Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

Examining the Intricacies of Infrared Data Communication Protocols in Wireless Communication

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Within the field of wireless communication, this study explores the intricate world of infrared data communication protocols. The need for secure and effective wireless data transfer is increasing, making it critical to comprehend the nuances of infrared protocols. The aim of the study is to assess key features of the chosen wireless communication technology and provide a solution to the problem of selecting a better technology while satisfying the needs of the intended application. The effectiveness of the several wireless technologies is evaluated in comparison, with an emphasis on their performance in the different application domains. It also illustrates the limits of their characteristics. Programmers and engineers can use the study's findings to ascertain the most effective way to build and operate a system in order to ensure communication quality while avoiding time constraints, using the least amount of energy, and paying the least amount of money for implementation. The results of this study provide important new information to the sector, facilitating the creation of sophisticated and dependable wireless communication systems.

Keywords: Wireless communication, Communication protocol, Infrared data, Wi-Fi,Wi-Max, UWB, Bluetooth, ZigBee.

1. Introduction

A quiet song is being played in the frantic world of wireless communication technologies by the mysterious infrared (IR) light. IR data communication methods, which are sometimes cast aside in favour of more obvious radio waves and microwaves, create a complex web of exchanges that are imperceptible to the unaided eye but have the power to completely alter how humans communicate. This paper sets out on a quest for knowledge, exploring the inner workings of this underutilised technology and painstakingly analysing the protocols that control its data dance.

We start our adventure by revealing the intrinsic charm of instant messaging. In contrast to radio-frequency rivals, infrared light functions inside an unseen spectrum, providing intrinsic benefits concerning privacy and security. It works well in close quarters, easily connecting equipment that is tucked away in a room or navigating the busy aisles of a data centre. Furthermore, in crowded wireless environments, its tolerance to electromagnetic interference makes it a beacon of stability.

But IR's allure isn't limited to its inconspicuousness; it also stems from its adaptability. When we dig further, we find a rainbow of protocols, each designed to fit into a particular data exchange symphony. We introduce you to the illustrious IrDA, a seasoned warrior who has devotedly guided data for decades between personal digital assistants (PDAs) and printers. We struggle with the high-speed goals of Free Space Optical (FSO) technology, which can send laser-sharp light beams across great distances that can carry gigabits of data. We also marvel at the rapidly developing possibilities of Li-Fi, which promises to cover our immediate surrounds with a silent internet of light as the omnipresent flicker of lightbulbs transforms into a covert information conduit.

In this study, we examine the several aspects that influence the standard and efficacy of an intelligent sensor-based wireless communication system, while also accounting for application requirements and cost.

1.1. Evolution of Wireless Technologies

Remote correspondence has progressed significantly, from murmured morse code to the omnipresent murmur of information. At the point when the message was designed in the nineteenth 100 years, data streamed across ethereal waves without being compelled by wires. Everything began with sparkles and static. In the twentieth 100 years, radio managed the planet, sending voices and tunes over huge distances and integrating the globe with impalpable sound waves. Phones jumped up, settling discussions in pockets and handbags, while TVs thrived, painting front rooms with variety and activity. A defining moment was the coming of the web, our eager computerized data set. Remote formed into its fast messenger, sending associations, amusement, and data at the speed of light. With the rise of Wi-Fi, Bluetooth, and various different abbreviations, availability became inescapable. The requirement for additional quick and viable information transmission turns out to be increasingly clearer with each new section. We are at present on the cusp of 5G, a gigantic mechanical progression that guarantees lightning-quick associations and a hyperconnected future.

1.2. Role of Infrared Technology

Among the many voices in the colourful symphony of wireless communication, infrared technology is one that is often overlooked. In contrast to its radio-frequency equivalents, infrared (IR) beams data over the near- and mid-infrared spectrum while operating covertly. The benefits of being invisible are manifold: protection against listening in on private conversations, immunity to electromagnetic interference, and a low-key presence in delicate areas. But there's more to its allure. In short-range situations, IR flourishes, enabling lightning-fast and highly effective communication between equipment tucked away in rooms or data centres. Consider switching channels on remote controllers, files being sent to printers, or data being shared between nearby computers. It is perfect for indoor positioning systems, guiding robots, and precisely tracking assets because it is impervious to obstructions like walls. Beyond this field, IR excels in specialised uses that require extreme privacy and security, such as safe medical data transfer or clandestine communication in delicate settings. Even though it can't match the wireless industry's titans of long-range transmission, infrared (IR) forges its own distinctive route as a dependable workhorse that transmits data quickly and discreetly while whispering its secrets into the invisible spectrum.

1.3. Objectives of the study

- To examine the advantages and disadvantages of Bluetooth, Wi-Fi, Wi-Max, UWB, and ZigBee in diverse applications.
- To provide a manual for selecting the optimal wireless communication technology according to application needs while taking implementation, cost, and energy efficiency into account.
- To provide programmers and engineers with useful guidance on creating effective wireless communication systems, with a focus on communication quality optimisation, energy conservation, and economical implementation

2. REVIEW OF LITERATURE

Amouri et al. (2020),The work addresses the growing worries about the vulnerabilities of mobile devices in interconnected environments by using ML approaches to detect and prevent potential security breaches in the Internet of Things. This study highlights the significance of protecting wireless communication in the context of the IOT in addition to highlighting the significance of incorporating cutting-edge technology like machine learning for strong security solutions.

Chen et al. (2020)examines the viability and effectiveness of optical wireless communication in submerged settings, providing information on the opportunities and difficulties related to this unusual communication method. Because it investigates communication options for difficult conditions and lays the groundwork for future uses in underwater data transmission, this study is especially important. By expanding the use of ordinary terrestrial communication to novel contexts, the research advances our understanding of the potential of wireless communication.

Hatzivasilis et al. (2017) discusses the important problem of security in wireless ad hoc networks and suggests SecRoute as a remedy. The project aims to provide end-to-end secure communication, emphasising how important data transmission security is in dynamic, decentralised wireless networks. The authors add to the continuing discussion about improving ad-hoc network security protocols, which is essential for their effective implementation in various settings, by presenting a secure routing method.

Kamila (2016)offers a comprehensive examination of wireless sensor network (WSN) developments, technologies, and applications. For researchers, practitioners, and students looking for a thorough grasp of the most recent developments and difficulties in WSNs, it is an invaluable resource. Numerous subjects are covered in the guidebook, such as application areas, communication protocols, security concerns, and sensor node architectures. With her work, Kamila adds to the body of knowledge in the industry by providing a reference manual for people working on wireless sensor network design, implementation, and analysis.

Nitin Goyal, et al. (2016)focuses on the particular difficulties that sensor networks face in the underwater environment. Within UWSNs, the authors suggest an energy-efficient architecture designed for intra- and inter-cluster communication. The research helps to build sustainable and efficient communication systems in underwater settings with an emphasis on energy optimisation. This work is especially important since it tackles the crucial problem of energy efficiency in UWSNs, where difficult circumstances and limited resources call for creative communication techniques.

Varshini and Rao (2017)examines the specific absorption rate (SAR), which is a critical factor in determining whether wearable wireless devices are biocompatible. The authors present a technique for measuring SAR using infrared thermography, offering important new information about the possible health effects of wearable technology. This study emphasises the significance of making sure wearable technologies comply with human health standards in light of the expanding popularity of wearable technology.

3. PROPOSED METHOD

3.1 Infrared Wireless Communication System

Data can be moved between two gadgets remotely, without the requirement for wires or links. The electromagnetic range, which goes from energy waves with Extremely Low Frequency (ELF) to energy waves with a lot higher frequency, for example, xrays, orders electromagnetic energy as indicated by frequency or frequency, is utilized to send and get information. As found in Figure 1, infrared radiation is a sort of electromagnetic radiation.

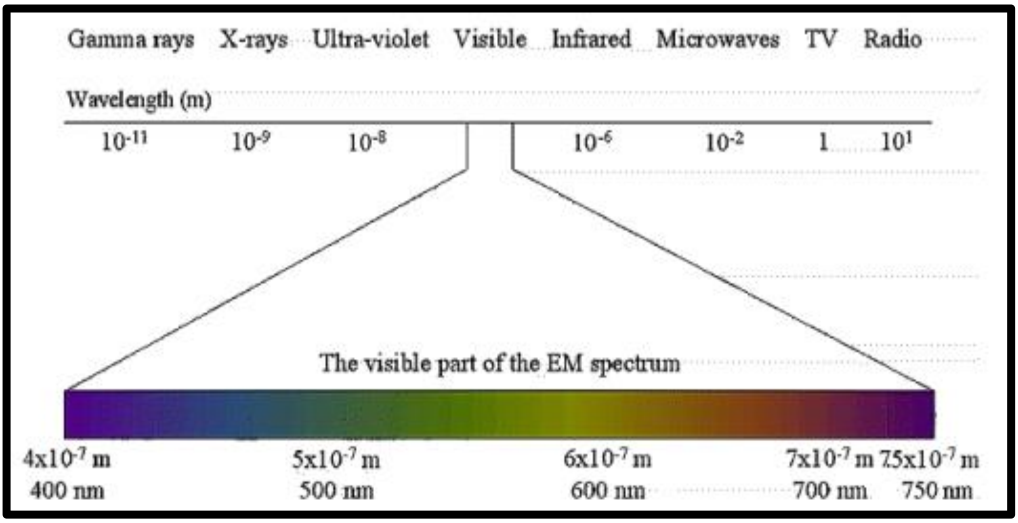

Figure 1: The electromagnetic field

There are two types of infrared LEDs: NIR &FIR. Our focus in this work is near-infrared (NIR), which is separated into two bands: long wave and short wave. The kind of NIR depends on how digital compact disc (CD) cameras that use film and cards respond to it. As a result, several bands within the infrared spectrum are used in laser communication systems, depending on the kind of light sources, transmitting materials (fibres), and detectors. As seen in Figure 2, the three primary components of an IR communication system are the transmitter circuit, the medium propagation (IR) circuit, and the reception circuit.

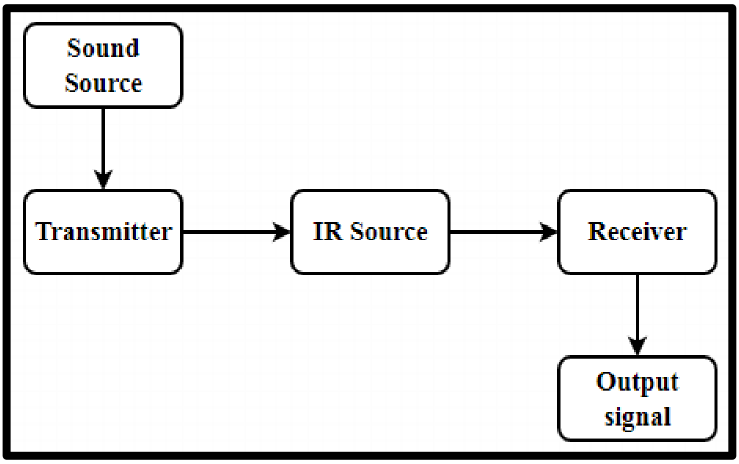

Figure 2: The IR communication system block diagram

Based on the factors given in the introduction—data rate, range, power consumption, and compatibility—the aforementioned protocols are compared. In this part, we depict the numerous measurements used to assess the presentation of a remote convention.

3.2 Network Size

The amount of impedance, the size of information bundles during traffic, the transmission procedures utilized, and the quantity of clients associated with the GSM voice administrations can all influence the number of GPRS open meetings there are in a solitary cell, which can arrive at north of 1000. The Wi-Fi network, which has 2009 nodes in the BSS structure, is ranked second. It is followed by the Wi-Max network, which has 1800 nodes, UWB, which allows 238 nodes in the piconet structure to be connected, and Bluetooth, which has 10 nodes in its piconet network. When it comes to networks with more nodes than 67,000, ZigBee star networks top the list. A feature shared by all these protocols is the ability to use increasingly complex network topologies composed of building blocks to expand the network's capacity.

3.3 Transmission Time

The information rate, message size, and distance between two hubs all affect how long it takes to send a message. This is how the transmission time in (s) recipe is shown:

$$T_{tx} = \left(N_{data} + \left(\frac{N_{data}}{N_{maxPld}} \times N_{ovhd} \right) \right) \times T_{bit} + T_{prop} \quad (1)$$

N_{data} Data volume

N_{maxPld} The largest possible payload

N_{ovhd} Size of the overhead

T_{bit} A brief moment

T_{prop} In this work, the propagation time between two nodes will be ignored.

Table 1: Standard Wireless Protocol Parameters

Protocol	Data Rate (Mbit/s)	Bit Interval (μs)	Max data payload (bytes)	Data Payload (bytes)	Coding efficiency+ (%)
Bluetooth	0.74	1.41	341 (DH5)	160/10	96.43
UWB	110	0.011	2246	44	99.96
ZigBee	0.27	6	104	33	78.54
Wi-Fi	56	0.0187	2514	60	99.20
Wi-Max	72	0.0145	2902	42	99.56

3.4 Transmission range and power

The relationship between the transmitted and received powers during wireless transmissions is given by the Friis equation.

$$\frac{P_r}{P_t} = G_t G_r \left(\frac{\lambda}{4\pi D}\right)^2 \quad (2)$$

P_t The power transmitted

P_r The derived authority

G_t The gain of the transmitting omnidirectional antenna

G_r Gain of the receiving antenna

D The separation of the two antennas

λ The signal's length of wavelength

The formula for the coverage range is given by equation (2) and is as follows:

$$D = \frac{1}{\frac{4\pi}{\lambda}\sqrt{\frac{P_r}{P_t G_t G_r}}} \quad (3)$$

4. SIMULATION RESULTS

4.1 Usage of energy

The energy utilization of canny sensors includes three cycles: procurement, correspondence, information accumulation, and information total. The sort of use decides the number of assets that are utilized during the obtaining system. Compared to other operations, data traffic consumes more energy, particularly during transmission. It is also affected by the distance between the transmitter and the recipient.

The model that illustrates how the communication range d(p) affects an intelligent sensor's E(p) energy usage is as follows:

$$E(p) = k.\, d^{\alpha}(p) + E_d \alpha \geq 2 \quad (4)$$

k Size of the packet

α The attenuation factor for signals

E_dThe cost of the transmission energy

Table 2: The parameters for the simulation

Protocols	Transmitted Power (Watt)
Bluetooth	.3
UWB	.06
ZigBee	.0065
Wi-Fi	3
Wi-Max	.27

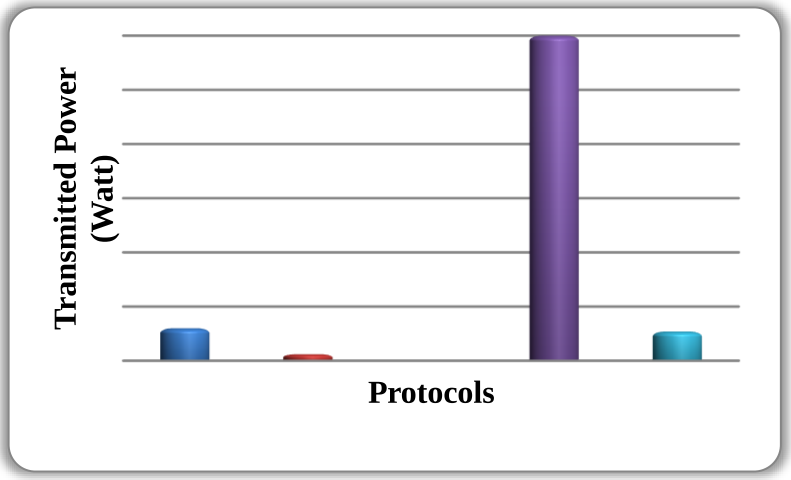

Figure 3: Visual depiction of simulation settings

4.2 Power consumption of the chip

To really survey the power utilization, we remember for Table 3 the exact ordinary highlights of a certain chipset for every convention. Figure 4 shows the power utilization for each methodology in milliwatts. The power misfortune coming about because of the sign's constriction all through the correspondence channel represents the distinction between the transmission influence and gathering influence for the WiMax conventions, which are both very far and wide.

Table 3: Features of Chipset Power Consumption

Protocols	Chipset	VDD (volt)	ITX (mA)	IRX (mA)	Bit rate (Mb/s)
Bluetooth	BlueCore2	1.10	59	49	0.74
UWB	XS110	3.5	~229	~229	116
ZigBee	CC2430	3.2	26.9	29	0.27
Wi-Fi	CX53111	3.5	221	219	56
Wi-Max	AT86 RF535A	3.5	322	202	72

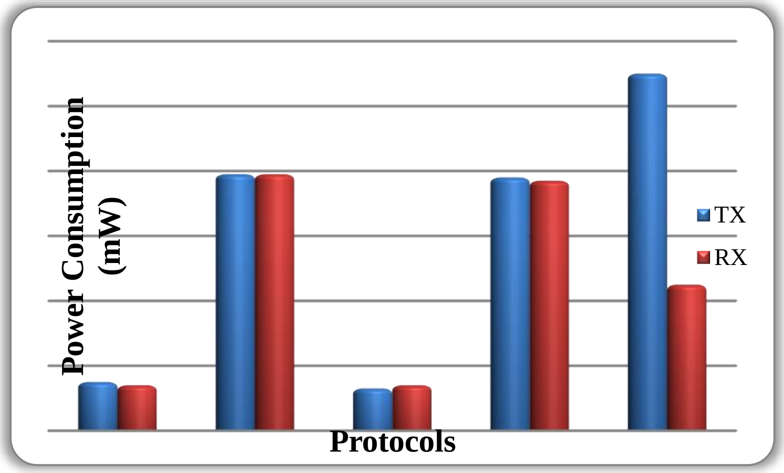

Figure 4: Chipset Power Consumption by Protocol

The standardized energy use in (mJ/Mb) for every convention is displayed in Figure 5 in light of its information rate. This outline clarifies that Wi-Max, UWB, and Wi-Fi have more prominent energy productivity. Be that as it may, for huge information rate organizations, UWB, WiFi, and Wi-Max would be the most ideal decisions in light of their low standardized energy use.

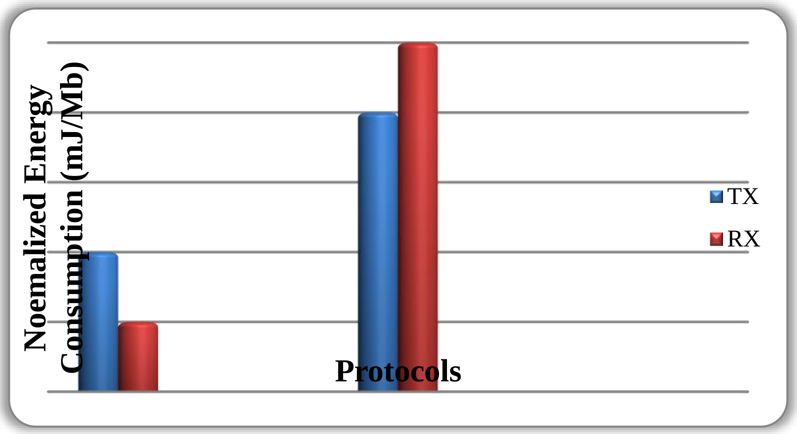

Figure 5:contrasting each protocol's average chipset energy consumption

4.3 Bit error rate

To assess the efficacy of digital transmissions, white noise known as additive white Gaussian noise (AWGN) is introduced into the broadcast signal. In addition to sending a data packet via a radio channel, a modulation strategy aims to do it as quickly, effectively, and efficiently as feasible while using the least amount of bandwidth possible.

To improve the robustness of a communication system, one particularly useful method for assessing modulation performance is the bit error rate. The following formula was used to compute it:

$$\mathrm{BER} = \frac{\mathrm{N_{Err}}}{\mathrm{N_{TXBits}}} \tag{5}$$

$\mathrm{N_{Err}}$The quantity of mistakes

$\mathrm{N_{TXBits}}$The total number of bits sent

4.4 Adaptability to current technology

All of the previously described protocols are currently supported by a wide range of commercial devices. It is theoretically expected that all modern mobile smart devices, such as smartphones and tablets, have built-in WiFi and Bluetooth connectivity. Nowadays, a wide variety of wireless speakers, cameras, and headsets are available that offer direct mobile device access for real-time music and video streaming. On the other hand, the lack of direct compatibility with 804.17.6 technologies like as Zigbee implies that a dedicated gateway is necessary to enable connectivity with commonly used commercial electrical equipment. Adding a requirement for end users to connect with their own smart devices to a system adds an unnecessary layer of complexity.

5. CONCLUSION

The analysis of infrared data transfer protocols in the context of wireless communication emphasises how crucial it is to comprehend these protocols' nuances in order to promote effectiveness, security, and peak performance. With the increasing need for dependable and safe wireless data transfer, this study offers insightful information about the specifications, difficulties, and technical features of infrared technology. The study not only adds to the body of information about these protocols by comparing the performance of different wireless technologies like Wi-Fi, Wi-Max, UWB, Bluetooth, and ZigBee, but it also has useful implications for system designers and engineers.

The performance of five wireless protocols—Bluetooth, UWB, ZigBee, Wi-Fi, and Wi-Max—is compared in this study. However, there are other wireless protocols as well, like DASH, HiperLAN, and 6LoWPAN. We have therefore made the decision to only land the most popular ones. One of this unique system's most important aspects is its capacity to interface with the end user's mobile device and glasses. As a result, selecting the wireless communication protocol to be employed is a crucial initial step in system building. The comparative study reported in this paper shows that two of the competing wireless protocols are fully compliant with the requirements of the application. The optimal protocol for audio transmission is Bluetooth since it offers fast enough data rates while using the least amount of battery life. WiFi was found to be the most effective protocol for sending videos since it can handle the challenging task of transmitting signals at high data rates. The results of this study greatly improve the creation of sophisticated and dependable wireless communication systems, opening the door for additional advancements in the area.

FUTURE SCOPE

Mobility is not taken into consideration, and the five methods used in this study are assumed to be applied in static situations. Additional Leader nodes (ALN) can be utilised for load balancing in the event that a leader node fails. Leader nodes and ALN can be utilised for data conveyance and aggregation, respectively, during inter-cluster communication. Energy loss can be prevented and data transmission reliability increased by doing this. There is no consideration given to the cost of the many stages of data sensing and transmission, the number of channels, the quality of the communication channel, path selection algorithms, and other variables. The system's performance can be enhanced in terms of dependability and power consumption by using multi-channels, more leader nodes, the mobility concept, selecting the shortest way based on different metrics, and the relay diversity concept. A mathematical framework can also be used to assess the proposed system.

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