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ESPRESSIF ESP32 DEVELOPMENT BOARD IN WIFI STATION COMMUNICATION MODE

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Abstract: The purpose of this paper is to present the possibilities offered by the ESP-NOW communication protocol on the development board ESP32 from Espressif [1]. The main problem in data acquisition from different sensor nodes is the lack of access to a local wireless network (locations outside the urban environment, urban periphery...). ESP32 is dual core MCU with WiFi and Bluetooth built-in, 240MHz clock frequency with 512KB RAM, 36 pins with wide variety of available peripherals: ADCs, DACs, UART, SPI, I2C, CAN2.0, PWM with built-in hall effect sensor and built-in temperature sensor. On the market, one of the best development board based on ESP32 mcu is DOIT ESP32 DEVKIT V1.

Keywords: *Development board, MCU, ESP32, ESP-NOW, Measurement, Data acquisition.*

1. INTRODUCTION

Today's measuring and acquisition systems are in widespread use, for example measuring systems for process control in various production plants, measuring systems for measuring air quality, measuring systems for traffic management…Characteristic problem for all of them is the storage of the measured data, especially when there is a need for real time measurements and display data. Wireless communication offers almost unlimited possibilities for collecting measured data.

ESP-NOW is a connectionless Wi-Fi communication protocol that is defined by Espressif [1]. Application data in ESP-NOW is encapsulated in a specific action frame and then transmitted from one Wi-Fi device to another without connection. CTR with CBC-MAC Protocol (CCMP) is used to protect the action frame for security. ESP-NOW supports the following features [2]:

- Encrypted and unencrypted unicast communication,
- Mixed encrypted and unencrypted peer devices,
- Up to 250-byte payload can be carried,
- The sending callback function that can be set to inform the application layer of transmission success or failure.

ESP-NOW technology also has the following limitations:

- Broadcast is not supported,

- Limited encrypted peers. 10 encrypted peers at the most are supported in Station mode; 6 at the most in SoftAP or SoftAP + Station mode. Multiple unencrypted peers are supported, however, their total number should be less than 20, including encrypted peers,
- Payload is limited to 250 bytes.

The default ESP-NOW bit rate is 1 Mbps. The format of the vendor-specific action frame is as follows:

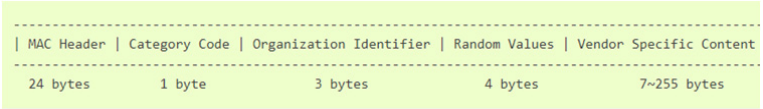

Fig.1: Format of the specific action frame

- Category Code: The Category Code field is set to the value (127) indicating the vendor-specific category.
- Organization Identifier: The Organization Identifier contains a unique identifier (0x18fe34), which is the first three bytes of MAC address applied by Espressif.
- Random Value: The Random Value filed is used to prevents relay attacks.
- Vendor Specific Content: The Vendor Specific Content contains vendor-specific fields as follows:

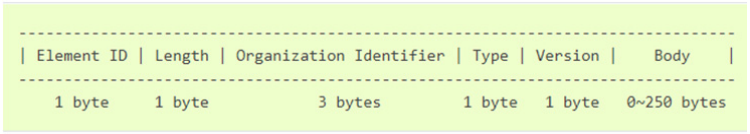

Fig.2: Vendor-specific fields

- Element ID: The Element ID field is set to the value (221), indicating the vendor-specific element.
- Length: The length is the total length of Organization Identifier, Type, Version and Body.
- Organization Identifier: The Organization Identifier contains a unique identifier(0x18fe34), which is the first three bytes of MAC address applied by Espressif.
- Type: The Type field is set to the value (4) indicating ESP-NOW.
- Version: The Version field is set to the version of ESP-NOW.
- Body: The Body contains the ESP-NOW data.

As ESP-NOW is connectionless, the MAC header is a little different from that of standard frames. The FromDS and ToDS bits of FrameControl field are both 0. The first address field is set to the destination address. The second address field is set to the source address. The third address field is set to broadcast address (0xff:0xff:0xff:0xff:0xff:0xff). ESP-NOW uses the CCMP method, which is described in IEEE Std. 802.11-2012, to protect the vendor-

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specific action frame. The Wi-Fi device maintains a Primary Master Key (PMK) and several Local Master Keys (LMK). The lengths of both PMK and LMk are 16 bytes.

2. PRESENTING THE METHOD AND POSSIBILITIES

ESP-NOW allows to exchange data between several ESP32 boards programmed with Arduono IDE. Multiple devices can tock to each other in an easy way.

Fig.3: ESP-NOW one-way communication protocol [3]

After pairing a device with each other, the connection is persistent. It very important to know, if suddenly one of your boards loses power or resets, when it restarts, it will automatically connect to its peer to continue the communication.

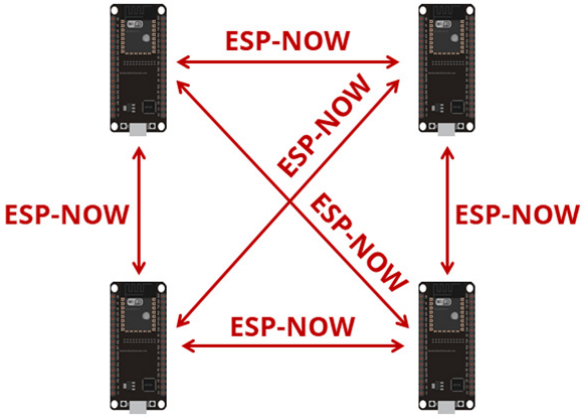

Fig.4: ESP-NOW two-way communication protocol [3]

In order to be able to communicate between multiple ESP32 via ESP-NOW, it is essential to know the ESP32 receiver MAC address. In this way it is determined which ESP32 node will receive the data. Each ESP32 board has unique MAC address.
Sender sketch must include:

- Initialize ESP-NOW;
- Register a callback function upon sending data;
- Add a peer device (the receiver with MAC address);

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- Send a message to the peer device.

Receiver sketch must include:

- Initialize ESP-NOW;
- Register for a receive callback function;
- Inside that callback function save the message into a variable to execute any task with that information.

In our case, we test communication range between two ESP32 boards, and we have stable communication up to 190 meters in open field.

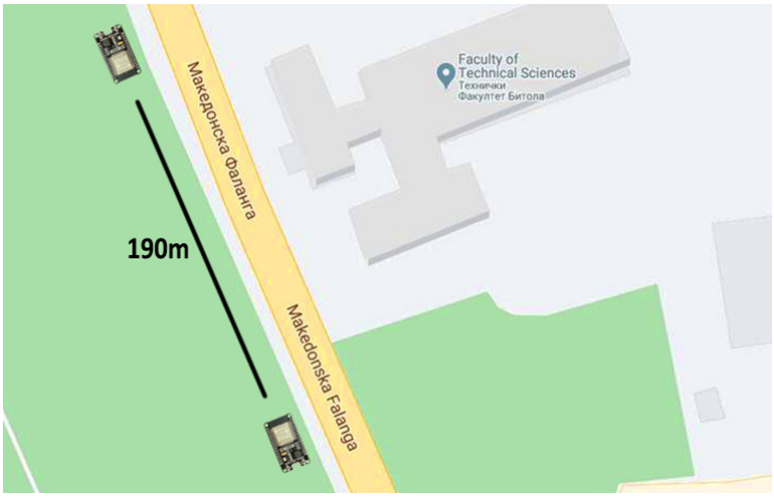

Fig.5: ESP-NOW communication range

3. EXPERIMENTAL PART

In our case, it has been tested ESP-NOW one-way communication protocol between two senders and one receiver ESP32 boards. Each sender has a combined sensor for measuring temperature and relative humidity based on AM2301.

Fig.6: AM2301 temp/hum sensor

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In order to be able to communicate between multiple ESP32 via ESP-NOW, it is essential to know the ESP32 receiver MAC address.

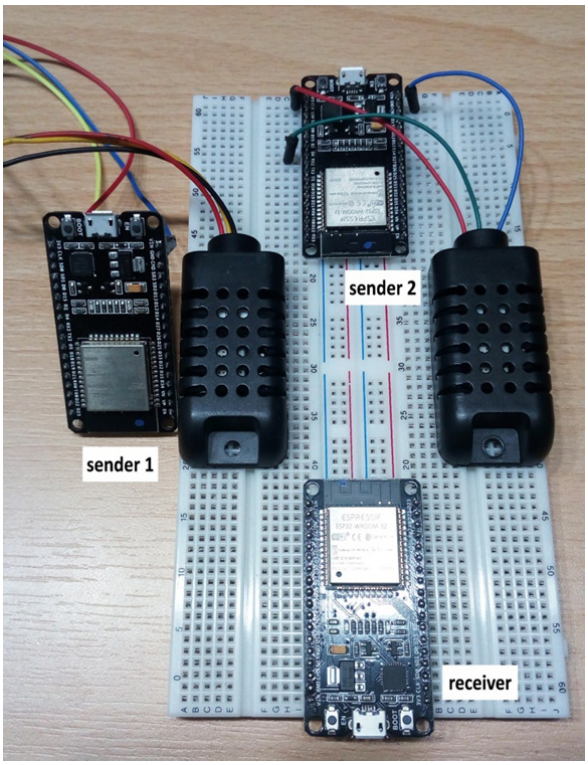

Fig.7: Two senders and on receiver ESP32 boards in one-way ESP-NOW comm. protocol

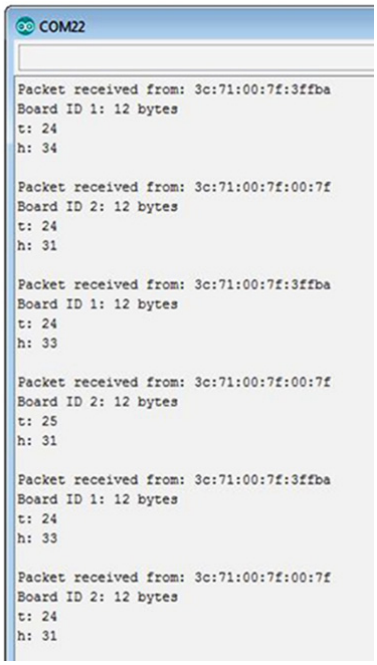

Fig.8: Arduino IDE serial monitor from receiver ESP32 board

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4. CONCLUSION

This communication protocol ESP-NOW from Espressif will greatly alleviate the problems of retrieving the measured data from sensor nodes placed in environments where there is no possibility to connect to a local wireless network. Robust design, ultra-low power consuptation, high level of integration and hibrid wifi and bluetooth chip on ESP32 MCU are ideal features of a platform for solving complex problems in real measurement systems and data acquisition from sensor node groups.

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