

A SYSTEM AND METHOD FOR AN INVISIBLE SENSOR AUTOMATIC FLUSH URINAL

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TECHNICAL CONTRIBUTION

The present disclosure relates to automatic flush urinals. More particularly, the present disclosure relates to an invisible sensor automatic flush urinal system and method.

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BACKGROUND

FIGs. 1A-1B are, respectively, a side view and a front view illustration of a prior art visible sensor automatic flush urinal **10**. **FIG. 1A** illustrates a cross-sectional view of the urinal basin **16** mountable on a wall (not shown) using wall mounts **12**. As illustrated in **FIG. 1A**, the user's view of the urinal is limited primarily to the user visible surface **17** of the urinal basin **16** and the visible proximity sensor **11a**. The visible proximity sensor **11a** has a proximity detection area **11b** to detect a user presence. The visible proximity sensor **11a** is visible to the user because it is typically an infrared sensor relying on line-of-sight to detect presence of the user. The urinal includes a liquid routing with a water inlet **14a**, a flush valve **13a** (typically a solenoid valve), a water outlet **14b**, a drain **15**, a trap **30**, and a trap outlet **32**. The visible proximity sensor **11a** is connected to the flush valve **13a** via a flush control link **13b** (such as an insulated copper wire). The urine from the user is swept through the drain **15** by the water from the water outlet **14b** into the trap **30** and out the trap outlet **32**.

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FIG. 2 is an illustration of a capacitive sensor **20a** configured for sensing a liquid level **26** of a container **20b** holding liquid **25**. The capacitive sensor **20a** illustrated in **FIG. 2** includes a shield **21**, a sensor plate **22**, and a ground plate **23**. The capacitive sensor **20a** produces an electric field **24** across the container **20b** between the sensor plate **22** and the ground plate **23**. The capacitive sensor **20a** is mounted such that it is best able to evaluate the liquid level **26** of the liquid **25** in the container **20b**.

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FIGs. 3A-3C are side view illustrations of, respectively, a trap **30** without liquid, the trap **30** filled with waste liquid **34** to a trap level **33**, the trap **30** with waste liquid **34** overflowing the trap level **33** with an overflow depth **36** (the difference between the trap level **33** and the overflow level **35**) of waste liquid **34** exiting the trap outlet **32**.
5 Along the path (represented by large arrows) of the waste liquid **34** through the liquid path of the trap **30**, the trap **30** includes a trap inlet **31**, a trap weir **37** at a trap level **33**, and a trap outlet **32**. As illustrated in **FIG. 3B**, waste liquid **34** does not pass the trap weir **37** if the level of the waste liquid **34** in the trap **30** is below the trap level **33**. As illustrated in **FIG. 3C**, waste liquid **34** will pass over the trap weir **37** and out the trap
10 outlet **32** if the level of waste liquid **34** exceeds that of the trap level **33** and creates an overflow depth **36**.

In the prior art automatic flush urinal **10** represented in **FIGs. 1A-1B**, the visible proximity sensor **11a** is employed to detect user presence, but the trap **30** is not
15 monitored. While the visible sensor automatic flush urinal **10** has the potential for improved water efficiency and greater cleanliness in the toilet room, this prior art urinal design is often prone to alternatively: (i) failing to flush; (ii) flushing too often, such as with changes in posture of the user; or (iii) or flushing continuously, thereby wasting water and potentially flooding the toilet area.

20 The prior art visible sensor automatic flush urinal **10** is also not connected to any network. Thus the malfunctions continue unabated until detected by maintenance staff (often after complaints from irate users). The introduction of visible sensor automatic flush urinal **10** into a toilet room thus can often result in a negative first impression of a
25 venue visited by customers. Especially for service industries such as airports and hotels, this negative customer experience in the toilet room can impact the venue's reputation with customers and its image within the industry.

What is needed in the art of automatic flush toilets is a design that is more reliable in
30 the field and also more easily monitored for faults requiring urgent maintenance.

SUMMARY

A first embodiment of the invention is an invisible sensor automatic flush urinal comprising: (a) a urinal basin with a user visible surface, wherein the user visible surface is water resistant and opaque; (b) a liquid routing including a water inlet, a flush valve, a water outlet, a drain, a trap, and a trap outlet; (c) an invisible proximity sensor (IPS) mounted within or behind the user visible surface, wherein the IPS is a microwave Doppler sensor capable of emitting and receiving microwave signals through the user visible surface; (d) a capacitive sensor mounted in proximity to the trap and configured to measure an overflow level of waste liquid above a trap level of the trap; (e) a master control unit (MCU) including a microcontroller in electrical communication with the flush valve, the IPS, the capacitive sensor, and a network module. The microcontroller is configured to execute a flush cycle comprising the steps of: (i) monitoring the capacitive sensor to detect a flow state of waste liquid above the trap level; (ii) monitoring the IPS to detect a user presence within a proximity detection area; (iii) upon confirming the flow state is concurrent with the user presence, monitoring the capacitive sensor to detect a no-flow state of waste liquid above the trap level; (iv) after detecting a no-flow state, flushing the urinal by activating the flush valve; and (v) transmitting metadata of at least one flush cycle from the network module. Metadata is routable to a server from the network module, through a gateway, and through a network. Metadata of each flush cycle includes at least one of: (i) a timestamp; (ii) a duration of the flow state; (iii) an output of the capacitive sensor during the flow state; and (iv) a duration of the user presence in the proximity detection area.

A second embodiment of the invention is a method of urinal management comprising the steps of: (a) providing: (i) a urinal basin with a user visible surface, wherein the user visible surface is water resistant and opaque; (ii) a liquid routing including a water inlet, a flush valve, a water outlet, a drain, a trap, and a trap outlet; (iii) an invisible proximity sensor (IPS) mounted within or behind the user visible surface, wherein the IPS is a microwave Doppler sensor capable of emitting and receiving microwave signals through the user visible surface; (iv) a capacitive sensor mounted in proximity to the trap and configured to measure an overflow level of waste liquid above a trap

level of the trap; (v) a master control unit (MCU) including a microcontroller in electrical communication with the flush valve, the IPS, the capacitive sensor, and a network module; (b) performing with the MCU a flush cycle comprising the steps of: (i) monitoring the capacitive sensor to detect a flow state of waste liquid above the trap level; (ii) monitoring the IPS to detect a user presence within a proximity detection area; (iii) upon confirming the flow state is concurrent with the user presence, monitoring the capacitive sensor to detect a no-flow state of waste liquid above the trap level; (iv) after detecting a no-flow state, flushing the urinal by activating the flush valve; and (v) transmitting metadata of at least one flush cycle from the network module. Metadata is routable to a server from the network module, through a gateway, and through a network. Metadata of each flush cycle includes at least one of: (i) a timestamp; (ii) a duration of the flow state; (iii) an output of the capacitive sensor during the flow state; and (iv) a duration of the user presence in the proximity detection area.

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BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present disclosure are described herein with reference to the drawings in which:

20 **FIGs. 1A-1B** are, respectively, a side view and a front view illustration of a visible sensor automatic flush urinal, in the prior art.

FIG. 2 is an illustration of a capacitive sensor configured for sensing a liquid level of a container, in the prior art.

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FIGs. 3A-3C are side view illustrations of, respectively, a trap without liquid, the trap filled with liquid to a trap level, the trap with liquid overflowing the trap level with an overflow depth exiting the trap outlet, and the trap paired with the capacitive sensor to measure the overflow depth, in the prior art.

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FIG. 4A illustrates a trap with waste liquid overflowing the trap level, wherein the trap is paired with the capacitive sensor to measure the overflow depth, in an embodiment of the invention.

5 **FIG. 4B** is a side view illustration of an embodiment of the invisible sensor automatic flush urinal, in an embodiment of the invention.

FIG. 5 is a block diagram of electrical components within an embodiment of the invisible sensor automatic flush urinal in electrical communication with a server, in an
10 embodiment of the invention.

FIG. 6 is a flowchart of a method performed by an MCU controlling operation of the invisible sensor automatic flush urinal, in an embodiment of the invention.

15 **DETAILED DESCRIPTION**

In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. The illustrative embodiments described in the detailed description, drawings and claims are not meant to be limiting. Other embodiments can be utilized, and other changes can be made, without departing from the spirit or scope
20 of the subject matter presented herein. Unless specified otherwise, the terms “comprising,” “comprise,” “including” and “include” used herein, and grammatical variants thereof, are intended to represent “open” or “inclusive” language such that they include recited elements but also permit inclusion of additional, un-recited elements. The term “connect,” “connected,” or “connecting” used herein, and grammatical
25 variants thereof, are intended to represent a linking of two items either directly together or linking them indirectly together through a wireless and/or wired network. The term “mount,” “mounted,” or “mounting” used herein, and grammatical variants thereof, are intended to represent a holding of two items either directly together mechanically or linking them indirectly together mechanically.

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As used herein, the term network **53** can be the internet, an intranet, and/or a combination of the two. The network module **43** may employ any combination of Wi-

Fi, WAN, LAN, **Bluetooth (BLE), NB-IOT (Narrowband Internet of Things), proprietary wireless communications**, cellular, wired, optical cable to transmit (or otherwise communicate) data to and to receive (or otherwise communicate) data from the gateway **52** or the server **54**.

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The gateway **52** can include at least one of: (a) a Wi-Fi Access Point to aggregate data packet transfer to and from the server **54**; (b) a local area network; and (c) a Narrowband IoT (NB-IoT) or 3G/**LTE/4G/5G** SIM card based mobile communication network.

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As used herein, a server **54** may be a single stand-alone server, multiple dedicated servers, and/or a virtual server running on a larger network of servers. The database **55** may be on the server **54** itself or accessible to the server **54** on a separate network or platform. Metadata may be stored in the server **54** or offsite on a data storage network.

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Access to the server **54** of the system **50** may be available through a visual screen on a portable tablet, a smart phone, a dedicated device, a laptop computer, or a desktop computer. In field usage may include a smaller visual screen, thus information formatting for mobile devices may differ from that shown on a laptop or desktop computer. Access levels between members of the staff may differ depending on the role such as between the cleaning staff, the technician staff, the supervisor staff, and the server administrator.

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As illustrated in **FIG. 4A**, the overflow level is measureable in an embodiment of the invention by a capacitive sensor **20a** located near the trap **30** as the electric field **24** passes through the overflow depth **36** of the waste liquid **34** in the trap **30**.

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For the sake of simplicity of the illustration, the capacitive sensor **20a** in **FIG. 4A** is represented as a planar device near the trap inlet **31**. In actual practice of the invention the capacitive sensor **20a** can be moldable so as to skirt the exterior of distinct portions of the trap **30**. The preferred location of the capacitive sensor **20a** is above the trap level **33**. The capacitive sensor **20a** can be located near the trap inlet **31**, the trap weir

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37, the trap outlet 32, or along the piping between the trap weir 37 and the trap outlet 32. Though not illustrated in FIG. 4A, the capacitive sensor 20a can include an integrated circuit in electrical connection with a flexible copper strip, wherein the integrated circuit is configured to detect variation in either: (i) an electric field 24 generated by the flexible copper strip; or (ii) a measured capacitance of the flexible copper strip. **The conductive copper strip can also be replaced by other types of conductive metal material or flexible conductive circuit.**

For the integrated circuit of the capacitive sensor 20a, an off-the-shelf packaged integrated circuit, such as that sold under the brand name TonTek TTP223-BA6, can be used due to low cost and ease in functional design. **Other types of capacitive sensor semiconductor integrated circuits (IC) can be used to replace the TTP223-BA6 for similar or additional functions.**

The flexible copper strip is useful for retrofit operations to install the invention on a set of existing urinals. The flexible copper strip is also useful for new urinals, which often include many distinct models for different price points and different aesthetic styles. The strip's flexibility also facilitates a close proximity between the capacitive sensor 20a and the outside of the trap 30. The capacitive sensor 20a is preferably mounted outside the piping of the trap 30 rather than within the piping of the trap 30.

As will be discussed in FIG. 6 below, FIG. 4A demonstrates the conditions under which a flow state is determined by the presence of waste liquid 34 above the trap level 33 as measured by the capacitive sensor 20a.

FIG. 4B is a side view illustration of an embodiment of the invisible sensor automatic flush urinal 40 in an embodiment of the invention. FIG. 4B illustrates a urinal basin 16 with a user visible surface 17 in a cross-sectional view. FIG. 4B illustrates a urinal basin 16 mountable on a wall (not shown) using wall mounts 12. As illustrated in FIG. 4B, the user's view of the urinal is limited primarily to the user visible surface 17 of the urinal basin 16. The urinal includes a liquid routing including a water inlet 14a, a flush valve 13a, a flow rate sensor 45, a water outlet 14b, a drain 15, a trap 30, and a trap

outlet **32**. An IPS **41** is mounted in this example behind the user visible surface **17** along the back side of the urinal basin. The IPS **41** is shown capable of emitting and receiving microwave signals through the user visible surface **17** to detect a user presence within a proximity detection area **11b**. The IPS **41** is not visible to the user.

5 A capacitive sensor **20a** is mounted in proximity to the trap **30**. The urinal includes a MCU **42** including a microcontroller **44** and a network module **43**.

Because the IPS **41** is hidden within or behind the ceramic of the urinal basin **16**, a urinal employing the invention can have a more Spartan and futuristic aesthetic appearance. Cleanliness is improved as there is no separate panel for a visible proximity sensor **11b** that can be fouled **or damaged or vandalized**.

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While **FIG. 4B** includes a urinal with all components mounted within the urinal basin, an implementation of the invention can also include a water outlet **14b** that is separately mounted on the wall. While **FIG. 4B** illustrates the urinal basin **16** mountable on the wall, implementation of the invention can also include the urinal basis **16** mounted on the floor or on both the floor and wall.

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The combination of the IPS **41** to determine user proximity and the capacitive sensor **20a** to determine a concurrent flow state of waste liquid **34** results in fewer unnecessary flushes. The capacitive sensor **20a** confirms actual flow in the urinal, rather than mere presence of a user. The capacitor sensor **20a** uses very little electricity, as discussed below in **FIG. 6** this allows the urinal to power up the IPS **41** within time windows where the IPS **41** sensor data is actually required, maximizing the low IPS power mode duration and thus saving electricity. With the use of less electricity, the invention enables the potential use of powering the urinal with batteries rather than direct electrical connection, lessening the installation cost and reducing potential electrocution hazards within the toilet room **51**. The use of the IPS **41** also reduces the potential frequency of unnecessary flushes, by confirming a user presence before flushing. **The IPS and Capacitive sensors uses less power than traditional infrared LED sensors and also have a longer lifespan which offers greater durability and usage life.**

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For the sake of simplicity of the illustration, electrical connections between the MCU 42 and other electrical components is not illustrated in FIG. 4B. As discussed below, the MCU 42 is preferably in electrical communication with the flush valve 13a, the flow rate sensor 45, the IPS 41, the capacitive sensor 20a, and a network module 43. While not illustrated in FIG. 4B, the IPS 41 and MCU 42 can be mounted within waterproof ABS (acrylonitrile butadiene styrene) packages to protect the electronics from corrosion and short circuits. The MCU 42 can be integrated or not integrated with the network module 43. The network module 43 can be wired or wireless, though wireless is preferred.

As discussed below with FIG. 6, the user presence in a proximity detection area 11b is determined by using the IPS 41 mounted behind the user visible surface 17.

FIG. 5 is a block diagram of electrical components within an embodiment of the invisible sensor automatic flush urinal 40 in electrical communication with a server 54 in an embodiment of the invention. The capacitive sensor 20a, the IPS 41, and the flow rate sensor 45 are inputs to an MCU 42. The MCU 42 is in bidirectional communication with a server 54 through a network module 43 (shown here as separate from the MCU 42), a gateway 52, and a network 53. The server 54 includes a database 55. All the illustrated electrical components create an overall system 50. The network 53, the server 54, and the database 55 are typically not present within the toilet room 51. The gateway 52 can be nearby or inside the toilet room 51.

FIG. 6 is a flowchart 60 of a method performed by an MCU 42 operation of the invisible sensor automatic flush urinal 40. After a start step 61, a flow state determination 62 is made. As illustrated in FIG. 4A, the flow state determination 62 is evaluated by the presence or absence of waste liquid 34 above the trap level 33 as measured by the capacitive sensor 20a. If the flow state determination 62 is not found then the evaluation is repeated until a flow state determination 62 is found. A flow state determination 62 triggers a user present determination 63. As illustrated in FIG. 4B, the user present determination 63 is made by scanning a proximity detection area

11b with the IPS **41** mounted behind the user visible surface **17**. In this manner, the capacitive sensor **20a** device is always actively evaluating the level of the waste liquid **34** in the trap **30**. **An anti-flooding algorithm is also incorporated in the MCU code to prevent excessive flushing that may overflow the urinal.**

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Per **FIG. 6**, if the flow state **62** and user presence **63** are concurrent, then the MCU waits for a no-flow state determination **64** prior to the flush step **67** by repeated output readings from the capacitive sensor **20a**. A no-flow state **64** determination is used to start a wait step **65**. To avoid multiple flushings for a single user due to intermittent urination by the user, a confirm no-flow state determination **66** is made after the wait step **65**. If there is no confirm no-flow state determination **66**, then the wait step **65** is repeated. Once the confirm no-flow state determination **66** is made, the urinal undergoes the flush step **67**.

15 To reduce power consumption, an optional process (represented by dashed outlines of the boxes in the flowchart **60**) starts with the IPS **41** in a low power mode. After a flow state determination **62** is made, the exit low IPS power mode step **71a** can be executed, so as to fully power up the IPS **41** and enable the user present determination **63**. A return to low IPS power mode step **71b** is executed after the confirm no-flow state determination **66** is made.

To further reduce power consumption, an optional process (represented by dashed outlines of the boxes in the flowchart **60**) starts with the network module **43** in a low network power mode. Upon the confirm no-flow state determination **66**, the MCU **42** instructs the network module **43** to exit low network power mode **72a**. After a transmit metadata step **68**, the MCU **42** instructs the network module **43** to return to low network power mode **72b**. To further save power, metadata for multiple flush cycles can be aggregated by the MCU **42** and stored locally prior to a later batched transmission of metadata of multiple flush cycles to the server **54** from the network module **43**.

Thus, while the capacitive sensor **20a** is always sensing for a flow rate determination **62** or a no-flow rate determination (**64** and **66**), the IPS **41** (using the optional power saving mode) is only fully powered up and scanning for a user in the proximity detection area **11b** after the trigger of the flow state determination **62** and the network module **43** is only fully powered up and transmitting when the transmit metadata step **68** is needed.

A first embodiment of the invention is an invisible sensor automatic flush urinal **40** comprising: (a) a urinal basin **16** with a user visible surface **17**, wherein the user visible surface **17** is water resistant and opaque; (b) a liquid routing including a water inlet **14a**, a flush valve **13a**, a water outlet **14b**, a drain **15**, a trap **30**, and a trap outlet **32**; (c) an invisible proximity sensor (IPS) **41** mounted within or behind the user visible surface **17**, wherein the IPS **41** is a microwave Doppler sensor capable of emitting and receiving microwave signals through the user visible surface **17**; (d) a capacitive sensor **20a** mounted in proximity to the trap **30** and configured to measure an overflow level of waste liquid **34** above a trap level **33** of the trap **30**; (e) a master control unit (MCU) **42** including a microcontroller **44** in electrical communication with the flush valve **13a**, the IPS **41**, the capacitive sensor **20a**, and a network module **43**. The microcontroller **44** is configured to execute a flush cycle comprising the steps of: (i) monitoring the capacitive sensor **20a** to detect a flow state of waste liquid **34** above the trap level **33**; (ii) monitoring the IPS **41** to detect a user presence within a proximity detection area **11b**; (iii) upon confirming the flow state is concurrent with the user presence, monitoring the capacitive sensor **20a** to detect a no-flow state of waste liquid **34** above the trap level **33**; (iv) after detecting a no-flow state, flushing the urinal by activating the flush valve **13a**; and (v) transmitting metadata of at least one flush cycle from the network module **43**. Metadata is routable to a server **54** from the network module **43**, through a gateway **52**, and through a network **53**. Metadata of each flush cycle includes at least one of: (i) a timestamp; (ii) a duration of the flow state; (iii) an output of the capacitive sensor **20a** during the flow state; and (iv) a duration of the user presence in the proximity detection area **11b**.

Mounting of the IPS **41** within or behind the user visible surface **17** maintains the IPS **41** in a dry condition. Microwave signals can easily pass through the vitreous china ceramic of the urinal basin **16**, unlike infrared signals which require an uninterrupted line-of-sight (**LoS**).

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In an alternative embodiment, the MCU **42** executes the flushing step only upon the occurrence of at least one of: (a) a flow state duration exceeds a flow confirmation period, wherein the flow state duration is measured from a start of the flow state to a start of the no-flow state; (b) the no-flow state continues without an interrupting flow
10 for a no-flow confirmation period commencing from the start of the no-flow state; and (c) an output window of the capacitive sensor **20a** matches a flow pattern detectable by the MCU **42**. The MCU **42** can be configured to receive from the server **54** a plurality of updates from the server **54** for at least one of: (a) the flow confirmation period; (b) the no-flow confirmation period; and (c) the flow pattern.

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The flow confirmation period can be set at 2 seconds. This allows the urinal to save water by avoiding flushes that are not required. If the flow confirmation period is not exceeded, the MCU **42** suppresses the flush step **67**. **The flow confirmation period is reprogrammable and can be set by a remote device or server.**

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The no-flow confirmation period is useful for avoiding multiple flush steps **67** for a single use, as there are sometimes paused at the tail end of urination when the user's urine bladder is nearly empty. This feature saves water and also avoids startling the users during their urination into the urinal.

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Use of a flow pattern by the MCU **42** to time the flush step **67** can also be useful. Metadata from previous flush cycles can be used to create or improve the flow pattern, which may be influenced by the location of the toilet room **51** or user traffic in and near the toilet room **51**.

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Evaluation of capacitive sensor **20a** readings by the MCU **42** can take into account capacitance levels or electric field measurements. Capacitance levels typically range

between 0 and **50** pF, depending on the configuration and mounting of the capacitive sensor **20a** on the trap **30**. Local humidity in the toilet room **51** may also affect capacitance readings.

- 5 The flush step **67** can typically occur 3 to 5 seconds after the confirm no-flow state **66** determination, after the user has walked away from the urinal and is no longer detected by the IPS **41** in the proximity detection area **11b**.

10 The MCU **42** can also suppress the flush if the MCU **42** records a flow state of excessive duration, such as exceeding **60** seconds, as such a long flow state duration would be indicative of a fault with the urinal components. Such fault events can be recorded by the MCU **42** and transmitted to the server **50**, allowing the system 50 to alert maintenance staff of the fault.

- 15 In another alternative embodiment, the MCU **42** executes the additional steps of: (a) maintaining the IPS **41** in a low IPS power mode; (b) after detection of a start of the flow state, exiting the low IPS power mode; and (c) after a start of the no-flow state, returning the IPS **41** to the low IPS power mode.

- 20 In another alternative embodiment, the MCU **42** executes the additional steps of: (a) maintaining the network module **43** in a low network power mode; (b) after detection of a start of the no-flow state, exiting the low network power mode; and (c) after the step of transmitting metadata, returning the network module **43** to the low network power mode.

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- In another alternative embodiment, the liquid routing includes a flow rate sensor **45**, wherein the flow rate sensor **45** is upstream from the water outlet **14b** and the flow rate sensor **45** is in electrical communication with the MCU **42**. The MCU **42** can monitor an output from the flow rate sensor **45** to execute the additional step(s) of at least one of: (a) including the output of the flow rate sensor **45** in metadata for each flush cycle; (b) limiting the liquid routing to a volume flow maximum; and (c) alerting the server **54** of an excessive flow fault.
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The flow rate sensor **45** can be used to more accurately control the volume of water used in each flush cycle. Local governmental authorities often limit the amount of water used per flush. The maximum or minimum flow rate can be programmed i the
5 MCU **42** on initial installation or through communication with the server **54**. For instance water volume per flush cycle or per minute can be established and monitored.

In another alternative embodiment, the capacitive sensor **20a** includes: (a) a flexible copper strip with a pair of wires configured to skirt at least a portion of the trap **30**; (b)
10 an integrated circuit in electrical connection with the flexible copper strip, wherein the integrated circuit is configured to detect variation in either: (i) an electric field **24** generated by the flexible copper strip; or (ii) a measured capacitance of the flexible copper strip. The flexible copper strip can be mounted in at least one of the following configuration: (a) above the trap level **33**; and (b) between a trap weir **37** and the trap
15 outlet **32**.

In another alternative embodiment, the urinal basin **16** is vitreous china ceramic.

A second embodiment of the invention is a method of urinal management comprising
20 the steps of: (a) providing: (i) a urinal basin **16** with a user visible surface **17**, wherein the user visible surface **17** is water resistant and opaque; (ii) a liquid routing including a water inlet **14a**, a flush valve **13a**, a water outlet **14b**, a drain **15**, a trap **30**, and a trap outlet **32**; (iii) an invisible proximity sensor (IPS) **41** mounted within or behind the user visible surface **17**, wherein the IPS **41** is a microwave Doppler sensor capable of
25 emitting and receiving microwave signals through the user visible surface **17**; (iv) a capacitive sensor **20a** mounted in proximity to the trap **30** and configured to measure an overflow level of waste liquid **34** above a trap level **33** of the trap **30**; (v) a master control unit (MCU) **42** including a microcontroller **44** in electrical communication with the flush valve **13a**, the IPS **41**, the capacitive sensor **20a**, and a network module **43**;
30 (b) performing with the MCU **42** a flush cycle comprising the steps of: (i) monitoring the capacitive sensor **20a** to detect a flow state of waste liquid **34** above the trap level **33**; (ii) monitoring the IPS **41** to detect a user presence within a proximity detection

area **11b**; (iii) upon confirming the flow state is concurrent with the user presence, monitoring the capacitive sensor **20a** to detect a no-flow state of waste liquid **34** above the trap level **33**; (iv) after detecting a no-flow state, flushing the urinal by activating the flush valve **13a**; and (v) transmitting metadata of at least one flush cycle from the network module **43**. Metadata is routable to a server **54** from the network module **43**, through a gateway **52**, and through a network **53**. Metadata of each flush cycle includes at least one of: (i) a timestamp; (ii) a duration of the flow state; (iii) an output of the capacitive sensor **20a** during the flow state; and (iv) a duration of the user presence in the proximity detection area **11b**.

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In an alternative embodiment, the MCU **42** executes the flushing step only upon the occurrence of at least one of: (a) a flow state duration exceeds a flow confirmation period, wherein the flow state duration is measured from a start of the flow state to a start of the no-flow state; (b) the no-flow state continues without an interrupting flow for a no-flow confirmation period commencing from the start of the no-flow state; and (c) an output window of the capacitive sensor **20a** matches a flow pattern detectable by the MCU **42**. The MCU **42** can be configured to receive from the server **54** a plurality of updates from the server **54** for at least one of: (a) the flow confirmation period; (b) the no-flow confirmation period; and (c) the flow pattern.

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In another alternative embodiment, the MCU **42** executes the additional steps of: (a) maintaining the IPS **41** in a low IPS power mode; (b) after detection of a start of the flow state, exiting the low IPS power mode; and (c) after a start of the no-flow state, returning the IPS **41** to the low IPS power mode.

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In another embodiment, the MCU **42** executes the additional steps of: (a) maintaining the network module **43** in a low network power mode; (b) after detection of a start of the no-flow state, exiting the low network power mode; and (c) after the step of transmitting metadata, returning the network module **43** to the low network power mode.

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In another embodiment, the liquid routing includes a flow rate sensor **45**, wherein the flow rate sensor **45** is upstream from the water outlet **14b** and the flow rate sensor **45** is in electrical communication with the MCU **42**. The MCU **42** can monitor an output from the flow rate sensor **45** to execute the additional step(s) of at least one of: (a) including the output of the flow rate sensor **45** in metadata for each flush cycle; (b) limiting the liquid routing to a volume flow maximum; and (c) alerting the server **54** of an excessive flow fault.

In another embodiment, the capacitive sensor **20a** includes: (a) a flexible copper strip with a pair of wires configured to skirt at least a portion of the trap **30**; (b) an integrated circuit in electrical connection with the flexible copper strip, wherein the integrated circuit is configured to detect variation in either: (i) an electric field **24** generated by the flexible copper strip; or (ii) a measured capacitance of the flexible copper strip. The flexible copper strip can be mounted in at least one of the following configuration: (a) above the trap level **33**; and (b) between a trap weir **37** and the trap outlet **32**.

In another embodiment, the urinal basin **16** is vitreous china ceramic.

While various aspects and embodiments have been disclosed herein, it will be apparent that various other modifications and adaptations of the invention will be apparent to the person skilled in the art after reading the foregoing disclosure without departing from the spirit and scope of the invention and it is intended that all such modifications and adaptations come within the scope of the appended claims. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit of the invention being indicated by the appended claims.

CLAIMS

1. An invisible sensor automatic flush urinal comprising:
 - (a) a urinal basin with a user visible surface, wherein the user visible surface is water resistant and opaque;
 - (b) a liquid routing including a water inlet, a flush valve, a water outlet, a drain, a trap, and a trap outlet;
 - (c) an invisible proximity sensor (IPS) mounted within or behind the user visible surface, wherein the IPS is a microwave Doppler sensor capable of emitting and receiving microwave signals through the user visible surface;
 - (d) a capacitive sensor mounted in proximity to the trap and configured to measure an overflow level of waste liquid above a trap level of the trap;
 - (e) a master control unit (MCU) including a microcontroller in electrical communication with the **solenoid** flush valve, the IPS, the capacitive sensor, and a network module, wherein the microcontroller is configured to execute a flush cycle comprising the steps of:
 - (i) monitoring the capacitive sensor to detect a flow state of waste liquid above the trap level;
 - (ii) monitoring the IPS to detect a user presence within a proximity detection area;
 - (iii) upon confirming the flow state is concurrent with the user presence, monitoring the capacitive sensor to detect a no-flow state of waste liquid above the trap level;
 - (iv) after detecting a no-flow state, flushing the urinal by activating the flush valve; and
 - (v) transmitting metadata of at least one flush cycle from the network module;
 - (f) wherein metadata is routable to a server from the network module, through a gateway, and through a network; and
 - (g) wherein metadata of each flush cycle includes at least one of:
 - (i) a timestamp;
 - (ii) a duration of the flow state;

- (iii) an output of the capacitive sensor during the flow state; and
 - (iv) a duration of the user presence in the proximity detection area.
- 2. The urinal of claim 1, wherein the MCU executes the flushing step only upon the occurrence of at least one of:
 - (a) a flow state duration exceeds a flow confirmation period, wherein the flow state duration is measured from a start of the flow state to a start of the no-flow state;
 - (b) the no-flow state continues without an interrupting flow for a no-flow confirmation period commencing from the start of the no-flow state; and
 - (c) an output window of the capacitive sensor matches a flow pattern detectable by the MCU.
- 3. The urinal of claim 2, wherein the MCU is configured to receive from the server a plurality of updates from the server for at least one of:
 - (a) the flow confirmation period;
 - (b) the no-flow confirmation period; and
 - (c) the flow pattern.
- 4. The urinal of claim 1, wherein the MCU executes the additional steps of:
 - (a) maintaining the IPS in a low IPS power mode;
 - (b) after detection of a start of the flow state, exiting the low IPS power mode; and
 - (c) after a start of the no-flow state, returning the IPS to the low IPS power mode.
- 5. The urinal of claim 1, wherein the MCU executes the additional steps of:
 - (a) maintaining the network module in a low network power mode;
 - (b) after detection of a start of the no-flow state, exiting the low network power mode; and
 - (c) after the step of transmitting metadata, returning the network module to the low network power mode.

6. The urinal of claim 1, wherein the liquid routing includes a flow rate sensor, wherein the flow rate sensor is upstream from the water outlet and the flow rate sensor is in electrical communication with the MCU.
7. The urinal of claim 6, wherein the MCU monitors an output from the flow rate sensor to execute the additional step(s) of at least one of:
 - (a) including the output of the flow rate sensor in metadata for each flush cycle;
 - (b) limiting the liquid routing to a volume flow maximum; and
 - (c) alerting the server of an excessive flow fault.
8. The urinal of claim 1, wherein the capacitive sensor includes:
 - (a) a flexible copper strip with a pair of wires configured to skirt at least a portion of the trap;
 - (b) an integrated circuit in electrical connection with the flexible copper strip, wherein the integrated circuit is configured to detect variation in either:
 - (i) an electric field generated by the flexible copper strip; or
 - (ii) a measured capacitance of the flexible copper strip.
9. The urinal of claim 8, wherein the flexible copper strip is mounted in at least one of the following configuration:
 - (a) above the trap level; and
 - (b) between a trap weir and the trap outlet.
10. The urinal of claim 1, wherein the urinal basin is vitreous china ceramic.

11. A method of urinal management comprising the steps of:
 - (a) providing:
 - (i) a urinal basin with a user visible surface, wherein the user visible surface is water resistant and opaque;
 - (ii) a liquid routing including a water inlet, a flush valve, a water outlet, a drain, a trap, and a trap outlet;
 - (iii) an invisible proximity sensor (IPS) mounted within or behind the user visible surface, wherein the IPS is a microwave Doppler sensor capable of emitting and receiving microwave signals through the user visible surface;
 - (iv) a capacitive sensor mounted in proximity to the trap and configured to measure an overflow level of waste liquid above a trap level of the trap;
 - (v) a master control unit (MCU) including a microcontroller in electrical communication with the flush valve, the IPS, the capacitive sensor, and a network module;
 - (b) performing with the MCU a flush cycle comprising the steps of:
 - (i) monitoring the capacitive sensor to detect a flow state of waste liquid above the trap level;
 - (ii) monitoring the IPS to detect a user presence within a proximity detection area;
 - (iii) upon confirming the flow state is concurrent with the user presence, monitoring the capacitive sensor to detect a no-flow state of waste liquid above the trap level;
 - (iv) after detecting a no-flow state, flushing the urinal by activating the flush valve; and
 - (v) transmitting metadata of at least one flush cycle from the network module;
 - (c) wherein metadata is routable to a server from the network module, through a gateway, and through a network; and
 - (d) wherein metadata of each flush cycle includes at least one of:
 - (i) a timestamp;
 - (ii) a duration of the flow state;

- (iii) an output of the capacitive sensor during the flow state; and
- (iv) a duration of the user presence in the proximity detection area.

12. The method of claim 11, wherein the MCU executes the flushing step only upon the occurrence of at least one of:

- (a) a flow state duration exceeds a flow confirmation period, wherein the flow state duration is measured from a start of the flow state to a start of the no-flow state;
- (b) the no-flow state continues without an interrupting flow for a no-flow confirmation period commencing from the start of the no-flow state; and
- (c) an output window of the capacitive sensor matches a flow pattern detectable by the MCU.

13. The method of claim 12, wherein the MCU is configured to receive from the server a plurality of updates from the server for at least one of:

- (a) the flow confirmation period;
- (b) the no-flow confirmation period; and
- (c) the flow pattern.

14. The method of claim 11, wherein the MCU executes the additional steps of:

- (a) maintaining the IPS in a low IPS power mode;
- (b) after detection of a start of the flow state, exiting the low IPS power mode; and
- (c) after a start of the no-flow state, returning the IPS to the low IPS power mode.

15. The method of claim 11, wherein the MCU executes the additional steps of:

- (a) maintaining the network module in a low network power mode;
- (b) after detection of a start of the no-flow state, exiting the low network power mode; and
- (c) after the step of transmitting metadata, returning the network module to the low network power mode.

16. The method of claim 11, wherein the liquid routing includes a flow rate sensor, wherein the flow rate sensor is upstream from the water outlet and the flow rate sensor is in electrical communication with the MCU.

17. The method of claim 16, wherein the MCU monitors an output from the flow rate sensor to execute the additional step(s) of at least one of:

- (a) including the output of the flow rate sensor in metadata for each flush cycle;
- (b) limiting the liquid routing to a volume flow maximum; and
- (c) alerting the server of an excessive flow fault.

18. The urinal of claim 11, wherein the capacitive sensor includes:

- (a) a flexible copper strip with a pair of wires configured to skirt at least a portion of the trap;
- (b) an integrated circuit in electrical connection with the flexible copper strip, wherein the integrated circuit is configured to detect variation in either:
 - (i) an electric field generated by the flexible copper strip; or
 - (ii) a measured capacitance of the flexible copper strip.

19. The method of claim 18, wherein the flexible copper strip is mounted in at least one of the following configuration:

- (a) above the trap level; and
- (b) between a trap weir and the trap outlet.

20. The method of claim 11, wherein the urinal basin is vitreous china ceramic.