

SMART WATER MANAGEMENT SYSTEMS BASED ON INTERNET OF THINGS TECHNOLOGY

FIELD OF THE INVENTION

The present invention relates to the smart water management systems, in particular to a water management system based on the Internet of Things (IoT) technology. More particularly to a water management system with unique IoT based controllers using specified protocols and Standard Operating Procedures (SOPs) that enable higher level of efficiency in water management.

BACKGROUND OF THE INVENTION

The need for water is a non-negotiable aspect of life in any form. Safe drinking water is a basic human requirement, which is essential for good health. Drinking water is the major source of health concern all over the world and clean drinking water is a medium to deliver health and wellness to communities.

There is a wide gap in the demand and supply of safe drinking water. Nearly 680 million Indians have no access to safe water. Thus, there is a serious need to deliver clean and safe drinking water at affordable cost by developing water treatment technologies.

Water Treatment Plants have been installed extensively in the country and globally for several decades. While these are considered to be a critical piece of infrastructure, the operations are completely manual in nature thereby leading to excessive down-time and very often, cases of complete plant level

break-down. This has led to gross under-utilization of every plant and even if they are working, their capacity is heavily under-utilized. The need of the hour is development, installation and implementation of a technology based controller that is connected to a central server through GSM/Wi-Fi connectivity and provides information, data and above all, remote control of all plants thereby building efficiency not only in their operations but also in scaling up the footprint by installation of new plants that can collectively work in tandem and deliver safe water to people in a sustainable and consistent manner.

The aim of the present invention is to bring health and wellness in the lives of people through sustainable operating models implemented by way of the developed internet based unique technology. Accordingly, a unique IoT (Internet of Things) based controllers have been developed using specified protocols and SOPs (Standard Operating Procedures) that enable higher level of efficiency in water management.

The present invention provides a unique technology agnostic approach to solve different water related issues. A globally unique world class IoT (Internet of Things) based controllers connected to a cloud-based platform has been developed.

The unified technology has been developed that connects all water infrastructure and purification systems that allows remote management, monitoring, control and even calibration of the dispensers. The data gathered from every collection centre on technical parameters such as water flow,

pressure, temperature, TDS level and conductivity is stored in cloud, analysed and monitored on a 24X7 basis. The information allows to predict maintenance issues in advance and to optimize the scheduling of manpower. This saves money for all concerned stake-holders and increases efficiency across the
5 operations. The unique technology platform also helped to move from preventive to predictive maintenance.

The present invention aims towards providing safe water Available, Accessible and Affordable to all, while keeping technological advancement and implementation at its core.

10 **OBJECTS OF THE INVENTION**

It is the main object of the invention to provide clean and safe drinking water available, accessible and affordable in a sustainable and efficient manner.

It is another object of the invention to develop a unified technology platform that connects all water infrastructure and purification systems.

15 Another object is to revolutionize the way clean and safe water is delivered to communities through Water ATMs, Water on Wheels, Drinking Water Station and Community Drinking Water Projects.

Yet another object of the invention is to provide clean and safe drinking water at an affordable cost.

SUMMARY OF THE INVENTION

The present invention provides a unique IoT (Internet of Things) based controllers connected to a cloud based platform using specified protocols and SOPs (Standard Operating Procedures) to solve water related issues and to
5 provide delivery of safe drinking water at affordable cost through remotely controlled and monitored Water ATMs, Water on Wheels, Drinking Water Station and Community Drinking Water Projects in order to bring health and wellness in the lives of people.

The present invention provides a smart water management system based
10 on the Internet of Things (IoT) technology comprising: the controller unit operating in tandem with input data and conducting edge based analysis while communicating with a central cloud based server to enable transmission of data through GPRS or Wi-Fi connectivity that data is further processed and appears on the central dashboard to allow real time control and data visualization on the
15 cloud based backend and generates further inputs for improved operating efficiencies and for data analysis and is connected to the flow sensor and the solenoid for controlling the water to be dispensed; the user selects the start dispensing option on the UI after payment, the controller puts the solenoid in open state and counts the number of pulses of the flow sensor which is
20 calibrated for ml/sec and when the selected amount of water is reached the solenoid is put to off state; the reader connected to the DC will get the unique number of the payment and then the DC will send the number along with the DC

ID and SKU to the IoT cloud for authentication and once the authentication is received on the DC from IoT cloud dispensing screen will appear; water quality sensor unit (WQSU) controlling and monitoring the sensors for the measurement of the quality of the water containing various sensor to monitor the
5 water quality from the water outlet line which comes out of the chiller to the dispenser wherein WQSU is connected to the IoT cloud via Wi-Fi and will publish the quality readings to the cloud in real time gathering the temperature, pH readings, TDS Readings and turbidity of water; authentication service; device backend service; data logger; integration services; User Interface (UI)
10 services; and Calibration services.

In an embodiment of the present invention, said authentication service authenticates the communication between MQ Telemetry transport protocol (MQTT) broker and the devices with the use of device store consisting of information related to the devices i.e. username, password, and client-ID and
15 response from authentication service allows or rejects the request for connection from the devices through the MQTT broker.

In still another embodiment of the present invention, said device backend Service while subscribing to the MQTT topics assigned to devices, and on receiving the data packet from devices, passes data packet and update the
20 dispenser status to ON or OFF/Update the ATM status to ON or OFF/Store the collection information in a time series database and authenticate payment cards

with Database services and publish the status message to devices after successful authentication.

In yet another embodiment of the present invention, said data logger logs the data packets received from the devices and stores the same in a log store
5 required for maintenance.

In a further embodiment of the present invention, said integration service exposes and connects through API's with the database to perform the functions.

In a still further embodiment of the present invention, said User Interface (UI) Service provides access to web dashboard to monitor the WATMs, access
10 WATM's logs for maintenance purposes and survey the revenue collection and total water dispensed information.

In another embodiment of the present invention, said calibration service provides access to the Android application as well as mobile/web application required to calibrate flow sensors of water dispensing unit to ensure a reliable
15 and steady rate of water flow.

In another embodiment of the present invention, said API Gateway performs the tasks of authenticating the accessing clients by validating JWT token & redirects the requests from the clients to requesting services and send the response from the requesting services to the clients.

20 In a still another embodiment of the present invention, said dispenser controller (DC) control the water flow of the Dispenser gives a Touch Screen

interface to the User and which is Wi-Fi/GPRS Enabled, Touch Screen with User Interface to guide the customer, connectors for Coin Sensor, RFID and OTP keypad for payment, flow sensor and solenoid connector, FOTA (Firmware Over The Air) and USB based configuration.

- 5 Still another embodiment of the present invention, said GPS tracker is integrated in the system which provides real-time location which helps locating the WATM on the map sitting in the central command centre in event of any failure or alert trigger at any WATM, WoW or Water Station.

BRIEF DESCRIPTION OF THE FIGURES

- 10 Figure 1 depicts block diagram of the hardware, cloud infrastructure & application layers that work in tandem to create the Smart Water Management System. Marked in Blue is the cloud backend & outside are the hardware and software including WATM Dispensers, Control Applications and Database Services. WATM interacts with the Backend through the MQTT Broker which
15 helps authenticate and process the data for Application and Database. Control Applications like calibration & SKU Tool enable remote configuration and testing of the device.

- Figure 2 depicts the Architecture showing the communication between MQ Telemetry Transport Protocol (MQTT) broker and the devices with the use of
20 device store consisting of information related to the devices. Where D1, D2, D3 are local clients that talk to MQTT over Wi-Fi or 2G, individually and independently of other Dispensers or WQUSU devices. This provides high

availability of the WATM in case of a Dispenser failure. Also shown in the figure are RFID & COIN Sensors connected as well as the Solenoid Valve & Flow Sensors to control the dispensing.

Figure 3 depicts structure overview and flow of commands happening at the Dispenser Level. Showing capability of the dispenser to handle multiple SKU & Payments Mode. The complete process is a Graphical Interface on a Touch Control Screen for ease of use.

Figure 4 depicts block diagram of Water Quality Sensor Unit with various kind of Quality and Quantity Sensors it can handle. The Sensor can capture in real time the sensor values like but not limited to TDS, pH, Turbidity, Temperature & Water levels. This communicates to the Gateway over Wi-Fi or 2G for transmitting the data to MQTT Broker.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a unique IoT (Internet of Things) based controllers connected to a cloud-based platform using specified protocols and SOPs (Standard Operating Procedures) to solve water related issues.

The present invention provides delivery of safe drinking water at affordable cost through remotely controlled and monitored Water ATMs, Water on Wheels, Drinking Water Station and Community Drinking Water Projects to bring health and wellness in the lives of people.

Customized remote monitoring and controller unit is an ideal use of IoT applications. The main controller controls all the Dispensers operating in tandem with various types of input data and conducts edge-based analysis while communicating with a central cloud-based server. This enables transmission of data through GPRS or Wi-Fi connectivity that is suitably processed and appears on the central dashboard. This allows real time control and data visualization on the cloud-based backend and generates further inputs for improved operating efficiencies. Data analysis helps not only in recording consumer profile and their consumption pattern but also track water demand through various cycles of operations. Thus, the present invention provides a self-operating touch screen interface thereby enhancing the UX.

The Dispensing setup includes Dispenser Controllers and Water Quality Sensor Unit connected to the Internet via Wi-Fi /Mobility Data network.

This unique setup has two type of devices, firstly for controlling the dispensing activity i.e. regulating the flow according to the specified SKU feed to the system through the UI, secondly to measure the water quality by measuring the quality of dispensed water i.e. pH, TDS etc while giving full control to central command for changing the values and turning the device On and Off and providing the status and readings in real time.

The device is carefully designed and implemented a concept wherein a Smart Water device that is responsible for dispensing and monitoring drinking

water in public as well as household environment is developed by way of implementing an IoT technology *as depicted in Figure 1*.

The device is enabled with the features of having active water sensors that are a critical piece of the IoT infrastructure. Using this, the essential details
5 such as Water quality, level, flow etc. can be monitored, measured and analysed. The device can exchange data and have access to data points from other devices such as your smartphone through app. Water vending machine can help the users monitor consumption data, spending patterns and Pre-paid Water Card usage in tandem.

10 The Water Dispenser is used mainly in the following three operating environments, viz, an enclosed fixed water ATM (WATM), a mobile WoW (Water on Wheels) and Ohiya corporate drinking water station.

The device is designed to be kept and can also operate in a humid environment inside the WATM. The device operates at a voltage regulated state
15 (9 Volt to 13 Volt DC / 180 – 240 watt). The LED touch screen of the Display Controllers is one of the most critical hardware pieces which can be controlled and updated remotely.

The optimum temperature required is Up-to 70-degree C and the prescribed Humidity Level ranges from low to medium with an operating
20 Voltage of 9 V to 13 V DC (200 – 240 V AC). Internet via Wi-Fi/Mobile Data is used to operate the system. The Internet provided is WAP2 PSK enabled and protected with a secure complex password and SSID as per policy. The DC

voltage input required is always (9 Volt to 13 Volt DC / 200 – 240 watts: Operating range). To enable the sensor connections, instruction stickers are placed on the device. Connection to the cloud server is enabled through encrypted transmission. For remote and rural installations device is capable to
5 connect and transmit over simple 2G network, further the device can remain operational uninterrupted in the absence of internet connectivity for a long period of time. This enables business continuity as builds redundancy for authentication of payments to dispense water which sync up with the broker when internet services are resumed.

10 Authentication Service

The architecture authenticates the communication between MQ Telemetry Transport Protocol (MQTT) broker and the devices with the use of device store consisting of information related to the devices i.e. Username, Password, and client-ID as ***depicted in Figure 2.***

15 On the basis of the response from authentication service, the MQTT broker allows or rejects the request for connection from the devices.

Device Backend Service

While subscribing to the MQTT topics assigned to devices, and on receiving the data packet from devices, it passes data packet and update the dispenser status to
20 ON or OFF/Update the ATM status to ON or OFF/Store the collection information in a time series database; and authenticate RFID cards with

Database services and publish the status message to devices after successful authentication.

Data Logger

5 The data logger logs the data packets received from the devices and stores the same in a log store required for maintenance.

Integration Services

An integration service exposes and connects through API's with the Database to perform the following functions

- Registers & Activates WATMs;
- 10 - Control the WATMs by switching it ON or OFF;
- Update the balance amount by recharging it to desired value;
- Get collection information for a particular WATM by passing the WATM's UID along with time period for which the collection information is required.

UI (User Interface) Services

- 15 Provides access to web dashboard to monitor the WATMs, access WATM's logs for maintenance purposes and survey the daily revenue collection and well as total water dispensed information.

Calibration Services

Provides access to the Android application as well as mobile/web application required to calibrate flow sensors of water dispensing unit so as to ensure a reliable and steady rate of water flow.

5 API Gateway

Performs the tasks of authenticating the accessing clients by validating their JWT token & Redirects the requests from the clients to requesting services and send the response from the requesting services to the clients.

Dispenser controller (DC)

- 10 The DC as ***depicted in figure 3*** used to control the water flow of the Dispenser gives a Touch Screen interface to the User and which is enabled with the following features:

- Wi-Fi Enabled and /or 2G connectivity
 - 3.5” or more Touch Screen with User Interface to guide the customer
- 15 - Connectors for Coin Sensor and RFID for payment.
- Flow sensor and solenoid connector.
 - FOTA (Firmware Over The Air) and USB based configuration update available.

Device Controller (DC)

The DC is connected to the flow sensor and the solenoid for controlling the water to be dispensed. Once the user selects the start dispensing option on the UI after payment, the controller puts the solenoid in open state and counts the
5 number of pulses of the flow sensor which is calibrated for ml/sec and when the selected amount of water is reached the solenoid is put to off state. There are three types of payment options, RFID card, E-Wallet/ UPI QR Code and by Coin.

For RFID card, the RFID reader connected to the DC will get the unique
10 number of the RFID and then the DC will send the number along with the DC ID and SKU to the IoT cloud for authentication and once the authentication is received on the DC from IoT cloud, Start Dispensing screen will appear.

In case of QR Code payment option, each dispenser has a unique QR code ID and it generates a unique transaction number every time customer
15 selects the payment option via QR Code option. The customer scans the code through his mobile wallet app or through specific application and makes the payment. Upon Success the gateway generates and sends a transaction ID to the IoT cloud server and the dispenser dispenses the desired quantity. If authentication is rejected or the time out happens, an error screen pops up and
20 then the main start screen appears. In case of coin, the machine identifies the coin value, through the coin acceptor and authenticates locally in the controller

and dispenses water. All this transaction information is transmitted in real time to the cloud server with a calculation of 0.000000001 of seconds.

The transactions from all the dispensers in the WATM are processed and captured individually and independent of each other, which keeps the WATM operational even if one or two of the dispensers go down at any given point in time.

Water Quality Sensor Unit (WQSU)

The WQSU (*as depicted in figure 4*) is the device Controlling and monitoring the sensors for the measurement of the quality of the water. The WQSU contains various sensor to monitor the water quality from the water Outlet line which comes out of the chiller to the dispenser. The WQSU is connected to the IoT cloud via Wi-Fi and will publish the quality readings to the cloud in real time gathering the key factors of water quality such as temperature, pH Readings, TDS Readings and turbidity. The WQSU is also monitoring the Water Level available in the raw water tank, treated water tank and reject water tank to maintain availability of water.

Another key feature integrated in the system is the GPS tracker which provides real-time location which helps locating the WATM on the map sitting in the Central Command Centre in event of any failure or Alert trigger at any WATM, WoW or Ohiya Drinking Water Station.

The monitoring system is a robust, remote enabled monitoring system with the unique features to ascertain the dispenser Status, WATM/WoW Status, different Sensor Readings, GPS Location Data and prepaid Balance WATM-wise.

Smart water management system is designed and integrated to prioritize energy efficiency savings by operating at a controlled level of functionality and only turn up performance when commands are given.

The technology also facilitates the automatic re-ordering and delivery of fresh mineral cartridges whenever required so that these replacements are based on personal usage and individual need. It adapts a sustainability element by replacing the need for continual purchase of bottled water over time, thus reducing cost.

The monitoring and Analytic setup is designed to improve current operational and customer decision making (collected real-time in milli-litre increments as the dispensing happens) and also includes accessible and user-friendly collected data. The solution can produce readily accessible and useful reports for management, stakeholders as well as customers. Monitoring solution gives the Periodic Data, but also gives an overall Sensor reading along with warning alerts when the Levels are beyond the threshold limits. The dashboard and data analytic also enable trend analysis based on Alert type, Location, Severity, Time and other Profile parameters. It gives the users complete control to correlate multiple data sources enables holistic view of WATM/ WOW / Ohiya corporate drinking water station in use.

The central command and control centre are an Intuitive, Intelligent & Integrated Operative Platform focused to provide agile services to monitor and support business users and end customer. The command centre is fully equipped and minutely handling operative functions, assets/ inventory functions, security parameters, facility management and business systems. The product is capable of delivering all these features and reports thereby creating a highly efficient environment for treatment, delivery and management of safe water infrastructure.

The salient features of Central command and control centre are:

- 10 - Computer aided dispatch
- Operator collaboration
- Respond collaboration with measurable KPI's
- Sensors status- Active/Inactive
- Mobile alerts- Active/Inactive
- 15 - Location information
- Alert evaluation
- Sensor visualization
- Contextual navigation
- Central diagnostics
- 20 - Two-way collaboration between mobile phone and central command centre
- Audio, video and text data sharing
- Incident Record

- WPP Performance Tracking
- Knowledge Repository
- Audit Trail
- Integration sensors for single-window alert management along with add-on
- 5 analytic data
- Integration for fault monitoring, network performance monitoring and network traffic monitoring
- Interface with Call Centre Application, Computer aided dispatch, Operator Collaboration and Responder Collaboration with measurable KPI's
- 10 - Complete O&M and life-cycle management for hardware and software
- Interface for ONVIF based cameras with memory and analytic
- Resources and alerts are tightly integrated with maps giving improved location awareness
- Multiple sites can be connected on to a central platform with quick access to
- 15 individual locations
- Response assets are tagged on the maps with information about contact information, distance, etc.
- Resources can be further searched and tracked based on geography, name, department, role, skill and availability
- 20 - Manages maintenance alerts like filter replacement, general servicing etc.
- Automate standard operating procedures to ensure measurable outcomes
- Escalation matrix defined

- Internal users and operator efficiency are also tracked through reports and dashboards
 - Index-based alert searches based on time, location, type and other alert properties
- 5 - Alert trends and patterns analysis through customizable dashboards.

In summary, the upgraded and improved features of the present invention as compared to the existing water services in the market are:

- Payment options- The payment options include RFID card, Coin, pay with E-Wallet/ UPI, BHIM, BharatQR through single QR Code supporting more than 100 e-wallets and digital payment platforms and USSD Code. QR Code payment option is designed in such a way that each dispenser has a unique QR code ID and it generates a unique transaction number every time customer selects the payment option via QR Code option. The customer scans the code through his mobile wallet app or through special application and makes the payment. Upon Success the gateway generates and sends a transaction ID to the IoT cloud server and dispenses the desired quantity; USSD Code is primarily integrated to empower remote & rural areas so dispensing can happen even without internet connectivity in a secure authentication process. Each dispenser has a unique USSD Code and is installed with a keypad and has unique OTP codes locally on the device. User sends a simple Text Message (SMS) USSD Code payment, upon successful payment receipt the server sends a Unique OTP over SMS to user that can be entered into the dispenser through the attached keypad, the

device locally authenticates the OTP and dispenses the desired quantity. All data is synced with cloud MQTT when internet connectivity is restored over Wi-Fi.

- Customised remote monitoring- A specialised mechanism to Customize Remote Monitoring and has designed the controller unit to make ideal use of IoT application in every Water ATM/ WOW and Ohiya Drinking Water Station;
- Single window alert management- The technology is one of its kind to Integrate and remotely maintain and manage SENSORS for single-window alert management along with add-on analytics;
- Single operating touch screen interface- It provides a Self-Operating touch screen interface thereby enhancing the User Experience increasing ease of use and integration of Command Centre – Internal Users and End Users;
- Call centre application-The invention combines interaction data between Operations Team and End users with Call Centre Application for parameters such as Computer aided dispatch, Operator Collaboration and Responder Collaboration with measurable KPI's thus enhancing Operational efficiency and User Delight.

We Claim:

1. A smart water management system based on the Internet of Things (IoT) technology comprising;

the controller unit operating in tandem with input data and conducting
5 edge based analysis while communicating with a central cloud based server to enable transmission of data through GPRS or Wi-Fi connectivity that is processed and appears on the central dashboard to allow real time control and data visualization on the cloud based backend and generates further inputs for improved operating efficiencies and for data analysis and is connected to the
10 flow sensor and the solenoid for controlling the water to be dispensed; the user selects the start dispensing option on the UI after payment, the controller puts the solenoid in open state and counts the number of pulses of the flow sensor which is calibrated for ml/sec and when the selected amount of water is reached the solenoid is put to off state; the reader connected to the DC will get the
15 unique number of the payment and then the DC will send the number along with the DC ID and SKU to the IoT cloud for authentication and once the authentication is received on the DC from IoT cloud dispensing screen will appear;

water quality sensor unit (WQSU) controlling and monitoring the sensors for the
20 measurement of the quality of the water containing various sensor to monitor the water quality from the water outlet line which comes out of the chiller to the dispenser wherein WQSU is connected to the IoT cloud via Wi-Fi and will

publish the quality readings to the cloud in real time gathering the temperature, pH readings, TDS Readings and turbidity of water;

authentication service;

device backend service;

5 data logger;

integration services;

User Interface (UI) services; and

Calibration services.

2. The smart water management system based on the Internet of Things
10 (IoT) technology as claimed in claim 1, wherein the authentication service authenticates the communication between MQ Telemetry transport protocol (MQTT) broker and the devices with the use of device store consisting of information related to the devices i.e. username, password, and client-ID and response from authentication service allows or rejects the request for connection
15 from the devices through the MQTT broker.

3. The smart water management system based on the Internet of Things (IoT) technology as claimed in claim 1, wherein the device backend Service while subscribing to the MQTT topics assigned to devices, and on receiving the data packet from devices, passes data packet and update the dispenser status to
20 ON or OFF/Update the ATM status to ON or OFF/Store the collection

information in a time series database and authenticate payment cards with Database services and publish the status message to devices after successful authentication.

4. The smart water management system based on the Internet of Things
5 (IoT) technology as claimed in claim 1 wherein the data logger logs the data packets received from the devices and stores the same in a log store required for maintenance.

5. The smart water management system based on the Internet of Things (IoT) technology as claimed in claim 1 wherein the integration service exposes
10 and connects through API's with the database to perform the functions.

6. The smart water management system based on the Internet of Things (IoT) technology as claimed in claim 1 wherein User Interface (UI) Service provides access to web dashboard to monitor the WATMs, access WATM's logs for maintenance purposes and survey the revenue collection and total water
15 dispensed information.

7. The smart water management system based on the Internet of Things (IoT) technology as claimed in claim 1 wherein calibration service provides access to the Android application as well as mobile/web application required to calibrate flow sensors of water dispensing unit to ensure a reliable and steady
20 rate of water flow.

8. The smart water management system based on the Internet of Things (IoT) technology as claimed in claim 1 wherein API Gateway performs the tasks of authenticating the accessing clients by validating JWT token & redirects the requests from the clients to requesting services and send the response from the requesting services to the clients.

9. The smart water management system based on the Internet of Things (IoT) technology as claimed in claim 1 wherein the dispenser controller (DC) control the water flow of the Dispenser gives a Touch Screen interface to the User and which is Wi-Fi Enabled, Touch Screen with User Interface to guide the customer, connectors for Coin Sensor and RFID for payment, flow sensor and solenoid connector, FOTA (Firmware Over The Air) and USB based configuration.

10. The smart water management system based on the Internet of Things (IoT) technology as claimed in claim 1 wherein the GPS tracker is integrated in the system which provides real-time location which helps locating the WATM on the map sitting in the central command centre in event of any failure or alert trigger at any WATM or WoW.

11. The smart water management system based on the Internet of Things (IoT) technology as claimed in claim 1 wherein provides for complete redundancy from 4G internet connectivity issues and operate in a 2G GPRS environment in a reliable manner.

12. The smart water management system based on the Internet of Things (IoT) technology as claimed in claim 1 wherein it can be accessed by users that use conventional mobile phone by making digital payments through text messaging based OTP.