. **1**. Each of the described methods may be embodied by a set of circuits that are permanently or semi-permanently configured (e.g., an ASIC or FPGA) to perform logical functions of the respective method or that are at least temporarily configured (e.g., one or more processors and a set instructions or routines, representing the logical functions, saved to a memory) to perform the logical functions of the respective method.

[0086] While the present disclosure has been described with reference to specific examples, which are intended to be illustrative only and not to be limiting of the present disclosure, it will be apparent to those of ordinary skill in the art that changes, additions or deletions may be made to the disclosed embodiments without departing from the spirit and scope of the present disclosure.

[0087] Throughout this specification, plural instances may implement components, operations, or structures described as a single instance. Although individual operations of one or more methods are illustrated and described as separate operations, one or more of the individual operations may be performed concurrently in certain embodiments.

[0088] As used herein, any reference to "one embodiment" or "an embodiment" means that a particular element, feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. The appearances of the phrase "in one embodiment" in various places in the specification may not be all referring to the same embodiment.

[0089] As used herein, the terms "comprises," "comprising," "includes," "including," "has," "having" or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a process, method, article, or apparatus that comprises a list of elements may not be limited to only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. Further, unless expressly stated to the contrary, "or" refers to an inclusive "or" and not to an exclusive "or." For example, a condition A or B is satisfied by any one of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

[0090] In addition, use of the "a" or "an" are employed to describe elements and components of the embodiments herein. Generally speaking, when a system or technique is described as including "a" part or "a" step, the system or technique should be read to include one or at least one part or step. Said another way, for example, a system described as including a blue widget may include multiple blue widgets in some implementations (unless the description makes clear that the system includes only one blue widget).

[0091] Throughout this specification, some of the following terms and phrases are used.

[0092] Communication Interface according to some embodiments: Some of the described devices or systems include a "communication interface" (sometimes referred to as a "network interface"). A communication interface enables the system to send information to other systems and to receive information from other systems, and may include circuitry for wired or wireless communication.

[0093] Each described communication interface or communications unit (e.g., communications unit **160**) may enable the device of which it is a part to connect to components or to other computing

systems or servers via any suitable network, such as a personal area network (PAN), a local area network (LAN), or a wide area network (WAN). In particular, the communication unit **160** may include circuitry for wirelessly connecting the smart ring **101** to the user device **104** or the network **105** in accordance with protocols and standards for NFC (operating in the 13.56 MHz band), RFID (operating in frequency bands of 125-134 kHz, 13.56 MHz, or 856 MHz to 960 MHz), Bluetooth (operating in a band of 2.4 to 2.485 GHz), Wi-Fi Direct (operating in a band of 2.4 GHz or 5 GHz), or any other suitable communications protocol or standard that enables wireless communication.

[0094] Communication Link according to some embodiments: A "communication link" or "link" is a pathway or medium connecting two or more nodes. A link between two end-nodes may include one or more sublinks coupled together via one or more intermediary nodes. A link may be a physical link or a logical link. A physical link is the interface or medium(s) over which information is transferred, and may be wired or wireless in nature. Examples of physicals links may include a cable with a conductor for transmission of electrical energy, a fiber optic connection for transmission of light, or a wireless electromagnetic signal that carries information via changes made to one or more properties of an electromagnetic wave(s).

[0095] A logical link between two or more nodes represents an abstraction of the underlying physical links or intermediary nodes connecting the two or more nodes. For example, two or more nodes may be logically coupled via a logical link. The logical link may be established via any combination of physical links and intermediary nodes (e.g., routers, switches, or other networking equipment).

[0096] A link is sometimes referred to as a "communication channel." In a wireless communication system, the term "communication channel" (or just "channel") generally refers to a particular frequency or frequency band. A carrier signal (or carrier wave) may be transmitted at the particular frequency or within the particular frequency band of the channel. In some instances, multiple signals may be transmitted over a single band/channel. For example, signals may sometimes be simultaneously transmitted over a single band/channel via different sub-bands or sub-channels. As another example, signals may sometimes be transmitted via the same band by allocating time slots over which respective transmitters and receivers use the band in question.

[0097] Memory and Computer-Readable Media according to some embodiments: Generally speaking, as used herein the phrase "memory" or "memory device" refers to a system or device (e.g., the memory unit **144**) including computer-readable media ("CRM"). "CRM" refers to a medium or media accessible by the relevant computing system for placing, keeping, or retrieving information (e.g., data, computer-readable instructions, program modules, applications, routines, etc.). Note, "CRM" refers to media that is non-transitory in nature, and does not refer to disembodied transitory signals, such as radio waves.

[0098] The CRM may be implemented in any technology, device, or group of devices included in the relevant computing system or in communication with the relevant computing system. The CRM may include volatile or nonvolatile media, and removable or non-removable media. The CRM may include, but is not limited to, RAM, ROM, EEPROM, flash memory, or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store information, and which can be accessed by the computing system. The CRM may be communicatively coupled to a system bus, enabling communication between the CRM and other systems or components coupled to the system bus. In some implementations the CRM may be coupled to the system bus via a memory interface (e.g., a memory controller). A memory interface is circuitry that manages the flow of data between the CRM and the system bus.

[0099] Network according to some embodiments: As used herein and unless otherwise specified, when used in the context of system(s) or device(s) that communicate information or data, the term "network" (e.g., the networks **105** and **440**) refers to a collection of nodes (e.g., devices or systems capable of sending, receiving or forwarding information) and links which are connected to enable

telecommunication between the nodes.

[0100] Each of the described networks may include dedicated routers responsible for directing traffic between nodes, and, optionally, dedicated devices responsible for configuring and managing the network. Some or all of the nodes may be also adapted to function as routers in order to direct traffic sent between other network devices. Network devices may be inter-connected in a wired or wireless manner, and network devices may have different routing and transfer capabilities. For example, dedicated routers may be capable of high-volume transmissions while some nodes may be capable of sending and receiving relatively little traffic over the same period of time. Additionally, the connections between nodes on a network may have different throughput capabilities and different attenuation characteristics. A fiberoptic cable, for example, may be capable of providing a bandwidth several orders of magnitude higher than a wireless link because of the difference in the inherent physical limitations of the medium. If desired, each described network may include networks or sub-networks, such as a local area network (LAN) or a wide area network (WAN).

[0101] Node according to some embodiments: Generally speaking, the term "node" refers to a connection point, redistribution point, or a communication endpoint. A node may be any device or system (e.g., a computer system) capable of sending, receiving or forwarding information. For example, end-devices or end-systems that originate or ultimately receive a message are nodes. Intermediary devices that receive and forward the message (e.g., between two end-devices) are also generally considered to be "nodes."

[0102] Processor according to some embodiments: The various operations of example methods described herein may be performed, at least partially, by one or more processors (e.g., the one or more processors in the processor unit **142**). Generally speaking, the terms "processor" and "microprocessor" are used interchangeably, each referring to a computer processor configured to fetch and execute instructions stored to memory. By executing these instructions, the processor(s) can carry out various operations or functions defined by the instructions. The processor(s) may be temporarily configured (e.g., by instructions or software) or permanently configured to perform the relevant operations or functions (e.g., a processor for an Application Specific Integrated Circuit, or ASIC), depending on the particular embodiment. A processor may be part of a chipset, which may also include, for example, a memory controller or an I/O controller. A chipset is a collection of electronic components in an integrated circuit that is typically configured to provide I/O and memory management functions as well as a plurality of general purpose or special purpose registers, timers, etc. Generally speaking, one or more of the described processors may be communicatively coupled to other components (such as memory devices and I/O devices) via a system bus.

[0103] The performance of certain of the operations may be distributed among the one or more processors, not only residing within a single machine, but deployed across a number of machines. In some example embodiments, the processor or processors may be located in a single location (e.g., within a home environment, an office environment or as a server farm), while in other embodiments the processors may be distributed across a number of locations.

[0104] Words such as "processing," "computing," "calculating," "determining," "presenting," "displaying," or the like may refer to actions or processes of a machine (e.g., a computer) that manipulates or transforms data represented as physical (e.g., electronic, magnetic, or optical) quantities within one or more memories (e.g., volatile memory, non-volatile memory, or a combination thereof), registers, or other machine components that receive, store, transmit, or display information.

[0105] Although specific embodiments of the present disclosure have been described, it will be understood by those of skill in the art that there are other embodiments that are equivalent to the described embodiments. Accordingly, it is to be understood that the present disclosure is not to be limited by the specific illustrated embodiments.

# Claims

**1**. A charging system, comprising: a housing, comprising: a controller; and a power source configured to power the controller; and a wireless charger configured to transfer energy to the power source, comprising: a first indicator configured to provide: a first non-flashing visual output at a first brightness level and indicative of a first charging status of the power source; and a second non-flashing visual output at a second brightness level indicative of a second charging status of the power source.

**2**. The charging system of claim 1, wherein: the first indicator is configured to indicate a charging rate of the power source.

**3**. The charging system of claim 1, wherein: the first indicator comprises a light emitting diode (LED).

**4**. The charging system of claim 1, wherein: the first indicator is configured to prompt a user to adjust a position of the housing relative to the wireless charger to achieve a higher charging rate for the power source of the housing.

**5**. The charging system of claim 1, wherein: the wireless charger is integrated into an object in an environment of a user of the housing.

**6**. The charging system of claim 5, wherein: the object in the environment of the user is one or more of: a vehicle interface, a recreational accessory, or a wearable device.

**7**. The charging system of claim 1, further comprising: one or more of audio output or haptic output indicative of the first charging status of the power source or the second charging status of the power source.

**8**. The charging system of claim 1, wherein: the wireless charger uses inductive coupling to transfer energy from the wireless charger to the power source.

**9**. The charging system of claim 1, wherein: the controller is configured to detect that a charging rate at which the power source is receiving energy from the wireless charger is above a threshold.

**10**. The charging system of claim 1, further comprising: a second indicator disposed at the housing.

**11**. A method for charging a housing, comprising: providing the housing, comprising: providing a controller; and providing a power source configured to power the controller; and providing a wireless charger configured to transfer energy to the power source, comprising: providing a first indicator configured to provide: a first non-flashing visual output at a first brightness level and indicative of a first charging status of the power source; and a second non-flashing visual output at a second brightness level indicative of a second charging status of the power source.

**12**. The method of claim 11, wherein: the first indicator is configured to indicate a charging rate of the power source.

**13**. The method of claim 11, wherein: the first indicator comprises a light emitting diode (LED).

**14**. The method of claim 11, wherein: the first indicator is configured to prompt a user to adjust a position of the housing relative to the wireless charger to achieve a higher charging rate for the power source of the housing.

**15**. The method of claim 11, wherein at least one of: the wireless charger is integrated into an object in an environment of a user of the housing; or the object in the environment of the user is one or more of: a vehicle interface, a recreational accessory, or a wearable device.

**16**. The method of claim 11, further comprising: one or more of audio output or haptic output indicative of the first charging status of the power source or the second charging status of the power source.

**17**. The method of claim 11, further comprising: transferring energy from the wireless charger to the power source using inductive coupling.

**18**. The method of claim 11, further comprising: detecting, by the controller, that a charging rate at which the power source is receiving energy from the wireless charger is above a threshold.

**19**. The method of claim 11, further comprising: disposing a second indicator at the housing.

**20**. A charging system, comprising: a housing, comprising: a controller and at least one sensor; and a power source configured to power the controller; and a wireless charger configured to transfer energy to the power source, comprising: a first indicator configured to provide: a first non-flashing visual output at a first brightness level and indicative of a first charging status of the power source; and a second non-flashing visual output at a second brightness level indicative of a second charging status of the power source.