

## **AN IRRIGATION SYSTEM AND METHOD**

### **FIELD OF INVENTION**

- 5 The invention pertains to an irrigation system and method for supplying water across a wide area and multilevel landscape or structure. More particularly, the invention relates to the use of wireless and remote sensing technologies for providing a smart irrigation system and method.

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### **BACKGROUND OF THE INVENTION**

- The goal of water management in irrigation system is to achieve responsible and cost-effective water consumption. However, traditional irrigation system that operates on a pre-set irrigation schedule lacks the ability to take adaptive measures for water management. Therefore, smart irrigation system is introduced to offer solutions for promoting sustainable use of water through providing customized watering schedules and automated irrigation function that meets specific landscape needs.
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- 20 The advancement in technology negates human intervention in irrigation management and improves water efficiencies. An example of such technology is introduced in US9131642B2 that describes a system and method that apply remote sensing to estimate crop water use. As weather and new Earth observation satellite data becomes available, the crop water use is constantly forecasted and updated. These data enable
- 25 the system and method to employ a water accounting algorithm to prescribe irrigation differentially for regions of a field or for the entire field as an average. Irrigation prescription is delivered remotely through Internet technology. The crop water use estimate ensures precise irrigation supply needed by the crop, thereby conserving water and energy as well as reducing leaching of soil nutrients caused by excess water

percolating below the root zone.

Whilst the system and method of US9131642B2 take a lot of environmental factors including weather, soil water, solar radiation, rainfall, earth condition and the like into  
5 consideration in its algorithm to estimate crop water use control irrigation across large geographical areas, there is no approach to irrigate multilevel landscapes or structures.

On the other hand, US11099098B2 discloses a solution for irrigating multilevel buildings through an improved sensor system that monitors and controls a dendritic  
10 fluid system such as a building liquid supply system that comprises a plurality of liquid subsystems. Each of the liquid subsystems includes a valve that is configured to stop a flow of liquid into its liquid subsystem in an off state; a liquid meter configured to monitor liquid flow into the liquid subsystems; and a server comprising a processor and memory. The memory includes instructions that, when executed, cause the server  
15 to transmit signals to the valves to turn on and off the valves in a pseudorandom sequence; instruct the liquid meter to capture a measurement in response to the respective valve being turned off for each of the valves; and apply a transform to the measurements captured by the liquid meter to determine liquid flow rates of the valves respectively.

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Pressure regulators are adopted to adjust and control water pressure in the dendritic water system of a building. For example, the building can be provided with a main water supply line that is metered outside of the building and regulated by a first pressure regulator. The main water supply then then enters the building through the  
25 basement under the street level and be metered again by a second pressure regulator. The second pressure regulator controls the water pressure to a lower pressure for distribution throughout the building. Several more pressure regulators can be located throughout the building as the top floors of the building may not receive as much water pressure as the lower floors due to the weight of the water column.

Although US11099098B2 offers sensors to measure flow of fluid to detect potential leaks so as to adjust the fluid levels in the system to a desired level, there is not much emphasis on water and power saving. Irrigating a large and multi-level region  
5 consumes water and energy. There is, hence, a need to reduce wastage and improve water and power efficiencies.

## **SUMMARY OF INVENTION**

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In a first aspect of the invention, there is provided an irrigation system for performing an irrigation process to supply water across one or more zones of at least one level that comprises a server having a processor for managing operation of the irrigation system through wireless communication; a piping system including one or more  
15 pipelines, with each pipeline being provided at each zone to deliver water from a water source, and having at least one valve; an irrigation management module that runs an irrigation determining process, having one or more types of sensors for obtaining environmental data to determine watering needs for each zone; and an irrigation controller configured to regulate water delivery through controlling opening  
20 and closing of the valve based on the environmental data; wherein the irrigation determining process is run for the valves of a single pipeline in a one-by-one manner and the irrigation determining process ends when there is no watering need for each zone as determined by the sensor.

25 Based on a preferred embodiment, the irrigation system is configured to customize the irrigation process including any one or a combination of the irrigation determining process, frequency of irrigation, irrigation time, and duration of irrigation, for each zone, level, or a combination thereof based on their watering needs.

Preferably, the types of sensors include a soil moisture sensor, current rain sensor, weather forecasting apparatus, wind speed sensor, wind direction sensor, air temperature sensor, humidity sensor, air pressure sensor, or a combination thereof.

- 5 It is preferred that the types of sensors are configured to operate sequentially until the irrigation instruction is provided to open the valve to supply water.

In a preferred embodiment, the system further includes a water leakage detecting module having either or both of a water flow meter and pipe pressure sensor that  
10 determine amount of water consumption and pipe pressure respectively to detect water leakage.

According to a preferred embodiment, the valve is incorporated with the water flow meter.

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The valve is preferred to be battery powered.

It is preferred that the system further comprises a valve power saving module configured to wake up the valve that is put into a sleep mode periodically with a non-  
20 active interval during non-watering period, and with an active interval during watering period for receiving instructions from the server, updating water consumption data, opening or closing the valve, or a combination thereof.

Furthermore, the system may include a fail-safe module for automatically closing the  
25 valve after a predefined time during an emergency.

In another aspect of the invention, there is provided an irrigation method for supplying water across one or more zones of at least one level through an irrigation process using an irrigation system according to any one of the preceding claims, that

comprises the steps of determining watering needs for each zone upon obtaining environmental data from one or more types of sensors of an irrigation management module through an irrigation determining process; and regulating water delivery by an irrigation controller through controlling opening and closing of one or more valves of a pipeline based on the environmental data; wherein the irrigation system, that operates using wireless communication, comprises a piping system having one or more pipelines, with each pipeline being provided at each zone to deliver water from a water source, and the irrigation determining process is run for the valves of a single pipeline in a one-by-one manner and the irrigation determining process ends when there is no watering need for each zone as determined by the sensor.

In accordance with a preferred embodiment, the irrigation process includes any one or a combination of the irrigation determining process, frequency of irrigation, irrigation time, and duration of irrigation, is customized for each zone, level, or a combination thereof based on their watering needs.

In a preferred embodiment of the invention, the irrigation determining process for determining watering needs for each zone comprises the steps of detecting soil moisture level by a soil moisture sensor at the zone; detecting rain by a current rain sensor when soil moisture level is lower than a predetermined soil moisture level; and predicting occurrence of rain at a predetermined time by a weather forecasting apparatus when rain is not detected by the current rain sensor; wherein the irrigation controller sends a signal to instruct the valve to open for supplying water to the zone when rain is not expected to happen as predicted by the weather forecasting apparatus.

It is preferred that the irrigation determining process ends when rain is detected by the current rain sensor, or when rain is expected at the predetermined time by the weather forecasting apparatus.

Preferably, the irrigation determining process repeats at a predetermined irrigation time or when instructed by a user.

According to a preferred embodiment of the invention, the irrigation determining  
5 process further comprises the step of determining whether the valve is a last valve of the pipeline upon detecting the soil moisture level to be equal or higher than the predetermined soil moisture level, upon closing the valve after supplying water to the zone, or a combination thereof.

10 It is preferred that the irrigation determining process repeats for a subsequent valve of the pipeline when the valve being a preceding valve of the subsequent valve is determined to be a non-last valve.

Otherwise, the irrigation controller is deactivated to end the irrigation determining  
15 process when the valve is determined to be the last valve.

Based on a preferred embodiment, the method also includes the step of detecting water leakage by a water leakage detecting module, upon closing the valve after supplying water, based on either or both amount of water consumption and pipe  
20 pressure that are measured by a water flow meter and pipe pressure sensor respectively.

Preferably, the method further comprises the step of waking up the valve that is put into a sleep mode periodically, by a valve power saving module, with a non-active  
25 interval during non-watering period, and with an active interval during watering period for receiving instructions from the server, updating water consumption data, opening or closing the valve, or a combination thereof.

In a preferred embodiment, the method further comprises the step of automatically

closing the valve after a predefined time during an emergency by a fail-safe module.

These aspects of the invention provide an irrigation system and method that employ the smart technology, especially, to serve large, complex, and multilevel landscapes, terrains, or structures. Wireless communication is enabled between the user and components of the irrigation system, thereby permitting remote monitoring, and controlling of the components. The invention is created to precisely target the irrigation requirements to provide profound water and power conservation while achieving the desired watering effect. These requirements are based on environmental factors such as soil moisture, current weather, forecasted weather, air pressure, temperature, humidity etc. Therefore, it is also an object of the invention to allow remote and accurate sensing of factors that would affect watering needs, such as the environment factors, to enhance automation of irrigation and permitting tailored watering schedules to meet specific landscape requirements. Although wired technology can be employed, it is an object that the invention utilizes wireless technology for powering the components such as battery, solar, or AC-DC adaptor.

Since the invention is catered for irrigating either or both a large and multilevel landscape or structure, irrigation management that offers water and power saving solutions are crucial. With respect to water saving, the invention takes on several measures including the provision of an irrigation determining solution for irrigating only when needed; the ability to control the opening and closing of valves through an irrigation controller based on irrigation instruction as provided by the user or as pre-programmed, especially during emergency to avoid water wastage; and the function to detect water leakage. Emergency includes low battery level for components powered by battery, communication interruption, and interference.

In terms of power saving, the irrigation determining solution adopted by the invention is capable of making quick, decisive and effective judgement without the need to run

through complicated algorithms that involve complex calculations. Also, the sensors involved in determining irrigation are only activated when needed, preferably on a 'one by one' basis in sequential order. Further, the components like the valves are put into sleep mode when operation is not required to conserve power. When low battery level is detected for components that are powered by battery, the irrigation system deactivates the component. For example, a battery-operated valve is closed when its battery level is running out.

One skilled in the art will readily appreciate that the invention is well adapted to carry out the objects and obtain the ends and advantages mentioned, as well as those inherent therein.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

For the purpose of facilitating an understanding of the invention, there is illustrated in the accompanying drawings the preferred embodiments from an inspection of which when considered in connection with the following description, the invention, its construction and operation and many of its advantages would be readily understood and appreciated.

**Fig. 1** is a diagram showing a preferred embodiment of the irrigation system.

**Fig. 2** is a flowchart showing a preferred embodiment of the irrigation method applied onto one or more valves of a pipeline at a zone, that involves the irrigation determining process, opening and closing of valve as controlled by the irrigation controller and detection of water leakage.

## DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, the invention shall be described according to the preferred embodiments of the present invention and by referring to the accompanying description and  
5 drawings. However, it is to be understood that limiting the description to the preferred embodiments of the invention is merely to facilitate discussion of the present invention and it is envisioned that those skilled in the art may devise various modifications without departing from the scope of the appended claim.

10 Disclosed herein is a computer-implemented irrigation system and method. The computing devices of the system involved in performing the operations to carry out the method may be specially constructed for the required purposes, or they can be a general-purpose computer selectively activated or reconfigured by a computer program stored in the computer to execute computer program instructions, as  
15 specified in the flowchart presented in the drawings, via processors of the computer or other programmable data processing apparatus.

A computer-readable memory may also be used for storing the computer program instructions, which can direct a computer or other programmable data processing  
20 apparatus to function in an intended manner to carry out the steps of the method as illustrated in the drawings.

The invention will now be described in greater detail, by way of examples, with reference to the drawings.

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Irrigation is a process to supply water to foster growth of crops, pasture, landscape plants and lawns. The invention disclosed herein is applicable for any one or a combination of farmland, park, garden, field, golf course and horticulture that spans across any one or a combination of large, complex, multilevel landscape, terrain, or

structure such as a building that covers one or more zones of at least one level. A single level may comprise one or more zones and there can be more than one level.

The irrigation system is implemented with the Internet of Things (IoT) technology  
5 that spawns a network of interconnected devices and sensors to collect data for making intelligent decisions to achieve efficient irrigation management, especially with respect to water and power savings. A preferred embodiment of the irrigation system is shown in **Fig. 1**. A server **110** having a processor is provided by the system to regulate operation of the system, which includes management of components of the  
10 system that comprises modules, irrigation controller, sensors, valves **125**, water pump **124**, water flow meter, and network devices. The server **110** may be operated locally or in the cloud.

In a preferred embodiment, cloud computing is employed in the irrigation system  
15 such that applications of the system are managed by a cloud server **110** and data is stored remotely in a cloud database. Cloud computing services facilitate instantaneous, on-demand delivery of data collection over large or multileveled zones through the IoT based irrigation system. The cloud server facilitates aggregation and processing of data that are passed to the cloud from the components like the sensors  
20 of the system. Further, the cloud server **110** eliminates the need of computational power on each sensor that can be energy-intensive, thus conserving power of the sensors.

A platform connected to the server **110** and accessible by a web browser, software  
25 application, or a combination thereof using a user device such as a computer, smartphone, tablet, or a similar type of device is provided by the system to allow the user to monitor and control the system. Besides that, interaction between the users and system can be done via the platform through sending and receiving data with each other. For example, irrigation instructions can be inputted and sent by the user to the

system via the platform, while data sent by components of the system can be displayed on the interface of the platform to be conveyed to the user.

To supply water to the one or more zones of at least one level, the system provides a  
 5 piping system that includes a main water supply line **121** and one or more pipelines **122** branching therefrom. The main water supply line **121** is connected to a water source **123** and extends to each level. Each zone is provided with a pipeline **122** that branches from the main water supply line **121** to deliver water from the main water supply line **121** that obtains water from the water source **123**. The piping system is a  
 10 water supply network comprising pipes, water pumps **124**, valves **125**, sprinklers, or a combination thereof. Each pipeline **122** has at least one valve **125** to regulate supply of water to each zone.

For multilevel landscapes or structures, water pumps **124** are used to pump water  
 15 from a lower to a higher level from which water flows through the pipes from the main water supply line **121**, pipeline **122** and to the zone requiring irrigation. Water may be raised to the required pressure head so that it can be sprayed at the zone by sprinkles. Applicable water pump includes centrifugal pump, vertical turbine pump, submersible pump, and propeller pump. The water pump can be powered by battery,  
 20 solar, or AC-DC adaptor.

An irrigation management module, that is included in the system, is used for determining watering needs to each zone in terms of the need to irrigate, duration of irrigation, amount of irrigation, or a combination thereof. The irrigation management  
 25 module, that has one or more types of sensors, runs an irrigation determining process for obtaining environmental data from the sensors respectively to determine the watering needs for each zone. The sensors are applied for detecting different environmental factors that affect watering needs, including soil moisture, weather, air temperature, wind speed, wind direction, humidity, air pressure, or a combination

thereof. Therefore, the sensors applicable to the irrigation management module includes but not limited to a soil moisture sensor **131**, current rain sensor **132**, weather forecasting apparatus **133**, wind speed sensor, wind direction sensor, air temperature sensor, humidity sensor, air pressure sensor, or a combination thereof. Rainfall is preferred to be used as an indication of the weather. Therefore, the environmental data obtained from the weather forecasting apparatus is the expected rainfall. The weather forecasting apparatus **133** can be a weather forecast station provided locally at or nearby the zone to detect weather data and forecast the weather based on the detected weather data. Optionally, the weather forecasting apparatus **133** can be an apparatus that obtains weather forecast data from other sources via the Internet or any other wireless communication, or as inputted by the user.

Preferably, the types of sensors are configured to operate sequentially until the irrigation instruction is provided to open the valve to supply water. Therefore, all sensors are not activated simultaneously and will only be activated when necessary, according to the irrigation determining process. With the use of long-range wireless communication, the sensors can be positioned far away from each other and located at an optimal position for effective detection. For example, the soil moisture sensor **131** is placed at an optimal point of each zone that allows the soil moisture level of the whole zone to be detected.

An irrigation controller is provided by the system and configured to be in communication with the valves **125**, irrigation management module and the server **110**. The irrigation controller regulates water delivery through controlling opening and closing of the valve **125** based on the environmental data obtained from the sensors. Force opening and closing of the valves **125** can also be done by sending instructions to the irrigation controller through the server **110** as instructed by the user or pre-programmed when responding to an emergency. The irrigation controller can be integrated with the valve **125** or separated from the valve **125**. It is also optional to

have the irrigation controller configured to control opening and closing of a plurality of valves **125**.

As a water saving measure, the system further comprises a water leakage detecting module having either or both of a water flow meter and a pipe pressure sensor **126** that determine amount of water consumption and pipe pressure respectively to detect water leakage. The water leakage detecting module carries out a water leakage detecting process when the valve **125** is closed. It is preferred that the water leakage detecting module is incorporated to parts of the piping system that are prone to water leakage, especially close to each valve **125**. The pipe pressure sensor **126** can be placed at far end of the pipeline **122** of each zone to detect water leakage through wireless communication.

In a preferred embodiment, the valve **125** is located near to each zone at the upstream of the pipeline **122** and far away from the water pump **124**. To accurately measure water consumption data including amount of water consumption and detect water leakage of each zone, the water flow meter can be incorporated to the valve **125**. Preferably, an ultrasonic water flow meter is used. Wireless communication is implemented to the valve **125** to allow the valve **125** to receive instructions to open or close the valve **125** as well as the server **110** to receive the water flow meter readings from the water flow meter. Further, the valve is wirelessly powered by using battery so that the valve can be conveniently located at a desired location without being restricted by wires.

To conserve power, a valve power saving module is provided to put the valve **125** into a sleep mode whenever operation of the valve is not needed, which is during non-irrigation times. The valve power saving module is configured to wake up the valve **125** periodically with a non-active interval, preferably of an hour, during non-watering period, and with an active interval, preferably of a minute, during watering

period. The purpose of waking up the valve **125** from sleep mode is to ensure irrigation instructions can be received from the server **110**, update water consumption data, open or close the valve **125**, or a combination thereof. If there is no irrigation needs, the valve **125** can be put into sleep mode for an entire day.

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The system further comprises a fail-safe module for automatically closing the valve **125** after a predefined time when an emergency occurs. Emergency includes low battery level for components powered by battery, especially the valve **125**, wireless communication interruption or instability, and interference. The fail-safe module ensures valve **125** is closed to prevent water wastage, especially water flooding during times of emergency in case valve closing instruction fails to reach the valve **125** from the server **110** to the irrigation controller, or from the irrigation controller to the valve **125**. The predefined time is changeable remotely by sending the setting instruction through the server **110** upon inputting a desired predefined time through the platform.

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In a preferred embodiment as illustrated in **Fig. 1** of the IoT based irrigation system, long range wireless communication is implemented in the irrigation system by having a network gateway **141** connected to the server **110** which is a cloud server **110** wirelessly through technologies such as Long-Term Evolution (LTE), 5G, and WiFi, and through a communication protocol of a wireless wide area network technology with other components. The components include the sensors, namely the current rain sensor **132** and the soil moisture sensors **131**; the valves **125**, especially those integrated with the water flow meter; the irrigation controller which can be provided for each valve or is a central controller for a plurality of valves; and any other components of the system especially those provided at the pipelines **122** of ground level and above. The network gateway **141** collects or concentrates data from these components that are end nodes and acts as a bridge between these components with the server **110**.

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In the basement, an indoor network gateway **142** connected to the server **110** through wireless technology is linked to the valve **125** of the pipeline **122** and a network relay **143** through long range signals. The network relay **143** is connected to the water source **123**. The weather forecasting apparatus **133** that is preferably configured to  
 5 obtain weather forecast data as one of the environmental data through third party sources is linked to the server **110** to send the weather forecast data thereto for the irrigation determining process.

The wireless wide area network technology employed in this system is preferably a  
 10 low-power wide-area network (LPWAN) that interconnects low-bandwidth, battery-powered devices with low bit rates over long ranges. Applicable LPWAN technologies include but not limited to long range signals (LoRaWAN), LTE-M and Narrowband-IoT (NB-IoT), Sigfox, Symphony Link, and Weightless. Therefore, the network gateway **141**, indoor network gateway **142**, and network relay **143** used in  
 15 the system should correspond to the type of wide area network utilised in the system. For example, should LoRaWAN be used as the wide-area network, the network gateway **141** is a LoRaWAN gateway, the indoor network gateway **142** is an indoor LoRaWAN gateway and the network relay **143** is a LoRaWAN relay.

20 The system is scheduled to water the zones periodically at an irrigation time, preferably twice in the morning and once in the evening each day. The irrigation time is set by the user and can be changed any time by the user. Other than the predetermined irrigation time, the user of the system can instruct the system to irrigate when desired. Also, the user can configure the system to irrigate the zone  
 25 automatically or with approval of the user when irrigation need is detected by sensors.

**Fig. 2** shows a preferred embodiment of the irrigation method applied onto one or more valves **125** of a pipeline **122** at a zone. The irrigation method shown in **Fig. 2** involves the irrigation determining process, opening and closing of valve as controlled

by the irrigation controller and detection of water leakage. The irrigation determining process as well as the control of opening and closing of the valve **125** shown in **Fig. 2** forms an irrigation process at an irrigation time for all valves **125** of the same pipeline **122** at each zone. The irrigation process involves steps of **201** to **212**, the irrigation  
 5 determining process involves steps of **201** to **205**, and the water leakage detection process involves steps of **301** to **303**.

The irrigation method for supplying water across one or more zones of at least one level is performed using an irrigation system. During irrigation time, the irrigation  
 10 process starts with the irrigation determining process to determine watering needs for each zone based on environmental data obtained from one or more types of sensors of the irrigation management module.

In a preferred embodiment of the invention, the irrigation determining process utilises  
 15 a soil moisture sensor **131**, current rain sensor **132** and weather forecasting apparatus **133**. At step **201**, the irrigation determining process firstly detects soil moisture level by the soil moisture sensor **131**. If the detected soil moisture level is the same or higher than the predetermined soil moisture level, the irrigation determining process ends for the current valve **125** and proceeds to step **210** to determine whether the  
 20 valve **125** is a last valve of the pipeline **122**. Should the valve **125** be determined to be the last valve, the irrigation controller is checked whether it is deactivated or closed at step **211**. If the irrigation controller is not deactivated or closed, a command or instruction to do so will be sent to the irrigation controller at step **212**. Else, should the valve **125** be determined to be a non-last valve through detecting a subsequent valve  
 25 **125** of the same pipeline at step **209**, the determining process will be repeated on the subsequent valve **125** of the same pipeline **122**.

When the detected soil moisture level is lower than a predetermined soil moisture level such as lower by  $z\%$  by step **202**, the irrigation determining process proceeds to

the next step which is step **203**, that is to detect rain by the current rain sensor **132**. If rain is detected at the time of detection, the irrigation determining process ends and will commence again at another scheduled irrigation time or upon receiving irrigation instruction by the user.

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When no rain is detected by the current rain sensor, the weather forecasting apparatus **133** predicts occurrence of rain at a predetermined time at step **204**. For example, the weather forecasting apparatus **133** predicts rainfall after a predetermined period of 2 hours. The weather forecasting apparatus **133** can either make the weather forecast  
10 through a weather forecast station that collects weather data locally and runs a weather forecasting algorithm, or obtain weather forecast data from other sources through wireless communication.

If rainfall is expected to happen based on the weather forecast data, the irrigation  
15 determining process ends. Otherwise, the system checks whether the irrigation controller is activated or opened at step **205** and sends a signal to instruct the valve to open, at step **206**, for supplying water to the zone when no rain is predicted to happen at the predetermined time by the weather forecasting apparatus **133**. The valve **125** is opened for a pre-set duration and closes thereafter at step **207**.

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If the valve **125** fails to open within a certain window-period, an instruction to open the valve **125** is resent to the irrigation controller automatically by the server **110** or manually by the user through the server **110** using the platform. In a preferred embodiment, the instruction to open the valve **125** is resent to the irrigation controller  
25 for a predetermined number of times, such as three times, to retry opening the valve **125**. The irrigation determining process ends when the irrigation controller still fails to instruct opening of the valve **125** after all the retry. If the irrigation controller successfully sends the open instruction to the valve **125**, but the valve **125** fails to respond, the irrigation management module moves on to run the irrigation

determining process on a subsequent valve **125** of the same pipeline **122**. Should the valve **125** remain open upon being instructed by the irrigation controller to close, or the irrigation controller fails to send valve closing instruction to the valve **125**, the irrigation determining module ends to prevent irrigation to happen or stop irrigation.

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Upon closing the valve **125**, the irrigation determining process proceeds to determine whether the valve **125** is a last valve of the pipeline at step **208**. Should the valve **125** be determined to be not the last valve, the server **110** detects whether there is a subsequent valve for the valve **125** that is a preceding valve of the subsequent valve

10 **125** at the same pipeline at step **209**. If a subsequent valve **125** is detected, the irrigation determining process repeats for the subsequent valve **125** of the pipeline **222** when the valve **125** being a preceding valve of the subsequent valve **125** is determined to be not the last valve. On the contrary, should the valve **125** be determined as the last valve of the pipeline **122**, the irrigation controller is deactivated

15 at step **211** to end the irrigation determining process. If the irrigation controller fails to be deactivated or closed, a command or instruction to do so is sent to the irrigation controller through step **212**.

As a measure to prevent water leakage, the irrigation method further comprises the

20 step of detecting water leakage, by a water leakage detecting module, upon closing the valve after supplying water to the zone at step **207**. Water leakage detection is conducted based on either or both amount of water consumption and pipe pressure that are measured by a water flow meter and pipe pressure sensor **126** respectively through steps **301** and **302**. Should the amount of water consumption exceed a

25 predetermined water consumption amount, for example  $x\%$ , the pipe pressure is lower than a predetermined pipe pressure, for example  $y\%$ , or a combination thereof, water leakage is deemed to be happening. Water leakage notification is then sent, at step **303**, to the server **110** to take action such as to instruct the irrigation controller to close the valve **125**, or to notify the user about the water leakage through the platform.

To conserve power, the irrigation method also includes putting the valve **125** into a sleep mode by a valve power saving module that wakes the valve **125** up periodically with a non-active interval, such as every hour during non-watering period, and with  
 5 an active interval, such as every minute during watering period for receiving instructions from the server **110**, updating water consumption data, opening or closing the valve **125**, or a combination thereof.

During occurrence of an emergency such as low battery of the valve **125**, wireless  
 10 communication interruption or instability, and interference that causes risk in closing the valve **125**, the fail-safe module is programmed to automatically close the valve **125** after a predefined time when the emergency happens. Such risk mitigation measure reduces or prevents water wastage or flood to happen. Through the platform, the user can change the predefined time.

15 Irrigation process is repeated periodically at an irrigation time as scheduled, or voluntarily as instructed by the user. For each repeated irrigation process whenever irrigation is instructed by the server **110** as scheduled or as instructed by the user, it is not necessary that the irrigation management module conducts the weather forecast  
 20 for the irrigation determining process. For instance, the scheduled irrigation time at 8am skips the step of forecasting weather at step **401**. Upon ending the irrigation determining process, the system checks the status of the valve **125** to ensure that the valve **125** is closed at step **402**. The valve **125** is then put into sleep mode and is awakened to receive instructions from the server **110**, update water consumption data  
 25 to the server **110**, open or close the valve **125** as instructed by the server **110**, or a combination thereof. The irrigation process is repeated at a later time, such as evening as indicated by step **405** and upon completion the valves are ensured to be closed through step **406**. The valve **125** is waken up more frequently like every 20 minutes at step **403** or every 1 minutes at step **404** during active watering period such as after

8am until 5pm, and less frequently like every 1 hour at step **407** during non-active watering period such as after 5pm to 6am of the next day as depicted in **Fig. 2**.

The irrigation process illustrated in **Fig. 2** is an exemplary embodiment of the invention. It shall, thus, be understood that each zone and/or level may have a different approach in its irrigation process including any one or a combination of irrigation determining process, irrigation frequency, irrigation time and duration of each irrigation. For the irrigation determining process of each zone and/or level, the type and number of sensors used to determine watering needs, or operation sequence of the sensors may differ from each other. The customized approach depends on the watering needs of the zones or levels that are affected by the different terrains, landscape structures and environmental factors to ensure maximum water savings can be obtained based on the specific watering needs of the zones or levels respectively as determined through the irrigation determining process by the sensors of the irrigation management module.

The present disclosure includes as contained in the appended claims, as well as that of the foregoing description. Although this invention has been described in its preferred form with a degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangements of parts may be resorted to without departing from the scope of the invention.

**CLAIMS**

1. An irrigation system for performing an irrigation process to supply water across one or more zones of at least one level comprising
  - 5 a server (110) having a processor for managing operation of the irrigation system through wireless communication;
  - a piping system including one or more pipelines (122), with each pipeline (122) being provided at each zone to deliver water from a water source (123), and having at least one valve (125);
  - 10 an irrigation management module that runs an irrigation determining process, having one or more types of sensors for obtaining environmental data to determine watering needs for each zone; and
  - an irrigation controller configured to regulate water delivery through controlling opening and closing of the valve (125) based on the environmental data;
  - 15 wherein the irrigation determining process is run for the valves (125) of a single pipeline (122) in a one-by-one manner, and the irrigation determining process ends when there is no watering need for each zone as determined by the sensor.
  - 20
2. The irrigation system according to claim 1, wherein the irrigation system is configured to customize the irrigation process including any one or a combination of the irrigation determining process, frequency of irrigation, irrigation time, and duration of irrigation, for each zone, level, or a combination thereof based on their watering needs.
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3. The irrigation system according to claim 1 or 2, wherein the types of sensors include a soil moisture sensor (131), current rain sensor (132), weather forecasting apparatus (133), wind speed sensor, wind direction sensor, air

temperature sensor, humidity sensor, air pressure sensor, or a combination thereof.

4. The irrigation system according to any one of the preceding claims, wherein  
5 the types of sensors are configured to operate sequentially until an irrigation instruction is provided to open the valve (125) to supply water.
5. The irrigation system according to any one of the preceding claims, further  
10 comprising a water leakage detecting module having either or both of a water meter and pipe pressure sensor (126) that determine amount of water consumption and pipe pressure respectively to detect water leakage.
6. The irrigation system according to claim 5, wherein the valve (125) is  
15 incorporated with the water flow meter.
7. The irrigation system according to any one of the preceding claims, wherein  
the valve (125) is battery powered.
8. The irrigation system according to any one of the preceding claims, further  
20 comprising a valve power saving module configured to wake up the valve that is put into a sleep mode periodically with a non-active interval during non-watering period, and an active interval during watering period for receiving instructions from the server (110), updating water consumption data, opening or closing the valve (125), or a combination thereof.
- 25 9. The irrigation system according to any one of the preceding claims, further comprising a fail-safe module for automatically closing the valve (125) after a predefined time during an emergency.

10. An irrigation method for supplying water across one or more zones of at least one level through an irrigation process using an irrigation system according to any one of the preceding claims, comprising the steps of  
5 determining watering needs for each zone upon obtaining environmental data obtained from one or more types of sensors of an irrigation management module through an irrigation determining process; and  
regulating water delivery by an irrigation controller through controlling opening and closing of one or more valves (125) of a pipeline (122) based on the environmental data;  
10 wherein the irrigation system, that operates through wireless communication, comprises a piping system having one or more pipelines (122), with each pipeline (122) being provided at each zone to deliver water from a water source (123), and the irrigation determining process is run for the valves (125) of a single pipeline in a one-by-one manner and the irrigation determining  
15 process ends when there is no watering need for each zone as determined by the sensor.
11. The irrigation method according to claim 10, wherein the irrigation process including any one or a combination of the irrigation determining process,  
20 frequency of irrigation, irrigation time, and duration of irrigation, is customized for each zone, level, or a combination thereof based on their watering needs.
12. The irrigation method according to claim 10 or 11, wherein the irrigation  
25 determining process for determining watering needs for each zone comprises the steps of  
detecting soil moisture level by a soil moisture sensor (131) at the zone;  
detecting rain by a current rain sensor (132) when soil moisture level is lower than a predetermined soil moisture level; and

predicting occurrence of rain at a predetermined time, by a weather forecasting apparatus (133), when rain is not detected by the current rain sensor (132); wherein the irrigation controller sends a signal to instruct the valve (125) to open for supplying water to the zone when rain is not expected to happen as predicted by the weather forecasting apparatus (133).

5

13. The irrigation method according to claim 12, wherein the irrigation determining process ends when rain is detected by the current rain sensor (132), or when rain is expected at the predetermined time by the weather forecasting apparatus (133).

10

14. The irrigation method according to any one of claims 10 to 13, wherein the irrigation determining process repeats at a predetermined irrigation time or when instructed by a user.

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15. The irrigation method according to any one of claims 10 to 14, wherein the irrigation determining process further comprises the step of determining whether the valve (125) is a last valve of the pipeline (122) upon detecting the soil moisture level to be equal or higher than the predetermined soil moisture level, upon closing the valve (125) after supplying water to the zone, or a combination thereof.

20

16. The irrigation method according to claim 15, wherein the irrigation determining process repeats for a subsequent valve (125) of the pipeline (122) when the valve (125) being a preceding valve of the subsequent valve (125) is determined to be a non-last valve.

25

17. The irrigation method according to claim 15 or 16, wherein the irrigation controller is deactivated to end the irrigation determining process when the valve (125) is determined to be the last valve.

30

18. The irrigation method according to any one of claims 10 to 17, further comprising the step of detecting water leakage by a water leakage detecting module, upon closing the valve (125) after supplying water, based on either or  
5 both amount of water consumption and pipe pressure that are measured by a water meter and pipe pressure sensor (126) respectively.
19. The irrigation method according to any one of claims 10 to 18, further comprising the step of waking up the valve (125) that is put into a sleep mode  
10 periodically, by a valve power saving module, with a non-active interval during non-watering period, and with an active interval during watering period for receiving instructions from the server (110), updating water consumption data, opening or closing the valve (125), or a combination thereof.
20. The irrigation method according to any one of claims 10 to 19, further comprising the step of automatically closing the valve (125) after a predefined  
15 time during an emergency by a fail-safe module.