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Proposition of Smart Kitchen using Message Queuing Telemetry Transport Protocol

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Abstract: **Technology in the present world is growing at a rapid speed, adapting to it makes one's job easier in a way. Concept of Smart kitchen in the field of Internet of Things is making an ample development every day. Motivation towards the development of Smart kitchen helped us to take up this work. The vision of this proposed system is a Smart Kitchen 2020 which automates much of the work related to cooking with lesser manual effort. This system will automatically detect the cooking appliances placed over the cooking area on the surface table and power up the device. Application will behave according to the cooking appliance and will present the controls corresponding to the detected cooking appliance. The cooking appliances are identified and connected to the application using Message Queuing Telemetry Transport (MQTT) Protocol. Application can control the temperature, time setting and speed setting etc. of the cooking appliances. This system will suggest the user with pre-defined set of recipes. One can also browse through YouTube or any food recipe applications, right on the cooking surface. Given the input as what ingredients the user has, this system will suggest the recipe that can be made from them. The touch on the cooking surface or table will be detected by android phone and is processed by the application. Thus, our effort aims at bringing the smart kitchen into reality with much of the work being automated.**

***Keywords*— Internet of Things, MQTT, NodeMCU, REST**

I. INTRODUCTION

The vision of 50 billion devices connected each other will see a thorough change in the way, businesses, people and society interact [1]. HTTP has been the most preferred communication protocol since many years. For distributed computing, nowadays many of the Service providers use the concept of Middleware. Message-Oriented Middleware's stores the messages in different queues and distribute it to various clients when needed. Various protocols have been developed use Message-oriented middleware model. E.g. eXtensible Messaging and Presence Protocol (XMPP), Data Distribution Service (DDS), Advanced Message Queuing Protocol (AMQP), Message Queuing Telemetry Transport (MQTT) [2]. Most widely used protocols are MQTT and AMQP. MQTT is considered as one of the lightweight machine to machine messaging protocol [3]. We choose to use MQTT since it has effectively low message overhead that is based on TCP/IP. It uses Publish/subscribe transport mechanism.

This paper talks about the Interactive Cooktop. The main idea behind this work is to make the kitchen tasks function in a smarter way. People who cook everyday might find it boring or make them worried like what has to be cooked for the day. This proposed system will make their job much easier by suggesting the recipe every moment.

The technology behind the Interactive Cooktop is auto start-up of the device with a low power energy using induction, thereby identifying itself as a particular device.
Once the device has been detected the commands to the device can sent over Wi-Fi from the software module, residing and executing on supportive operating systems (Windows/Android). This will internally power up the actual induction coil to provide the required power. Thereby giving the user flexibility to control the device from the cooktop. This cooktop can further be extended to support multiple features like – social sharing, searching the web, video sharing, health suite etc.

The proposed system facilitates the Interactive cooktop application, have the control over the cooking appliances. This application is displayed on any flat surface table and one can interact with the application on touch of a finger. This touch is detected by the Android device which forwards the data to the application for processing. This system will use Wi-Fi as the basic means of communication over different devices and WPA has been used as the security mechanism for this implementation. Cooking devices are configured as the Wi-Fi access points which receive commands from the application. NodeMCU ESP8266 is flashed using Arduino board which acts as a Wi-Fi component for cooking appliance. MQTT protocol will facilitate the communication between various Cooking devices and the phone running the application.

Minimizing power consumption is a huge driving force in the internet of things since a vast majority of it relies on wireless, battery-powered embedded devices. In addition to creating chips and peripherals that use less and less power, it's also important to focus on wireless protocols that maximize reliability while also minimizing computational overhead and transceiver power. The data from an iot sensor generally isn't presented to a user directly, so they rely on machine-to-machine (m2m) communication protocols to get the data to a point where it can be processed and used in a meaningful way. One commonly used message to message protocol used by iot devices is called message queuing telemetry transport). The nodemcu will be connected to cooking device and the commands sent to the nodemcu will be reflected on the actual cooking device; changing the temperature, speed setting etc. Mqtt protocol is implemented on nodemcu and also on the android phone, which runs the application.

II. RELATED WORK

a. Touch Recognition using Android phone

We can implement a Virtual User Interface in several diversified techniques. We can use the process used in [4] which demonstrates a virtual keyboard (VKB) based on a true-3D optical ranging, is presented. It is accurate, efficient and robust, however it requires a 3D optical imaging system. Similarly if we look at the systems in [5] and [6], the systems provide special features such as hand gestures and multi–touch but the system in [5] requires multiple cameras, and the one in [6] requires a unique hardware. In [7], we see that the system detects the shadow of a finger, and a touch is assumed when it is occluded by the finger. The corresponding touch detection system created in [8] was designed to detect a touch by comparing the ratio of the number of black pixels to the number of white ones. It is understood that in the corresponding article [8], the ratio is acquired by searching small regions around the fingertips and comparing the number of white pixels to the black ones, where black pixels represent the shadow. If the ratio of white to black pixels exceeds more than a certain threshold, a touch has occurred. However these methods are sensitive to the direction of lighting, where, in many cases only a thin portion of the shadow is captured by the camera. Therefore, when the finger seems close to touching the surface, it is still far away from touching it, since the pixel difference is small.

In the systems presented in [9] and [10], high speed camera is used, and a special in-air movement should be made. The system demonstrated in [11] is based on the process of measuring a distance between corresponding points on the shadow and finger; rather than measuring ratio of finger and shadow pixels, and is therefore more robust to various illuminations conditions. Also, the hand detection is based on HSV color space, which although a heuristic method, still provides better results than the RGB color space. The touch accuracy is approximately 95% and false touch detection is very minimal. So, we can use either of the systems mentioned, preferably the ones in [4] or [11] to detect and fetch the coordinates of the touch made on the Cooktop surface (on the virtual user interface) and then activate the button/option corresponding to that touch. Hence we will able to control the kitchen appliances without actually touching them.

b. Wi-Fi enabled cooking devices

According to the survey report, around 70% of people around the world will have IoT devices at their home in the next 5 years. The number of connected devices would be expected to cross 17 billion [13]. 13% of people are expected to have at least one IoT device in their house by next year. Although there are already many existing devices from smart thermostats to security systems, it comes with little surprise that the next area around the house poised to be connected is the kitchen. There are many existing systems which tend to make the home kitchen smarter.

In our literature survey, we have gone through the set of connected cooking appliances which are Wi-Fi enabled which will take the cooking to next level. Table 1 shows the technical details and the usage of the cooking gadgets [14] [15].

III. APPLICATION CONTROLLED COOKING

Interactive cooktop application has control over the cooking device. This communication is done using Wi-Fi. NodeMCU ESP8266 sits inside each cooking device and does the Wi-Fi component job. MQTT protocol has been used for implementing the Connection establishment and the data transfer.

MQTT is a publish/subscribe protocol, where in any client can send a message and receive the message from other clients, without knowing the address of client. This responsibility of managing the clients is handled by the MQTT broker. MQTT protocol is more suitable for phone devices, hence we have chosen it over Advanced Messaging Queuing Protocol (AMQP) [16]. We shall briefly describe the architecture of MQTT and the role of each component in it. The TCP/IP stack for MQTT is shown in Fig 1.

Cooking Device	Technology	Usage	Product Company
Crock-Pot® Smart Slow Cooker	WeMo® using Belkin router	• Adjust the cooking temperature, cooking time.	Belkin
Phillips HomeCooker Next	Wifi Connection	• Combines food processor, blender and electric cooker	Philips
Nomiku Sous-Vide	Wifi Connection	• Used for cooking under hot water bath. • Change the temperature from remote place.	Nomiku
Vessyl	Molecular sensors to detect the type of drink	• Detects the type of drink • Sends the nutrition results to the smart phone	Vessyl
LG SmartThinQ	Wifi, Zigbie, Bluetooth	• Connects automatically to all the other kitchen IoT devices and can talk to them.	LG

Table 1. Comparison of different Wi-Fi Enabled kitchen appliance

a. MQTT Client

Any device ranging from a small microcontroller to a well-developed server can act as MQTT client. In our demonstration, each cooking appliance and android device will act as a MQTT client. Cooking appliances are loaded with NodeMCU (Wi-Fi component) to send and receive commands. Android devices have built in Wi-Fi component, and it is just to use the MQTT libraries for us to make the app act as MQTT client.

b. MQTT Broker

MQTT Broker is the heart of this protocol. It can handle up to thousand clients concurrently; connected at the same time, depending on the implementation.

MQTT Broker also does the session management of connected clients and the authentication and authorization at the time of connection. It is the server through which messages from each clients are distributed to the receiver clients. Broker manages the publish/subscribe protocol by making an agreement on fixed topic between the clients. Here topic refers to the message or a path which is a unique identifier used for message filtering and routing. Publisher clients will publish their message using some topic, where in subscribed clients will be informed when there is new message from this topic. This topic management is done by Broker.

c. Proposed Architectural Design

The proposed system architecture is shown in Fig 2. It consists of android phone, projector, router and a flat surface table. Android device is connected to a router and the cooking appliances will be configured to be connected to the same router. So that all the devices are in the same network.

d. Configuration of Node MCU ESP8266

Node MCU ESP8266 is flashed with the configuration code. It then broadcasts its network. We can configure this Micro-controller from its default URL 192.168.1.1. It will ask the basic information like, cooking appliance name, preferred URL for its recognition and the network details (SSID and password) over which the android device and cooking appliance will communicate each other

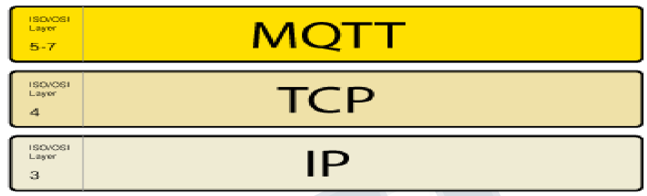

Fig 1. TCP/IP Stack with MQTT. (Source: hivemq.com) [17]

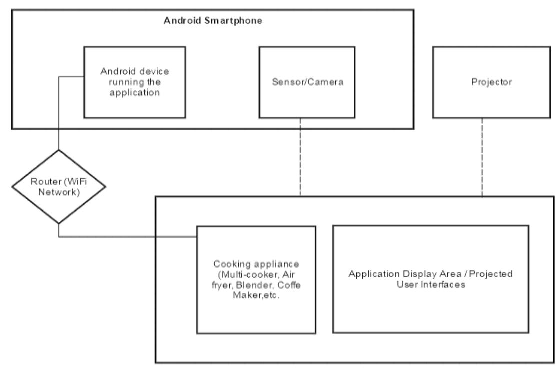

Fig 2. Architecture of Interactive cook top

e. Working Mechanism

Cooking devices usually come out without Wi-Fi component. Adding a Wi-Fi module to them will itself make the cooking smart. We have used NodeMCU v1.0 ESP8266 as a Wi-Fi component. This is developed using Arduino. Wi-Fi module can be added to the existing electric cooking appliance with few changes in the circuit connection. These Wi-Fi enabled cooking appliances will now act as MQTT clients. On the other hand, the cooktop application is developed for android phone. This application will be subscribed to each of the cooking appliance that is configured within the system. Whenever the cooking appliances are powered up, they publish the message to broker, on receipt of this message, application will display the screen pertaining to the cooking appliance. User can now interact with the cooking appliance on touch of table top.

In turn each cooking appliance would be subscribed to the android application, which is also a MQTT client. Whenever the user wants to interact with the cooking appliances (adjusting cooking time, cooking temperature, device rotation speed etc.), they just can simply to do it on touch of a cooktop table. This action will be notified to a MQTT broker, which in turn will send the command to cooking appliance. Usage of MQTT is very advantageous in this context over REST protocol. In the case of REST protocol, device need to continuously ping the URL to check for the existence of the cooking appliance. This might reduce the performance of an application. MQTT protocol just awakes the application whenever there is a device placed on the cooktop table. This application can also suggest the recipes based on the cooking appliances detected.

IV. CONCLUSION

Current cooktops are not hands free. All the cooktops currently available in the market need physical interaction with the device to operate. They also have limited functionalities attached to them. This Interactive Cooktop solution will not only produce a virtual screen which can sense the touch on any given surface to operate/control the user, but along with that it will also be providing an option to access various sites/apps on the web simultaneously.

The Interactive Cooktop also offers the flexibility to use/control multiple devices using the same cooktop. It contains separate UIs for each of the devices and offers the ease of controlling any device attached to the Interactive Cooktop.

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