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Toward an IoT-Based Software-Defined Plumbing Network System With Fault Tolerance

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ABSTRACT

In this paper, the authors show the application of computer science algorithms to the plumbing system. They propose a fault tolerant tap water system that is impossible without internet of things and algorithms. They show that the problem is a mutual exclusion group problem and propose an adapted algorithm version from the literature as a solution. Coupling algorithms with the configurable plumbing network will open a new field of research on IoT called software-defined plumbing network where components that have been traditionally implemented in hardware (e.g., water mixers, spring faucets, flow sensors, etc.) are instead implemented by means of software. This way we can solve other problems like instantaneous hot water, automatic cleaning of the water heater, etc. since, due to computer algorithms, the systems can be easily smart, extensible, and adaptive.

KEYWORDS

Fault Tolerant System, Group Mutual Exclusion, IoT-Based System, Software-Defined Plumbing Network System

INTRODUCTION

There are several problems with the plumbing system these days, the most important being that problems arise in system maintenance or emergencies, forcing the plumber to shut down part of the home's water supply system or of the whole network, which can disturb the inhabitants of the house. The problem can be serious in the case of a hotel practically the hotel will lose a certain percentage of customers and will have a bad reputation.

Another problem to consider is waiting and wasting water to get hot water. The cause of this problem is that the hot water pipes are filled with cold water. It is necessary to empty the cold water residing in the hot pipe to obtain the hot water requested.

Another possible scenario assumes someone is renting his house, because the water tap on the washing machine is usually only connected to the cold water pipe. If the customer's washing machine does not heat water, the home owner is forced to fix the problem for the customer to allow hot water to go to the faucet of the washing machine, if the house is well finished, capped…etc obliges the owner of the house to think twice before proceeding.

In this article, we propose a fault-tolerant and adaptive intelligent system with a piece of software, all the problems mentioned above can be solved easily and many other problems. In the case of the

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washing machine without adding additional heating, we can ensure that the tap dedicated to the washing machine serves hot water at the desired temperature thanks to the IoT system.

Our system can be enhanced with machine learning easy to solve other problem like water and energy consumption monitoring. For example the system can be smart enough to make a notification for washing clothes when the water is coming to the house from the external public water network, at the moment of notification no need for pumping the water with the pump which is noisy and consume electricity this can cause a reduced bill of electricity, if the washing machine smart enough it can even start washing automatically, user just get a feedback of the success of this operation. The system can be enhanced to know which faucet is opened by the user to warn him for example if he opened the faucet of the shower he get warning via his phone with a call telling him do not take a bath right-now since the tank is not enough for your bath!

The system based on internet of the things is easily extensible for adding more features like leakage detection, automatic cleaning of the water heater. In some places in the world the water is full of limestone, heating water with gas-fired water heaters; mouth the pipes of the water heater which causes the malfunction of the water heater for example cut off the hot water totally.

Even the actual technology of smart circulating pump for getting instant hot water which work with servo mechanism cannot turn off itself automatically at night but with an IoT based system you can for example schedule the circulating pump to turn off after 10 pm automatically for eliminating the noise. Even if this pump dotted with timer it is not easy to go outside in rainy day to set the timer if the pump is in the garden for example. IoT based system offer simple user interface using cell phone for example. The system can learn when you need frequently hot water to get really a smart system. Furthermore servo mechanism for triggering pump on the demand of water from a certain tap work with a principal of detecting a decreasing in pressure. This principal cannot make a distinction between a leakage and real requesting of water at certain faucets. In contrast IoT based system can detect leakage and can't rely on servo mechanism for triggering the pump.

For example if you want to fill a container with a certain amount of water let's said 5 liter you don't even monitor the operation of filling to avoid overflow of the container since the system can learn without an extra flow sensor the time needed for filling this container.

There are a number of ways in which IoT is revolutionizing tap water systems and bring new kind of product to the market of plumbing and house appliance. For example, making a bath to baby can cause possible accident of burn due to the change of heat suddenly. This last problem is due to the fact when someone open and close cold water faucets. In case of a bath directly from the shower faucet; Mothers always fill a container with warmed water for avoiding exposing the baby directly to the heated water of the shower. A possible product for this situation a temperature sensor which send temperature information to the cloud with a PID algorithm this last can open and close cold and hot water tap with feedback algorithm to control the temperature of water to be at the desired temperature. In case of high temperature at the faucet of bathroom it is smart enough to close the faucet automatically for avoiding any accident. In this paper, we will focus on the software defined plumbing network that enable fault tolerance we start first by discussing the Hardware needed and later the necessary software.

BACKGROUND

The notion of IoT based software defined plumbing network system is new I have inspired the name from software defined radio where Radio circuit are defined by software rather than hardware in the earlier day of electronics for example filters of frequency are implemented by analog circuit which are prone to errors since the physical components with time will be old and lose their physical properties for example a resistance of $1k\ Ohm$ with time can decrease to $0.8k\ Ohm$ and the circuit will not work properly. Furthermore software defined radio system can be configured to implement any radio circuit