Energy-Efficient Localization and Tracking of Mobile Devices in Wireless Sensor Networks

1. **DONTHARAPALLI ANUSHA** ,M.Tech , Deportment of embedded systems, Geethanjali college of engineering and technology (UGC Autonomous), cheeryal (V) ,keesara(M),Medchal district, Hyderabad, Telangana , India,

2. **M.Laxmi** ,Associate professor, Geethanjali college of engineering and technology (UGC Autonomous) ,cheeryal (V),Keesara (M),Medchal district , Telangana.

Abstract

The energy-efficient tracking and precise localization of continuous objects have long been key issues in research on wireless sensor networks (WSNs).Wireless sensor networks (WSNs) are effective for locating and tracking people and objects in various industrial environments. Since energy consumption is critical to prolonging the lifespan of WSNs, we propose an energy-efficient LOcalization and Tracking (eLOT) system, using low-cost and portable hardware to enable highly accurate tracking of targets. Various fingerprint based approaches for localization and tracking are implemented in eLOT. To achieve high energy efficiency, a network-level scheme coordinating collision and interference is proposed. On the other hand, based on the location information, mobile devices in eLOT can quickly associate with the specific channel in a given area, while saving energy by avoiding unnecessary transmission. Finally, a platform based on TI CC2530 and the Linux operating system is built to demonstrate the effectiveness of our proposed scheme in terms of localization accuracy and energy efficiency. Using temperature sensor, MEMS sensor to detect the temperature and tilt values and these values are display on LCD screen.

Keywords: ARDUINO Microcontroller. CC2530 module, MEMS, Temperature sensor, LCD module.

1. Introduction

Location-based wireless networks are considered as one of the main technological innovations in current industrial services, which can provide high reliability and efficiency through accurately locating and tracking people and objects. For example, there are numerous applications of location-based services (LBSs) in hospitals and retail outlets, which help staff and administrators better deliver care and manage costs . The ability of tracking the location of a subject in real time gives human operators the ability to effectively manage situations, tackle safety problems, increase efficiency, and thereby reduce costs while improving outcomes.

Traditional localization and tracking techniques such as GPS, cellular and Wi-Fi do not work well in many scenarios, such as high rises, underground, or disaster zones where signals from mobile infrastructure or satellites cannot be received. Neither their accuracy nor the physical size meets the demand of recent industrial applications, which aim to be highly precise in all environments even with devices of tiny sizes. Meanwhile, wireless sensor networks (WSNs) have gained much attention recently, and been in widespread use in various industrial applications.

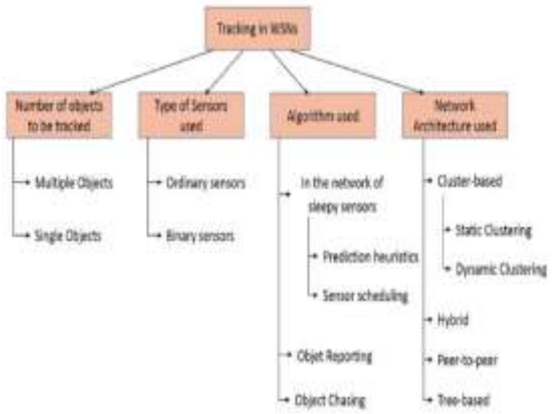
Usually a mobile node associated to an object in a WSN is a small device powered by battery with a limited energy budget. The battery is often disposable and inconvenient for replacement. Meanwhile, it is expected to work normally for a long enough lifetime, e.g., several months or even years. Therefore, energy-efficient techniques to reduce energy consumption are essential for wireless positioning and tracking systems.

In this paper, we develop an energy-efficient LOcalization and Tracking (eLOT) system, which uses low-cost, portable hardware to enable highly accurate tracking of targets. Then, avoiding unnecessary transmission can save the energy consumption of mobile nodes. Moreover, we implement a demonstration platform based on TI CC2530 chips for indoor and outdoor positioning and energy consumption.

2. Literature Survey

[1] Due to its importance for application domains in the sensor community, the object tracking and localization technique has attracted the interest of many researchers Existing research on object

tracking techniques and algorithms can be visualized in the taxonomy shown in Fig.



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[2] In regard to sensor collaboration with an energy-efficient mechanism, dynamic clustering-based algorithms are proposed. Among them,

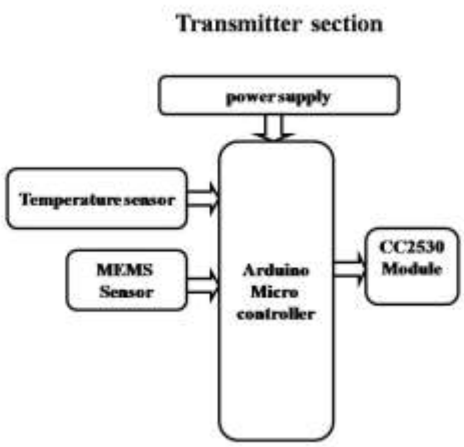
Yang *et al.* presented an Adaptive Dynamic Cluster-based Tracking protocol to select on-demand basis cluster heads. Wake up nodes and clusters form through a prediction-based algorithm during object moving throughout the network.

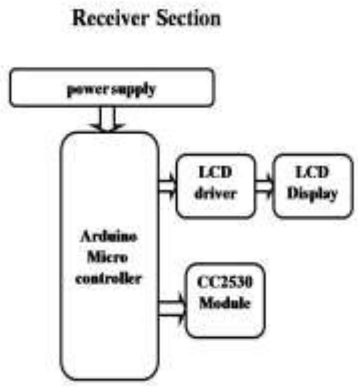
Rad *et al.* and Islam

researched the balance between energy consumption and the missing rate through his dynamic clustering mechanism.

Medeiros *et al*. Implemented an efficient dynamic clustering algorithm to work on camera networks for object tracking. Considering the holes phenomenon with a data structure, a Continuous Object Detection and tracking algorithm was proposed to reduce the communication cost in WSNs.

3. Implementation:





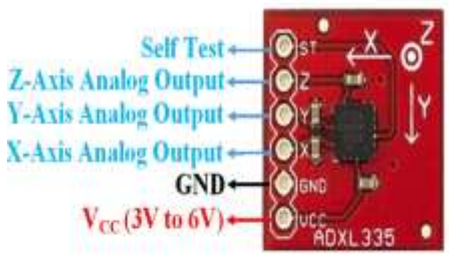
In this project we implement above system using Arduino Uno and CC2530 modules. We have one transmitter section and one receiver section. In transmitter section we are using temperature sensor, MEMS sensor to detect the temperature and tilt values and these values are display on LCD screen. Also CC2530 will sends the signals periodically in-order to improve the energy efficiency, this particular signal with received by the CC2530, which is connected at receiver end. In order to localize the transmitter we have two possible solutions which we discussed above, i.e., deterministic and probabilistic. Here we are going to implement deterministic matching schemes. Based on the received signal strength by arduino, between the real-time values and those stored in the database will localize the transmitter with approximate location name on LCD screen.

4. Related Work:

The brief introduction of different modules used in this project is discussed below:

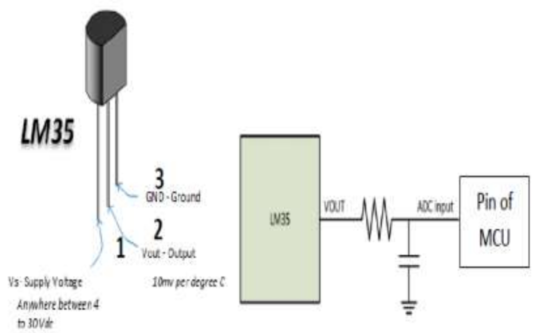
ARDUINO UNO:

The **Arduino Uno** is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.



Temperature sensor:

The most widely measured physical parameter is body temperature; it can be calculated by putting the sensor in contact with human body. The sensor used in this project is an LM35 temperature sensor. LM35 is a precision IC temperature sensor with its output proportional to the temperature (in ℃). The LM35 sensor has more features that attracted us to choose it, such as Calibrated directly in Celsius (Centigrade), Linear + 10-mV/°C scale factor; it measures temperatures from -55°C to +150°C range, the accuracy ±0.5°C.



MEMS:

ADXL335 Accelerometer module consists of six pins i.e. VCC, GND, X, Y, Z, and ST. Using the Accelerometer module with a microcontroller is very easy. Connect VCC and GND pins to 5V and GND pins of Microcontroller. Also connect X, Y, and Z pins to the Analog pins of Arduino. The basic structure of the accelerometer consists of fixed plates and moving plates. When the acceleration is applied on an axis capacitance between fixed plates and moving plates is changed. This results in a sensor output voltage amplitude which is proportional to the acceleration.

CC2530 MODULE:

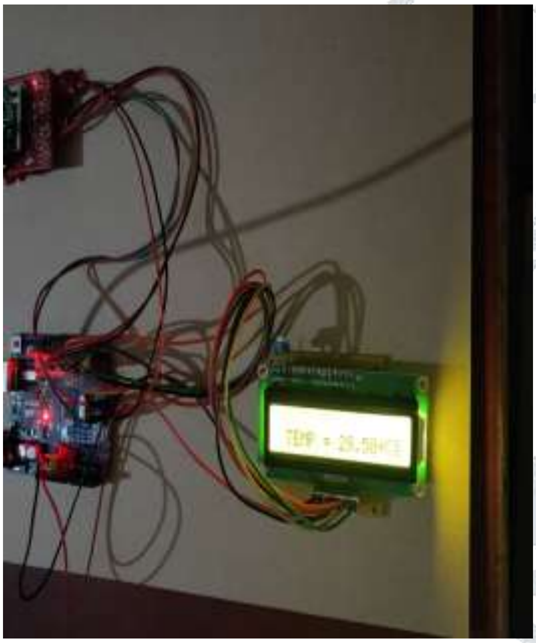
This module is the best way to establish wireless network connection and UART Zigbee wireless data connection which is fully compatible with DRF1605H pin up to 1.6 km transmission distance.

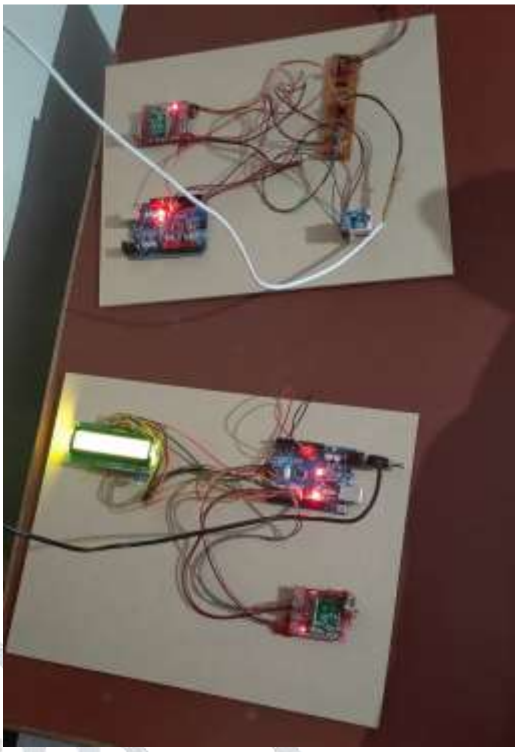
CC2530 is chosen to be the core chipset to implement the wireless communications module on a self-designed PCB. It is TI's second generation ZigBee/ IEEE 802.15.4 RF Systemon-Chip (SoC) for the 2.4 GHz unlicensed ISM band [33]. We only use 16 channels at 2.4 GHz in eLOT, i.e., from Channel 11 to Channel 26, as defined in IEEE 802.15.4 [34]. This chip enables industrial grade applications by offering good selectivity/co-existence, excellent link budget, and low voltage operation. It enables robust network nodes to be built with very low total bill-of-material costs. CC2530 combines the excellent performance of a leading RF transceiver with an industry-standard enhanced 8051 MCU, in-system. programmable flash memory, 8-KB RAM, and many other powerful features. CC2530 can be equipped with TI standard compatibility or a proprietary network protocol stack, e.g., ZStack and SimpliciTI, to streamline the development process. However, the output power of the RF transmitter of CC2530 is only 4.5 dBm with a receiver sensitivity of -97 dBm. Thus it is unable to satisfy the requirements of localization applications.

LCD (LIQUID CRYSTAL DISPLAY) :

One of the most common devices attached to a micro controller is an 16x2 LCD display. This means 16 characters per line by 2 lines and 20 characters per line by 2 lines, respectively. The project status will display on LCD.

4. RESULTS:





5. CONCLUSION:

We developed a CC2530-based localization and tracking system, which is applicable in ubiquitous environments including both indoor and outdoor. In order to well balance localization accuracy and energy efficiency, new designs at both the network and mobile nodes were implemented in the proposed system, where the mobile nodes can have quick access to the network and be located by the network with minimum energy consumption. The results have demonstrated that eLOT is energy efficient and effective in accurately estimating target positions with the unified method. In our future work, we plan to enlarge the network size of eLOT to include multiple buildings as well as roads.

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