Comparative Study and Performance Evolution of Wireless Data Transmission Techniques for an Integrated Bathymetry Survey for Reservoir

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ABSTRACT
Integrated bathymetry survey is only available technique to ascertain the capacity and the life of the reservoir. As the existing data collection process faces challenges regarding data logging in terms of equipment and its security a wireless data logging technology have been studied and its advantage over the existing system is proposed in this paper. This paper presents a description of the existing wireless technologies and tries to compare them with respect to which technology provides a better solution to build a wireless access infrastructure for the above said case study. One of the popular case study describing wireless communication standards and line coding techniques evaluating their main features and behaviours in terms of various metrics including the transmission time, complexity, and power consumption have been described. It is believed that the comparison presented in this paper would benefit the engineers in selecting an appropriate protocol for the Bathymetry survey application.

Keywords
Wireless Data Transmission, Zigbee, Line Coding Techniques

1. INTRODUCTION
Ministry of Water Resources has been working in the bathymetry survey activities for the last two decades. Traditionally a laptop is used for this activity in a survey boat. However the laptop is exposed to heat, wind, water, vibration etc and hence it fails on several occasions during survey, which results in huge loss to data and efforts. To overcome this problem, an indigenous hardware with the capability to log GPS data in NMEA format as well as depth in

DESO25 has been developed. This hardware will supersede the laptop by removing the hardware lock which is required for the commercial software to log the data as well as exclude the need of laptop on the survey boat. The logged data will be simultaneously transmitted from the boat to the control room via a proper wireless transmission protocol.

Wireless scene is currently held by few protocols: Bluetooth, ZigBee, Wi-Fi and RF (high data rate transceiver) which are corresponding to the IEEE 802.15.1, 802.15.4, and 802.11a/b/g standards, respectively. Section II briefly introduces the above wireless protocols. Section III gives a brief overview of the various line coding techniques that can be applied to the selected wireless protocol suited for bathymetry. This paper draws a conclusion regarding which one of the wireless protocols is superior since the suitability of network protocols is greatly influenced by practical applications [1].

2. WIRELESS PROTOCOLS
2.1 Bluetooth
Bluetooth or the IEEE 802.15.1 normal, is predicated on a wireless radio system. It has been designed for short-range and low-cost devices for replacing cables for pc peripherals [2]. Bluetooth operates based on the features of Adaptive Frequency Hopping (AFH) and Forward Error Correction (FEC). It operates in the 2.4 GHz frequency band and the devices within 10m of each other can share the data up to 720Kbps of capacity. This technology is also an authenticated one by sending the acknowledgement from the receiver to the transmitter before making the connection between devices. But its limitation is that upto eight devices can communicate in a single network and it asks the confirmation about receiving each data every time and also it limits the packet size [3]. Two connectivity topologies are defined in Bluetooth: the piconet and scatternet.

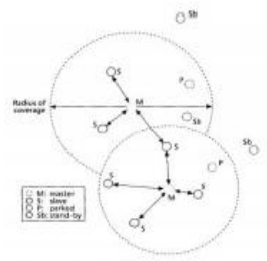
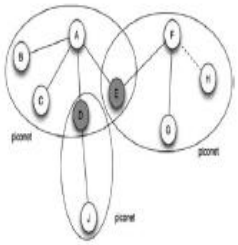


Fig1. Piconet



Scatternet

2.2 Zigbee
ZigBee or the IEEE 802.15.4 standard is an established set of specifications for wireless personal area networking (WPAN). The ZigBee standard provides network, security, and application support services operating on top of the IEEE 802.15.4 Medium Access Control (MAC) and Physical Layer (PHY) wireless standard [4]. ZigBee offers three operational frequency bands: 2.4 GHz, 915 MHz and 868 MHz. There is a single channel between 868 and 868.6 MHz, 10 channels between 902 and 928 MHz, and 16 channels between 2.4 and 2.4835 GHz. The data rates are 250 kbps at 2.4 GHz, 40 kbps at 915 MHZ and 20 kbps at 868 MHz. Lower frequencies are more suitable for longer transmission ranges due to lower propagation losses. However, the advantage of high data rate transmission is the provision of higher throughput, lower latency or lower duty cycles. All these frequency bands are based on the Direct Sequence Spread Spectrum (DSSS) spreading technique [5].

The specified maximum range of operation for ZigBee devices is 250 feet (76m) ZigBee incorporates power saving mechanisms for all device classes. Discovery and pairing Mechanism is with full application confirmation[6].

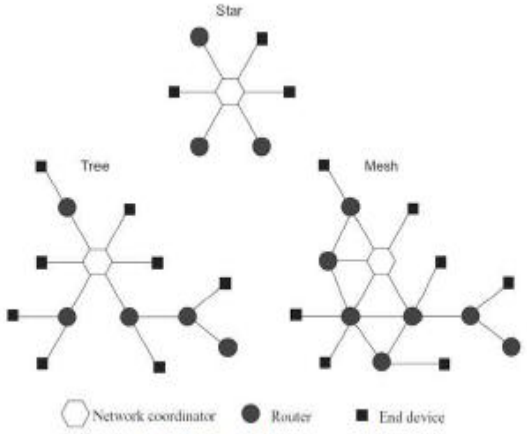


Fig2.ZigBee topologies

2.3 Wi-Fi

Wi-Fi is based on the IEEE 802.11 wireless local area network (WLAN) specification. The main goal of Wi-Fi technology is to provide service for mobile computing device like laptop. WiFi provides the highest transmission rate among standard wireless networking technologies and reduces the costs of network deployment and expansion.The transmission range of a typical WiFi device is up to 100m but its exact transmission range varies. Wifi operates in unlicensed bands at 2.4GHz and 5 GHz, where the exact available operation bands vary according to country. Due to the complex nature of radio propagation at typical Wi-Fi frequencies Mobility over wider ranges is limited. [7].

WiFi allows for both "Infrastructure" mode and "adhoc" mode of operation. A wireless access point is required for infrastructure mode operation to bridge wireless subnetwork to Internet or enable communication among wireless client stations (STA). In comparison, ad hoc mode is a method for wireless clients to directly communicate with each other. [8].

Each standard also use different types of radio-modulation technology, which is as follows:

- The 802.11b standard uses direct-sequence spread spectrum (DSSS) and supports bandwidth speeds up to 11 Mbps.
- The 802.11a and 802.11g standards use orthogonal frequency division multiplexing (OFDM) and support speeds up to 54 Mbps. Because OFDM is more suitable to outdoor environments and interference, that's why it is commonly used for Wireless LAN infrastructure.[10]

Table1. IEEE 802.11 WLAN technologies summary [9]

IEEE Standard o Amendment	Maximum Data Rate	Typical Range	Frequency Band	Comments
802.11	2 Mbps	50-100 meters	2.4 GHz	
802.11a	54 Mbps	50-100 meters	5 GHz	Not compatible with 802.11b
802.11b	11 Mbps	50-100 meters	2.4 GHz	Equipment based on802.11b has been th dominant WLAN technology
802.11g	54 Mbps	50-100 meters	2.4 GHz	Backward compatible with 802.11b

2.4 High Data Rate Transceiver

Adopting the low power consumption, simplified radio-circuitry and high data rate RF transceivers has become popular in many research works. Figure 3 shows a simplified block diagram of a complete BaseStation that can be generalized to all BS types, including macro, micro, pico and femto BSs.

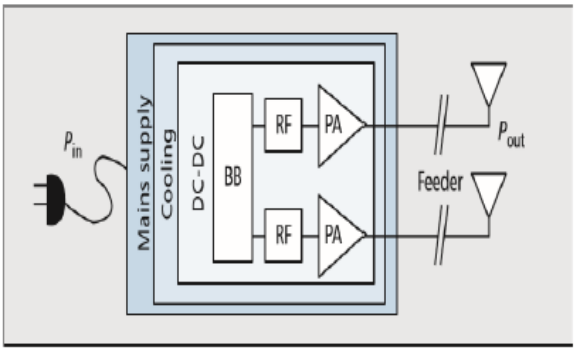


Fig 3: Block Diagram

A TRX comprises a power amplifier (PA), a radio frequency (RF) small-signal TRX module, a baseband engine including a receiver (uplink) and transmitter (downlink) section, a DC-DC power supply, an active cooling system, and an AC-DC unit (mains supply) for connection to the electrical power grid[11]

Earlier many low power transceiver like CC1000,CC2420,CC2550 were used in many applications. Table2 gives a brief description of the characteristics these transceivers.

Table2. Comparison between characteristics of transceivers

Transceiver / Parameters	CC1000	CC2420	CC2500
Bandwidth	300-1000MHz	2.4-2.483GHz	2.4-2483GHz
Data Rate	76.8kbps	250kbps	1.2-500kbps
Tx Current consumption	10.4mA	18.8Ma	Well above sensitivity limit
Rx Current Consumption	9.3mA	17.4mA	13.3mA
Sensitivity	-110dBm	-95dBm	-104dBm
Output Power	-20 -10dBm	-10dBm	1dBm

After comparing different high data rate transceivers, we find that CC2500 from Texas Instruments can provide satisfying data rate and power consumption and thus can be used for the specified application. Table3 gives a comparison of all the wireless protocols discussed aboveAfter comparing different high data rate transceivers, we find that CC2500 from Texas Instruments can provide satisfying data rate and power consumption and thus can be used for the specified application. Table3 gives a comparison of all the wireless protocols discussed above.

Table 3: Comparision of Wireless Protocol

Parameter \ Name	Bluetooth	ZigBee	Wi-fi	RF –Module
IEEE specs.	802.15.1	802.15.4	802.11a/b/g	802.11
Bandwidth	2.4GHz	2.4GHz	2.4GHz	2.4GHz
Modulation types	GFSK,PSK	BPSK, OQPSK	BPSK,QPSK, M-QAM	OOK,2FSK, GFSK,MSK
Spreading techniques	FHSS	DSSS	DSSS/OFDM	FHSS
Max. Data rate	1Mbps	250Kbps	54Mbps	1Mbps
Range	10m	10-75m	50-100m	60-80m

With the high data rate, the probability of collision incidences is greatly reduced because of a short transmission time, which also leads to the saving of more power in the whole network. The range of high data rate transceiver RF-module CC2500 can be extended using range extenders. Thus transceiver is an appropriate wireless protocol for the survey application.

3. LINE CODING TECHNIQUES

An information signal must first be formatted to represent it by digital symbols (usually binary digits or bits) to transmit it over a digital communication system without Inter symbol Interference (ISI) [12]. These representations need to be converted into electrical serial-bit signalling formats known as line codes that are transmitted over the communication channel. Line coding introduces spectral nulls at DC frequency when the channel is AC coupled and modifies the signal spectrum thereby reducing the cross talk into foreign systems [13, 14].

- Desirable properties of line codes are as follows:
- Transmission Bandwidth should be as small possible.
- Power Efficiency for given BW and probability of error should be minimum.
- Error detection and correction capability.
- Transparency: It should prevent long strings of 0s or 1s [13].
- Clock Signal: Synchronization between the transmitter and receiver is of critical importance in digital communications systems.

There are many line coding techniques which are used depending on their advantages, disadvantages and their applications. Few commonly used are given below

- Unipolar Non Return To Zero
- Unipolar Return To Zero
- Polar Non Return To Zero
- Polar Return To Zero
- Bipolar Non Return To Zero
- Bipolar Return To Zero / Alternate Mask Inversion Return To Zero.

Manchester bi-phase codes can eliminate the DC component, because each binary symbol is divided in two parts with an identical duration and different polarities. The main disadvantage of this line code is a large bandwidth as a result of a lot of transitions.

In Alternate Mark Inversion (AMI) code the polarity of a binary symbol is positive and negative alternatively AMI introduces very low DC component and very has short bandwidth. But here large number of consecutive 0V levels can produce a synchronization loss. If the bit rate is comparable Non-Return to Zero (NRZ) is adopted. But this introduces a DC component in the signal. A typical solution to this impairment is to use a bipolar variation of NRZ-L. Bipolar NRZ-L produces a small DC component if the probability of each polarity is approximately equal to each other; but the real applications have random information sources [14]. NRZ facilitates the use of matched filters at the receiving end thereby enhancing the reception capability. Thus NRZ coding suits best for the specified application.

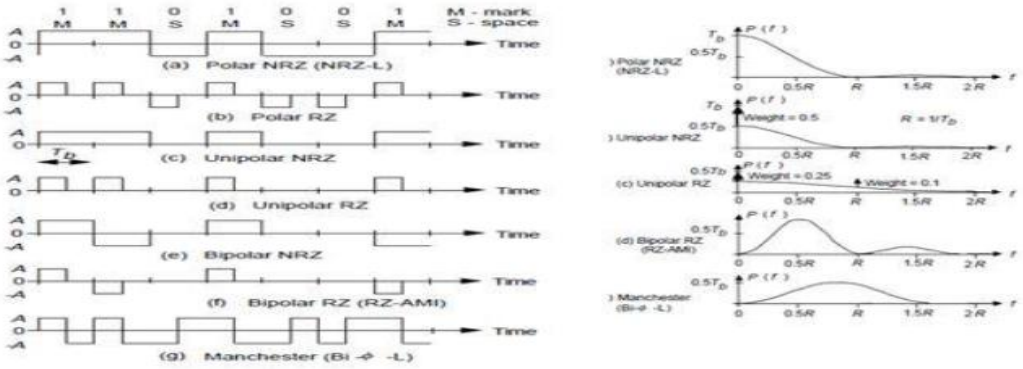


Fig 4: Coding technique and power spectral densities

4. CONCLUSION

This paper has presented a broad overview of the four most popular wireless protocols Bluetooth, ZigBee, WiFi and high data rate transceivers with a quantitative evaluation in terms of the transmission time, complexity, and power consumption. Furthermore various line coding techniques are also preliminary compared. This paper is draws a conclusion regarding which wireless protocol and coding technique is suitable for transmission for Bathymetry survey data.

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