INTERNET OF THINGS GROUP 4

IOT-SMART WATER MANAGEMENT

PHASE 2

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Introduction

Water represents an essential resource for survival. Today, the quality and quantity of water have decreased considerably. These are the effects of global industry development and the overexploitation of land and sea resources. Moreover, climate change has a strong impact on water resources, and drought is becoming more prevalent. All these factors can cause major damage to water resources, so intelligent water management systems are essential for maintaining efficient management in terms of the quality and quantity of drinking water.

One of the most important aspects of water sustainability is the continuous monitoring of water consumption in order to make the right decisions regarding the good management of this vital resource. Water scarcity, together with diseases caused by contaminated water, are major dangers that threaten humanity. Therefore, additional attention should be paid to this area, and the necessary resources should be allocated to monitoring water consumption. The collected data provide decision support for streamlining water resources.

Another important factor to note is population growth. The demand for water increases, and the need to develop an intelligent system becomes indispensable . An alternative that has become increasingly popular, with multiple benefits in many areas, is based on the concept of the Internet of Things (IoT) IoT has made significant contributions in various fields, including being integrated into intelligent water management systems.In households, the IoT concept can be implemented by installing sensors and collecting data in real time to provide continuous data monitoring. Solutions that include IoT in water management have multiple advantages including low costs and real-time remote data access. Furthermore, the integration of smart sensors in an existing system does not require many changes; IoT offers flexibility and only requires a few configurations to extend functionality

For the analysis of the collected data to provide results with high accuracy, it is recommended that they not vary too much and instead have a certain continuity and uniformity. From this point of view, Kofinas, Spyropoulou, and Laspidou [24] implemented an algorithm that can generate synthetic data related to domestic water consumption that they tested in two European countries with good results. In the data analysis stage, the data are pre-processed to remove zero values or small leaks that could negatively influence the data related to the use of water in households.

Methodology

It’s describes the proposed methodology for the data collection and process- ing pipelines, which provide the context for the experimental results obtained in Section . The system architecture describes the water consumption monitoring solution. The data processing pipeline presents the methodology for water consumption analysis, for which the clustering and classification methods are described.

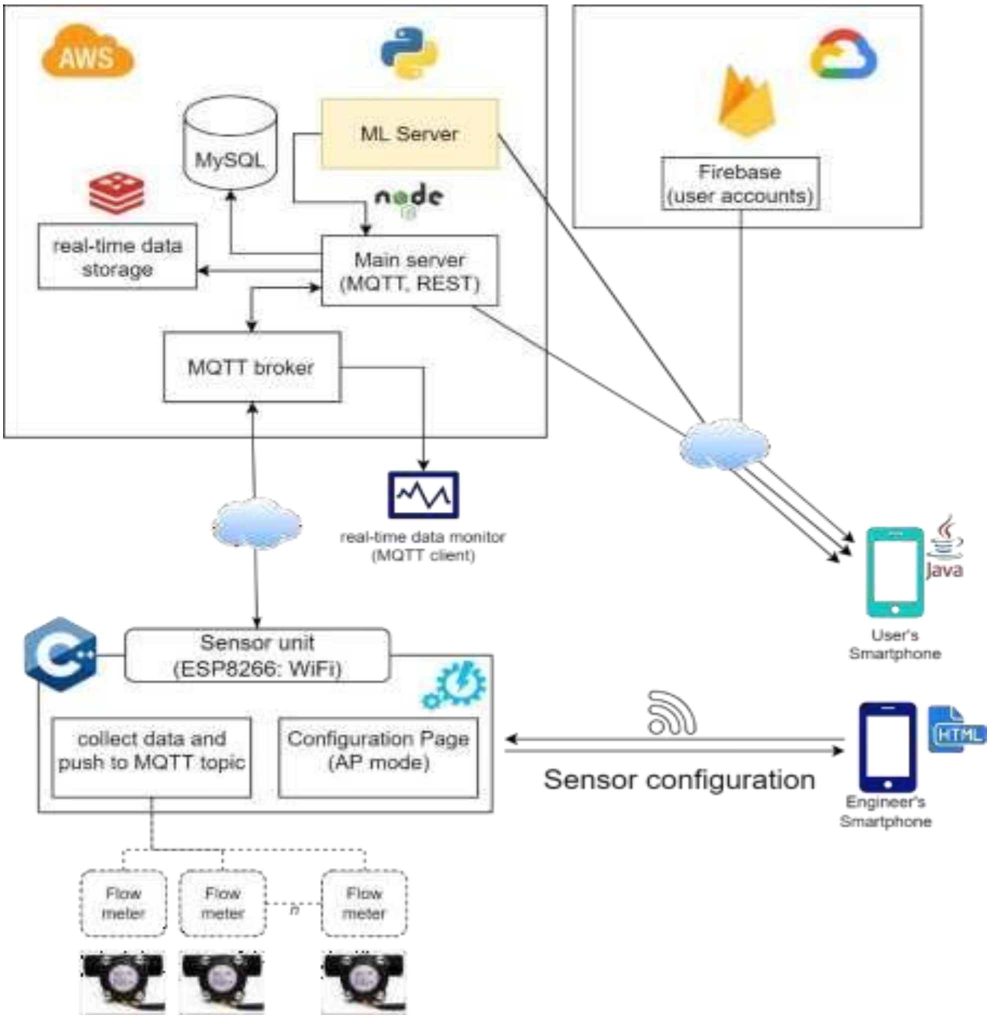
System Architecture

An intelligent water network management system is most effective when several factors are considered simultaneously, i.e., water suppliers, decision makers, and the direct involvement of consumers.

For efficient water consumption data collection, the sensor network is integrated into a cloud-based architecture . Data acquisition is performed using a NodeMCU development board based on the ESP8266 microcontroller, with Wi-Fi communi- cation. The platform has multiple GPIO pins (general-purpose input/output) connected to several YF-S201 flow meters and can be programmed using the Arduino environment to monitor and collect the water flow through several pipes. The acquisition module is pre-programmed before installation, providing a configurable interface for connecting to the local network and defining a variable number of flow meters attached. To display the required configuration data, the sensor interface queries the server that is hosted directly on the ESP8266 microcontroller, which is configured in both station and Wi-Fi client modes.

Collecting data from the sensors is based on the MQTT (MQ telemetry transport) messaging broker, which includes a standard communication protocol, adapted to the IoT domain .MQTT is a publish–subscribe communication protocol that is suitable for exchanging messages between IoT devices as it supports bidirectional TCP/IP connection.

Figure The water consumption monitoring system architecture.



The consumer can visualize the status of a sensor, as well as water consumption data through a mobile application. The Firebase component provides mechanisms for the authentication and management of user accounts (e.g., consumers, suppliers) and the data are displayed in the user interface through HTTP requests to the main server.

The processing pipeline

The processing pipeline For a better understanding, each step will be described below. The raw data set (time series) was generated by collecting data from sensors installed in multiple households. Four types of water outlets were considered, i.e., sink (cold and hot water measured separately), toilet, and shower. The raw data set were processed to be evaluated and tested by first eliminating nonrelevant data that could negatively impact the results.

The time series of daily consumption were further extracted from the raw data set to make it easier to assess and better understand water consumption patterns for each outlet with a high level of accuracy. Furthermore, based on the identified patterns, several tests were performed, K-means clustering, daily batch processing, and event processing, in order to evaluate consumption profiles from different perspectives that are not necessarily correlated with a particular consumer.

While the exact source of the consumption is known in the context of the experiments, the proposed methodology defines multiple strategies for uncovering various patterns in terms of overall consumer behaviors.

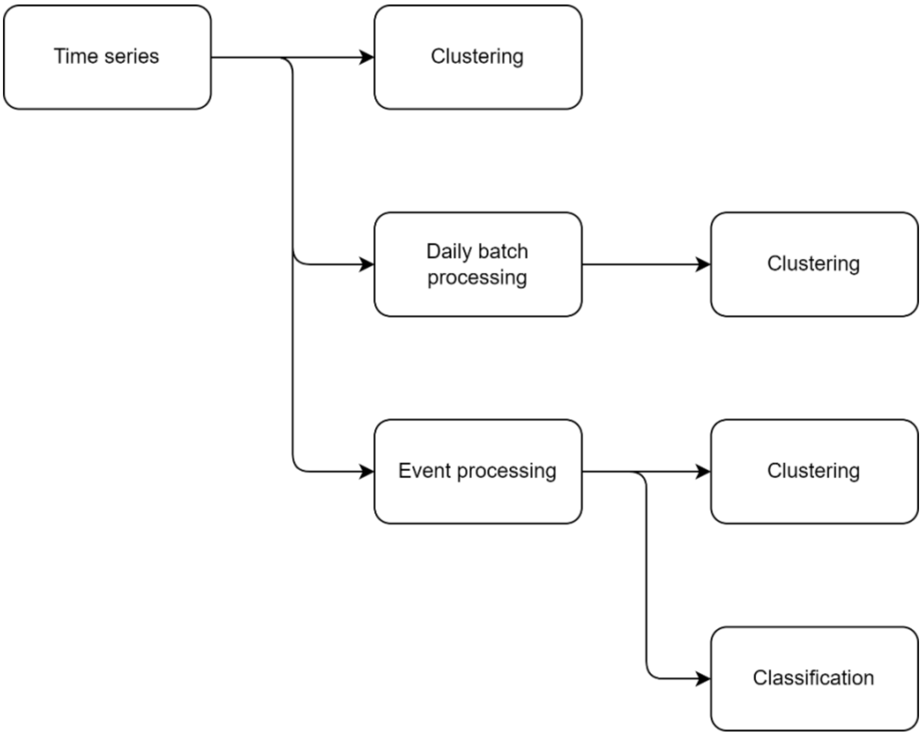


Figure The processing

Finally, a more in-depth analysis was performed, and the individual consumption events were extracted from the time series, being characterized by duration (minutes) and total volume (liters). In order to analyze the accuracy of the results in terms of identifying the types of consumer outlets, K-means clustering was again applied to the events extracted from the data set.

The classification stage, only two measuring points (combined hot/cold sink water and toilet water) were considered. The purpose of this stage was to train the classification models to predict the two types of consumption events based on the entire data set. Four classification methods .

Cluster method

Profiling consumer outlets by water consumption involves using the K-means cluster- ing algorithm with a predefined number of clusters. This approach was used to identify consumption patterns from the data set that were represented as time series as well as con- sumption events defined by duration and volume. Regardless of the data set, the algorithm iteratively assigns the data points to the nearest centroid, recalculating the centroid at each step using a stopping criterion based on Euclidean distance.

Bb bIn this study, we used clustering methods to analyze the quality of the results based on the data set. Furthermore, to evaluate the accuracy of clustering with regard to the known consumption outlets, we used the confusion matrix together with the following parameters: silhouette score (S), Rand index (RI), adjusted Rand index (ARI), purity (P), and entropy (E).

Classification Method

Consumer outlets are classified according to the water consumption using supervised learning algorithms. Training models are created with the main purpose of predicting the right class for a consumer outlet.

To test and evaluate the classification methods on our data set, we considered four different supervised learning algorithms: decision tree (DT) using the CART algorithm; ensemble methods using the random forests (RF) algorithm where we grow multiple CART trees; multilayer perceptron (MLP) using the Dense algorithm; and recurrent neural network (RNN) using LSTM cells.

The above four types of algorithms are divided into two groups. DT and RF are part of machine learning algorithms, while MLP and RNN represent deep learning algorithms. In the algorithm evaluation process, 80% of the data set was used for training, and the remaining 20% was be predicted by the supervised learning algorithms.

In the context of linear data sets, DTs present fast and efficient solutions. Given this aspect, we decided to implement them in our study. For greater accuracy, the RF algorithm provides better results, as will be seen from the tests applied to the data set. For comparing the two machine learning algorithms, RF combines several DTs to be more complex and more accurate, with lower overfitting.

Water Quality Management

Watching the quality of water that comes into our houses is crucial. Rivers, lakes, and reservoirsmay contain contaminants that are dangerous to us, and the increasing world population combined withurbanization has also worsened water quality. In our changing world, IoT can help monitor and analyze distributed water and ensure it complies with regulatory standards.

A water quality management system using IoT can deal with quality issues effectively. Youonly need to consider a simple comparison to appreciate the difference: Without IoT, water samples need to be collected and analyzed manually.

This process is costly and time-consuming because it requires large equipment and an expensive workforce. In contrast, IoT sensors can measure a variety of parameters like temperature and turbidity. Operators receive regular data from multiple samples, enabling them to remotely perform quality control on water reserves.

Water Level Monitoring and Dam Management

Dams bring water to livestock and irrigation and supply many industries.They also play a pivotal role in flood control and can assist river navigation, soit's crucial that dams and reservoirs function properly and their water levels are safe. The trouble is that traditional monitoring methods are time- consuming and complex.

Water level monitoring and management of dams using IoT can improvethis, using ultrasonic, vibration, and pressure sensors to help monitor dam function.

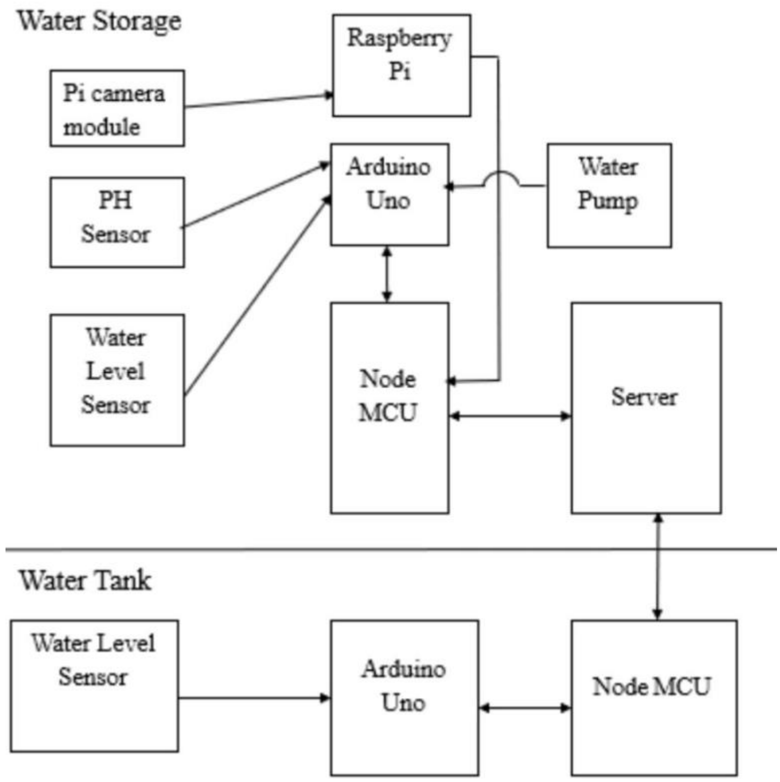
With pressure sensors, in particular, you can detect leaks in pipes and receive instant alerts. Predictive technologies ensure dam operator early warnings and are able to keep watch over water availability in eachreservoir. This may be particularly helpful for irrigation.

A smart solution can also give you remote control over the movement of gates, so there's no need to send staff to the site in severe weather conditionslike floods or storms. If the water reaches a certain level, the system can decide to open or close the gate.

Water management

The designed system is used for water monitoring and checking the quality of water. Initially, sensor in the base tank checks for the presence of water. In the presence of water, pump starts automatically and it starts pumping water to overhead tank. Over head tank is monitored for different water levels.

Once the water reaches the threshold specified, it notifies the user. If the water level reaches the maximum threshold, pump stops automatically. If water is flowing continuously than the expected time then it will be detected by water flow sensor and data will go to 10T server.



User can see the real time data in IOT server and in this condition one notification will be sent to mobile App from. IOT server. If the water PH level or dirt level is not good then the water will not be pumped into the tank. User can control water flow through mobile app by interacting with the server.