Analysis of Animals Health Condition after Post-Surgery using LoRa Communication

Vishal G Hegade[1] Vishwas V[2] Yadhu Krishna[3] Reon Menezes[4], Padma C R[5]

[1,2,3,4] *Student, BE, Department of Medical Electronics, DSCE Bangalore, India*

[1]hegadevishal28@gmail.com

[2]vishwasv278@gmail.com

[3]yadhuhere77@gmail.com

[4] reonmenezes@gmail.com

[5]*Assistant professor, Department of Medical Electronics, DSCE Bangalore, India*

[5] padma-mirc@dayanandasagar.edu

Abstract - In recent years, animal husbandry in the world has developed rapidly. However, due to poor network environment in pastoral areas, IoT technology is difficult to apply. Due to the lack of effective supervision, livestock suffer from varying degrees of health problems. This has seriously affected the development of animal husbandry. The emergence of low power, long-distance Internet of Things technologies, represented by Lora, has made it possible to establish a Realtime monitoring system for the behavior of livestock. This system includes nodes, gateways, and servers, and is based on LoRaWAN. These nodes take the SX1278 as the core and integrate the STM32L151 low-power controller, GPS, and accelerometer. The system is tested and analyzed. The experimental results show that the scheme has the characteristics of long communication distance, low power consumption, convenient networking, and good real-time performance. It has a wide range of application prospects.

I. INTRODUCTION

Monitoring of the animals in the field requires man power. Previous technologies available for monitoring the animals are high cost and less operating distance. In our proposed system we are overcoming those disadvantages by implementing LoRa technology. Lora is a 'Long Range' low power wireless standard intended for providing a cellular style low data rate communications network. Aimed at the M2M and IoT market, LoRa is ideal for providing intermittent low data rate connectivity over significant distances. The radio interface has been designed to enable extremely low signal levels to be received, and as a result even low power transmissions can be received at significant ranges.

II. BLOCK DIAGRAM

The sensors are attached to the collar of the animals. These sensors collect accelerometer, Pedometer data and heart rate of the animal is collected by non-invasive method using oximeter and microcontroller. The microcontroller then sends the collected data to the receiver side using LoRa Transmitter. The Lora transmitter has ability to transfer the data to long distance by consuming very low power. When there are vital changes in the sensor data is observed it sends the alert messages to the Receiver side

On the receiver side LoRa receiver receives the data from the transmitter and then process the data using microcontroller and displays the data on the OLED display locally, when there is a alert message it turns on the buzzer and alerts the user. The data can be stored on the SD Card memory locally for future references.

The processed data then transmitted to cloud server using LoRaWAN Gateway. The gateway sends all the data to cloud server using MQTT Protocols, the cloud severs stores the data in the form csv and then transfers the all the details received to android application. On the android application, Sensors data are displayed along with the geo locations of the animal and condition of the animal.

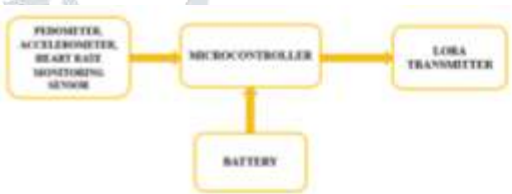

Fig (1) Transmitter Section

Fig (2) Receiver Section

III. IMPLEMENTATION

A. Software Implementation

(i). STM CUBE - STM32CubeMX is a graphical tool that allows a very easy configuration of STM32 microcontrollers and microprocessors, as well as the generation of the corresponding initialization C code for the Arm® Cortex®-M core or a partial Linux® Device Tree for Arm® Cortex®-A core), through a step-by-step process.

The first step consists in selecting either: an STMicrolectronics STM32 microcontroller, microprocessor or a development platform, which matches the required set of peripherals, or an example running on a specific development platform.

For microprocessors, the second step allows to configure the GPIOs and the clock setup for the whole system, and to interactively assign peripherals either to the Arm® Cortex®-M or to the Cortex A world. Specific utilities, such as DDR configuration and tuning, make it easy to get started with STM32 microprocessors .For Cortex®-M core, the configuration includes additional steps that are exactly similar to those described for microcontrollers.

For microcontrollers and microprocessor Arm® Cortex®-M, the second step consists in configuring each required embedded software thanks to a pinout-conflict solver, a clock-tree setting helper, a power-consumption calculator, and an utility that configures the peripherals (such as GPIO or USART) and the middleware stacks (such as USB or TCP/IP). The default software and middleware stacks can be extended thanks to enhanced STM32Cube Expansion Packages. STMicrolectronics or STMicrolectronics' partner packages can be downloaded directly from a dedicated package manager available within STM32CubeMX, while the other packages can be installed from a local drive. Moreover, a unique utility in STM32CubeMX delivery, STM32PackCreator, will help developers to build their own enhanced STM32Cube Expansion Packages. Eventually the user launches the generation that matches the selected configuration choices. This step provides the initialization C code for the Arm® Cortex®-M, ready to be used within several development environments, or a partial Linux® device tree for the Arm® Cortex®-A.

STM32CubeMX is delivered within STM32Cube.

(ii). MBED OS - Mbed OS provides the Mbed C/C++ software platform and tools for creating microcontroller firmware that runs on IoT devices. It consists of the core libraries that provide the microcontroller peripheral drivers, networking, RTOS and runtime environment, build tools and test and debug scripts.

These connections can be secured by compatible SSL/TLS libraries such as Mbed TLS or wolfSSL, which supports mbed-rtos.

A components database provides driver libraries for components and services that can be connected to the microcontrollers to build a final product.

Mbed is a platform and operating system for internet-connected devices based on 32-bit ARM Cortex-M microcontrollers. Such devices are also known as Internet of Things devices. The project is collaboratively developed by Arm and its technology partners.

Applications for the Mbed platform can be developed using the Mbed online IDE, a free online code editor and compiler. Only a web browser needs to be installed on the local PC, since a project is compiled on the cloud, i.e. on a remote server, using the ARMCC C/C++ compiler. The Mbed IDE provides private workspaces with ability to import, export, and share code with distributed Mercurial version control, and it can be used also for code documentation generation. Applications can be developed also with other development environments such as Keil µVision, IAR Embedded Workbench, and Eclipse with GCC ARM Embedded tools.

B. Hardware Implementation

(i). LoRa

Fig (C) LoRa Module

This LoRa 433MHz module designed by AI-THINKER, which based on the chip SX1278. The SX1278 RF module is mainly used for long-range spread spectrum communication. It can resist Minimize current consumption. Thanks to SEMTECH's patented Lora modulation technology, the SX1278 has a high sensitivity of -148 dBm with a power output of +20 dBm, a long transmission distance and high reliability. At the same time, compared with the traditional modulation technology, LoRa Modulation technology in anti-blocking and selection also has obvious advantages, to solve the traditional design cannot take into account the distance, interference and power consumption.

Features:

- LoRaTM spread spectrum communication
- +18dBm – 10mW. Stable RF output power when the input voltage changed
- Half-duplex SPI communication
- Programmable bit rate can reach to 300kbps
- Support FSK, GFSK, MSK, GMSK, LoRaTM and OOK Modulation Mode
- 127dB RSSI wave range.
- Automatically detect RF signal, CAD mode, and super high-speed AFC
- With CRC 256 bytes data engine.

(ii). Pedometer Sensor

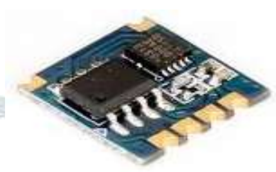

Fig (D) Pedometer Sensor

Pedometer consists of a 3 axes acceleration sensor (MEMS G sensor) and a low power high performance MCU. The MCU analyses the sensor data originated from physical movements. When there is a walking step or running step, the DSPX01 module will output the step information in the form of a high-level pulse so it is very easy to use. The output pulse width is 50ms in high level. In motionless status the output of DSPX01 module is low level. DSPX01 module can enter sleep mode by setting CS pin to low in order to save power consumption. This module works at 2.5~3.3V with extra low power consumption. Because of its compact size, DSPX01 module can be embedded into mini sports products such as Strip pedometer, Sports shoes, etc. Because the movements of human beings are different from animals and the forces in different parts of body are also different.

Features:

- Pulse output
- Counting Accuracy: ±3%
- Working current: <60uA
- Standby current: <5uA
- Supply voltage: 2.5~3.3V
- Working Temp: -10~+55°C

(iii). Accelerometer Sensor

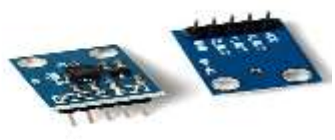

Fig (E) Accelerometer Sensor

The ADXL335 is a small, thin, low power, a complete 3-axis accelerometer with signal conditioned voltage outputs. The ADXL335 Module 3-axis Analog Output Accelerometer measures acceleration with a minimum full-scale range of ±3 g. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. This breakout board comes with an onboard voltage regulator and works at both 3.3V & 5V (3-5V).An accelerometer is an electro-mechanical device that will measure acceleration forces. These forces may be static, like the constant force of gravity pulling at your feet, or they could be dynamic – caused by moving or vibrating the accelerometer.

Applications:

- FPV, RC and Robots systems
- GPS navigation systems
- Impact recognition and logging
- Gaming and virtual reality input devices
- Motion-activated functions
- Intelligent power saving for handheld devices
- Vibration monitoring and compensation
- Free-fall detection
- 6D-orientation detection

(iv). Microcontroller

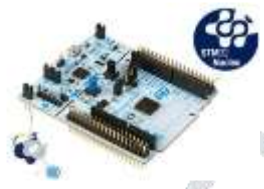

Fig (F) Microcontroller

The STM32 Nucleo-64 boards provide an affordable and flexible way for users to try out new concepts and build prototypes by choosing from the various combinations of performance and power consumption features, provided by the STM32 microcontroller. The V3 connectivity support and the ST morpho headers allow the easy expansion of the functionality of the STM32 Nucleo open development platform with a wide choice of specialized shields.
The STM32 Nucleo-64 board does not require any separate probe as it integrates the ST-LINK debugger/programmer.

Microcontroller features

- Core: Arm® 32-bit Cortex®-M0+ CPU, frequency up to 64 MHz
- -40°C to 85°C/125°C operating temperature
- Memories
  - Up to 128 Kbytes of Flash memory
  - 36 Kbytes of SRAM (32 Kbytes with HW parity check)
- CRC calculation unit
- Reset and power management
  - Voltage range: 1.7 V to 3.6 V
  - Power-on/Power-down reset (POR/PDR)
  - Programmable Brownout reset (BOR)
  - Programmable voltage detector (PVD)
  - Low-power modes:Sleep, Stop, Standby, Shutdown
  - VBAT supply for RTC and backup registers
- Clock management
  - 4 to 48 MHz crystal oscillator
  - 32 kHz crystal oscillator with calibration
  - Internal 16 MHz RC with PLL option (±1 %)
  - Internal 32 kHz RC oscillator (±5 %)
- Up to 60 fast I/Os
  - All mappable on external interrupt vectors
  - Multiple 5 V-tolerant I/Os
- 7-channel DMA controller with flexible mapping
- 12-bit, 0.4 µs ADC (up to 16 ext. channels)
  - Up to 16-bit with hardware oversampling
  - Conversion range: 0 to 3.6V
- Two 12-bit DACs, low-power sample-and-hold
- Two fast low-power analog comparators, with programmable input and output, rail-to-rail
- 14 timers (two 128 MHz capable): 16-bit for advanced motor control, one 32-bit and five 16-bit general-purpose, two basic 16-bit, two low-power 16-bit, two watchdogs, SysTick timer
- Calendar RTC with alarm and periodic wakeup from Stop/Standby/Shutdown
- Communication interfaces
  - Two I2C-bus interfaces supporting Fast-mode Plus (1 Mbit/s) with extra current sink, one supporting SMBus/PMBus and wakeup from Stop mode
  - Four USARTs with master/slave synchronous SPI; two supporting ISO7816 interface, LIN, IrDA capability, auto baud rate detection and wakeup feature
  - Low-power UART
  - Two SPIs (32 Mbit/s) with 4- to 16-bit programmable bitframe, one multiplexed with I2S interface
  - HDMI CEC interface, wakeup on header reception
- USB Type-C™ Power Delivery controller
- Development support: serial wire debug (SWD)

(v). Heart-Rate Sensor

The MAX86170B is an ultra-low-power optical data acquisition system with both transmit and receive channels. On the transmitter side, the MAX86170B has four LED driver output pins, programmable from three high-current, 8-bit LED drivers. On the receiver side, MAX86170B has a low noise charge integrating front-end that includes a 20-bit ADC and best-in-class ambient light cancellation (ALC) circuit, producing the highest performing integrated optical data acquisition system.

Applications

- Wearable Devices for Wellness, and Medical Applications
- Clinical Accuracy
- Optimized Performance to Detect:
- Optical Heart Rate
- Heart Rate Variability
- Body Hydration
- Muscle and Tissue Oxygen Saturation

IV. RESULTS

The animal heart rate, status of the body condition can be view on the LCD display and Android app, along with the animal walking speed and force applied by the animal to move from one place to another.

Fig (3) Output on LCD

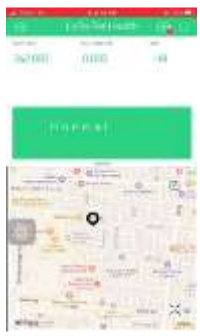

Fig (4) Reading on app

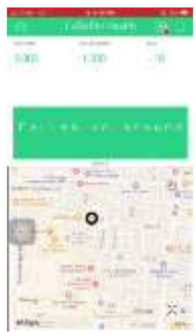

Fig (5) Fall Detection

V. DISCUSSION AND CONCLUSION

All existing system uses high cost, low efficiency data transmission techniques with less operating distance. Existing system requires internet to transmit and receive the data. The system we introducing Lora requires only receiver and transmitter to send and receive the data over a long Range. Using accelerometer sensor and pedometer sensor and heart rate Oximeter sensor we will get information and it will display on LCD and data can be stored on the SD Card memory locally for future references. And we are using Android application to get information to monitoring the health of animal.

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