WALRUS: A Retro Communication Gadget Based on Internet of Things Technologies

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Abstract - **In this work, a new system depending on a device that can encode and decode push-button signals, modulated using Morse code conventions, were developed to build a low-cost communication medium based on Internet of Things (IoT). The proposed system consists of two parts: a base station and handheld terminals. The base station is a single board computer with a web application based on Node.js. Handheld terminals are small battery powered devices, developed using MCU's, that can communicate with the base station over the wireless network. They can encode and decode Morse code, and convert to text or speech depending on the configuration of the terminal, which can be extended by using different add-ons, such as an OLED screen or a text to speech module. Communication between terminals is orchestrated by the base station using IoT Technologies like MQTT. The handheld terminals can be used by disabled people as a mean for private conversation, or a gadget for entertainment purposes. The system is an uncomplicated and low-cost communication medium and implemented to find alternative use cases for the IoT technologies.**

Keywords – **MQTT, Morse Code, Communication, Internet of Things**

I. INTRODUCTION

With the advancement in the era of the internet of things, every item can be connected over wireless technologies. Nowadays, IoT technologies are used in a wide range of application fields including home safety and remote monitoring, agriculture and animal husbandry (measurement of the temperature of the environment in animal farms, detection of unusual conditions), smart city applications (waste bins call for removal, parking spaces report free capacities) and communication (low-cost communication devices).

Internet of Things has three layers: perception layer, transport layer and application layer [1]. The perception layer is responsible for gathering data using wireless sensors. The transport layer integrates the collected data for the usage of upper layer. Finally, application layer offers services to the application or to the end-user for intelligent processing.

This paper applies IoT technologies to implement an efficient and low-cost communication medium. Current remote communication resources (telephone, computer, internet, etc.) are impractical for individuals with visual and hearing disabilities. It is very difficult for a sighted person to communicate with a hearing-impaired person. The purpose of our project is to solve the problem of communication between these individuals easier by using the IoT technologies.

We have developed a device capable of communicating via the Morse code. This is an effective communication method for solving the problem of communication between individuals with visual and hearing disabilities. Morse code [2, 3, 4] is a method of transmitting text information as a series of on-off tones, lights, or clicks that can be directly understood by a skilled listener or observer without special equipment.

The proposed system consists of two parts: a base station and handheld terminals. The base station is a single board computer with a web application based on Node.js. Handheld terminals are small battery powered devices, developed using MCU's, that can communicate with the base station over the wireless network. We used the MQTT protocol for data exchange on this system.

There are similar works in literature. For example, [5] implements a Morse code-based electronic lock using IoT technologies. The novel electronic lock can encode or decode optical signals, modulated using Morse code conventions. This work uses IoT technologies for building a smart home security system. Besides the convenience and cost reduction, the system provides a user-friendly interface for users of all ages.

[6] proposes a mobile solution for linguistic communication with deaf-blind people using Arduino and Android. They use an Arduino microcontroller connected to a vibrating micro-engine, command buttons and a Bluetooth module. The messages are sent/received via Bluetooth. At the end of the translation the user can read the message using the vibration of the Morse code. [6] allows any individual who has a mobile phone to communicate with a deaf-blind people.

On the contrary, we aim to make communication possible between two individuals with visual or hearing disabilities over an efficient, low cost and user-friendly medium. This system does not require users to have mobile phones or any other devices.

Next section describes the Morse code in detail. Section three introduces the WALRUS system and its functionality in detail. Section four presents the components of the system. Finally, section five concludes the paper with a brief talk about possible future work.

II. MORSE CODE

Morse code is a method for transmitting letters, numbers, and characters using standardized sequences of short and long signals called "dots" and "dashes", or "dits" and "dahs". Figure 1 shows the characters encoded by the International Morse Code.

Morse code was created by Samuel Morse in 1835 and started to be used in 1837. Morse code can be transmitted in various forms, such as by sounding, switching on and off the radio signals, the passing electric current through the wires, etc.

We used Morse code as a communication medium in our project Morse alphabet structure allows users to send a message with a single keystroke. All characters can be sent using a single key instead of using a keyboard. This is a more convenient way of communication for disabled users.

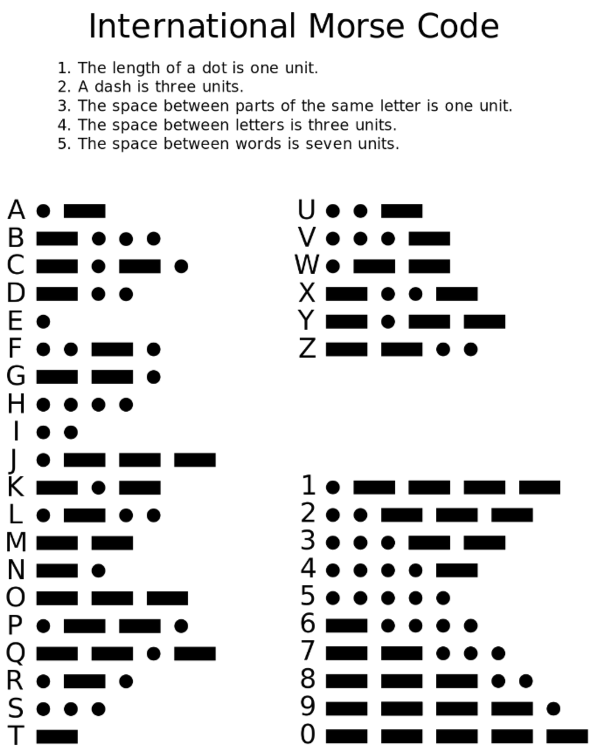

Figure 1: Characters encoded by the International Morse Code.

III. WALRUS SYSTEM

The proposed system, namely Walrus consists of two parts: a base station and handheld terminals (Figure 2).

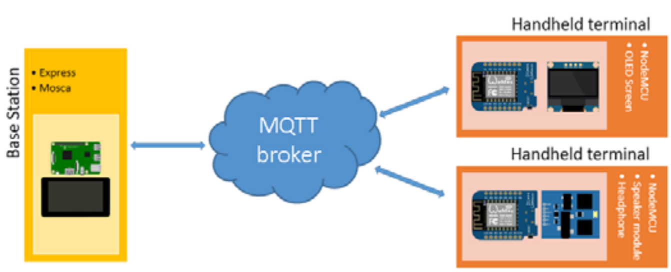

Figure 2: Architecture of the WALRUS system.

We used Raspberry Pi as a gateway in the implementation of the base station. Users connect Raspberry Pi to send their messages to recipients. Raspberry Pi is also used for managing and storing messages. We have two types of handheld terminals:

(a) Handheld terminal having a text to speech component for individuals with visual disability (Figure 3)

(b) Handheld terminal having an OLED screen component for individuals with hearing disability (Figure 4).

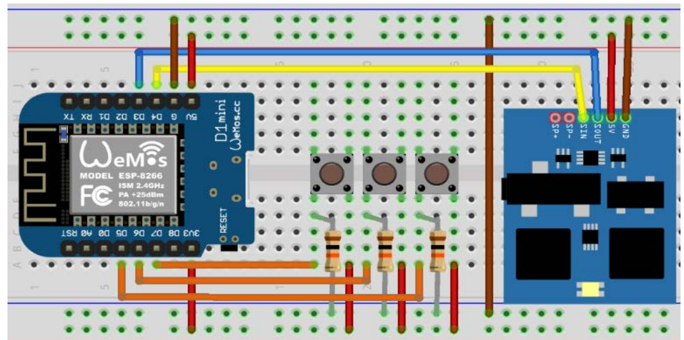

Figure 3: Handheld terminal having a text to speech component.

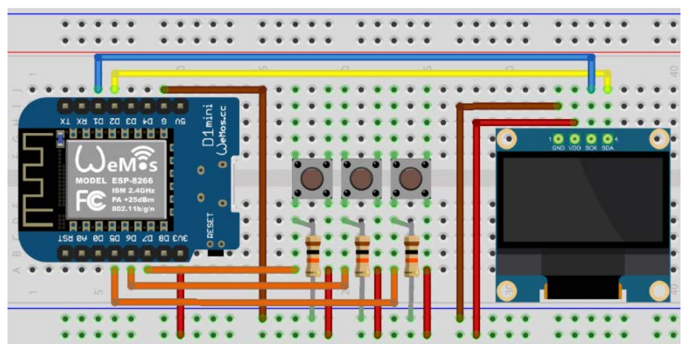

Figure 4: Handheld terminal having an OLED screen component.

The lifecycle of the system is based on four states:
State 1: Scanning and listing wireless networks
State 2: Connecting to a wireless network
State 3: Sending/Receiving messages
State 4: Defining the recipient

We define the encoding in Figure 5 for transitions between states and the encoding in Table 1 for functions in the states.

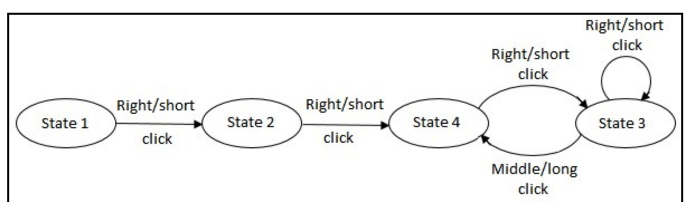

Figure 5: Encoding for the transitions between states.

According the Table 1, the functions of the buttons on the device depends on the state. In State 1 the left button allows scrolling down to switch between wireless network SSIDs. The middle button allows re-scanning of wireless networks. The right button is used to select the wireless network. Then the state is switched to State 2.

Table 1. Encoding for the functions in the states.

Short click				
	State 1	**State 2**	**State 3**	**State 4**
Left	Scroll Down	Morse Dot Input	Morse Dot Input	Scroll Down
Middle	Re-scan	Clear Password	Clear Screen	---
Right	Select	Send Encrypted Password	Send	Select Recipient
Long click				
	State 1	**State 2**	**State 3**	**State 4**
Left	Scroll Down	Morse Dash Input	Morse Dash Input	Scroll Down
Middle	Re-scan	Clear Password	State 4	---
Right	Select	Send Encrypted Password	Send	Select Recipient

In State 2, the left button has two different functions. In this state left button is used to enter the password. If you short click the left button, a short Morse signal is transmitted. If you long click the button, then a long Morse signal is transmitted. The middle button allows you to clear the wireless network password. Finally, the right button allows you to send the encrypted password. Then the state is switched to State 3 and State 4. The functions of these states are executed in parallel.

In State 3, you can send/receive messages. The system supports sending and receiving messages simultaneously. For selecting recipient user long clicks the middle button and switches to State 4. In State 4 the left button allows scrolling down to switch between recipients. The middle button has no function in State 4. Right button allows selecting the recipient and switching to State 3.

In State 3, left button is used to write a message. If you short click the left button, a short Morse signal is transmitted. If you long click the button, then a long Morse signal is transmitted. The right button is used to send the message. When you short click the middle button, then the screen is cleaned.

Figure 6 represents the flowchart of the WALRUS system. When the device is turned on by pressing the power button, The ESP module scans nearby wireless networks (State 1).

If a text-to-speech module is installed on the device, the SSIDs of wireless networks are read with the help of this module. If an OLED screen is installed on the device, the SSIDs of the wireless networks are written on the screen in Latin alphabet. User selects the network and switches to State 2. In State 2, user enters the password of the wireless network in Morse code and sends the password. Then the password is checked. If the password is not correct, the user is redirected to State 1. Otherwise, the state is switched to State 3 and State 4.

In State 4, a recipient is selected. If a text-to-speech module is installed on the device, recipients are read with the help of this module. If an OLED screen is installed on the device, the recipients are written on the screen. User selects the recipient and switches to State 3.

In State 3, the messages are send and received simultaneously. The message is entered using Morse code encoding. If the user wants to change the recipient, then he switches the State 4. The received messages are read or written depending on the module installed on the device.

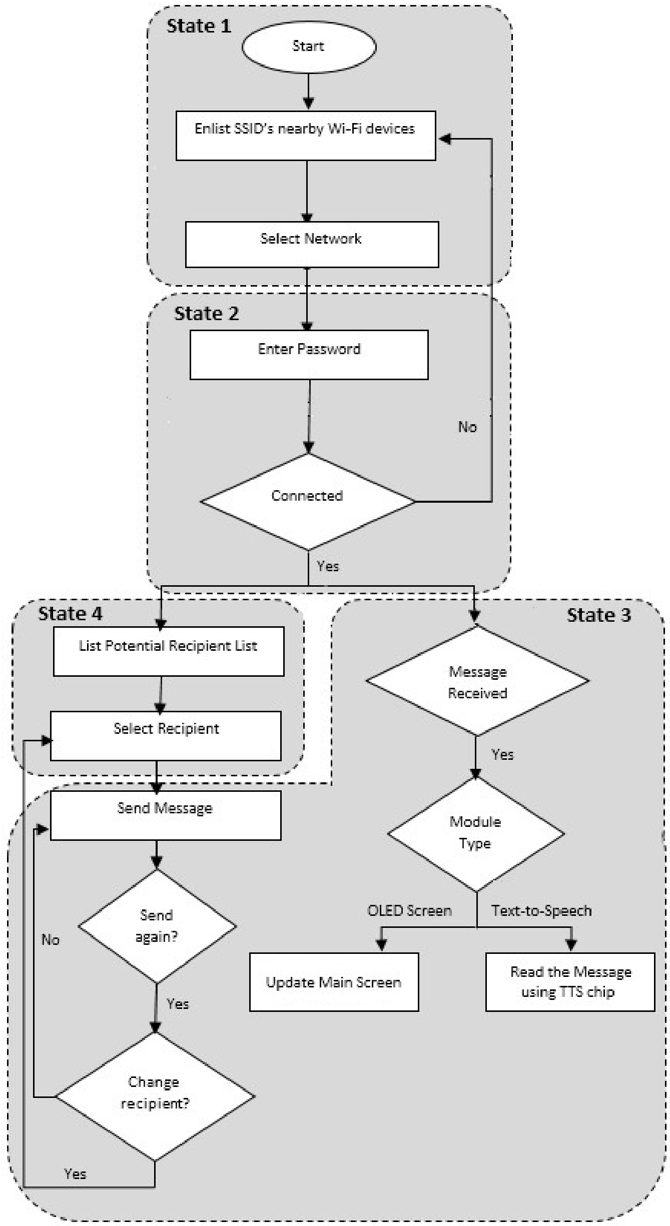

Figure 6: Flowchart of the WALRUS system.

IV. COMPONENTS OF THE SYSTEM

A. WeMos D1 Mini Pro

Wemos D1 Mini Pro (Figure 7) is a development card with an integrated ESP8266 module on it. It is designed for use in IoT projects. It provides eleven 3.3V I/O pins. A 5V output is also available.

The low cost WeMos D1 Mini Pro has a small footprint and supports the I2C protocol [7]. It has an external antenna connector on it, so an external antenna can be connected to increase the power of the device. For these reasons, it is frequently preferred in IoT projects.

The main reason for using the WeMos D1 Mini Pro in this project is that the text-to-speech module needs 5 volts to operate and Wemos D1 Mini Pro meets this requirement without an external power supply.

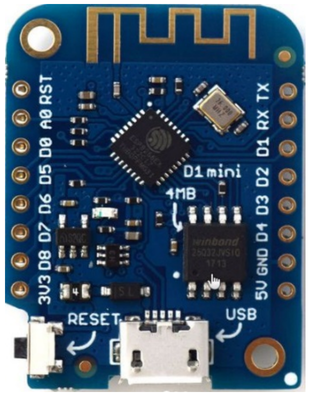

Figure 7. WeMos D1 Mini Pro module.

B. Emic-2 Text-to-speech Module

The Emic-2 text-to-speech module (Figure 8), which performs text-to-speech conversion, is used in the project with the aim of visually impaired users to listen to and control the messages they send.

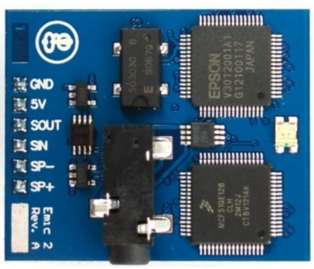

Figure 8. Emic-2 text-to-speech module.

C. I2C OLED Screen

OLED Screen module (Figure 9) is used in the project with the aim of hearing impaired users to write messages and read the incoming messages. The screen module supports I2C protocol therefore it can work with only two connections. In this case, the required I/O pin count is reduced.

Figure 9: OLED Screen.

D. MQTT

MQTT (Message Queuing Telemetry Transport) [8, 9, 10] is an ISO standard publish-subscribe-based messaging protocol. MQTT was invented in 1999 by Arlen Nipper. It is a low resource demanding protocol and it supports asynchronous operation and SSL/TLS security protocols.

MQTT is based on publish/subscribe method. The data is sent to the broker by the publisher, and the broker transmits this data to the subscriber. The MQTT broker uses topics to transmit the message to the relevant subscribers. The topic is a virtual channel that allows a publisher to connect to the relevant subscriber. Both the subject and the message are identified on the publisher side. This message is sent to the topic broker, and the broker redirects the message to the subscriber who subscribed to the topic.

In this project, handheld terminals are both MQTT publishers and subscribers. Each user has a unique topic. Thus, messages are sent only to relevant subscribers.

V. CONCLUSION

Using the internet of things technologies will change the communication between machines and even humans. We developed a new communication gadget by using open source software and hardware, using MQTT protocol for data exchange between the clients. The device is a user-friendly communication gadget, which can have exciting application areas such as lowering the communication barrier between disabled people. It is a modular device, which can be expanded with different output modules. An OLED Screen and a Text to Speech output modules are implemented during the project, but new output modules like Braille Displays will be implemented as a future work.

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