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LED Display System Characterisation Based on Wireless Communication Techniques: A Systematic Review

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Abstract: The display of information and data in control and automation systems, campuses, hospitals and shopping malls have become seamless and attractive since the advent of LED display systems. There has been a need in determining the best options available in sending information or data to the LED display system putting different options into consideration. This paper reviews among many available options, wireless communications techniques that are employed in updating information on a LED display system by analyzing their characteristics in terms of cost, power consumption, transmission range, typical join time and user friendly graphical user interface in a bid to help readers choose which technique best suit their needs in design process based on the analyzed characteristics of these techniques. The LED display system Wireless communication techniques considered in this work are Bluetooth, WI-FI, Radio Frequency, GSM and IOT. IOT is shown to be the cheapest with ₦ 2700; radio frequency has a faster join time of 0.03 seconds; Bluetooth has the smallest maximum power consumption of 0.3 W with GSM and IOT having an infinite transmission range based on network availability. This paper will help researchers and designers choose wisely the best optimal option that best fits their design.

Keywords: LED, Wireless, Display System, Communication, Bluetooth, WI-FI, GSM, IOT, Radio Frequency

1. Introduction

Light Emitting Diode (LED) display systems have in recent times become popular in information and data display in control and automation systems, university campuses, churches, supermarkets and shopping malls, banks, rail stations etc. [1, 2]. LED display systems which are flat panels uses light emitting diodes (LEDs) as its display element. LEDs used for LED displays have superior advantages over other light emitting. LEDs are made up of semiconductor chips surrounded by transparent plastic casing which allows light to pass through it [3]. LED has become popular and acceptable owing to its unique semiconductor characteristics, low voltage and energy consumption, low power consumption, low cost, light weight, wide angle vision range and its unique ability to display special characters when arranged in matrix form [4, 5].

Changing and updating information on a LED display system (LDS) through wireless communication techniques (WCT) as seen in Figure 1 has become a vital area of research as researchers tirelessly explore different means of ensuring a seamless means of updating information on a LDS without going through the rigour of re-programming the system.

This paper seeks to review existing methods and option available for seamlessly updating an LDS through WCT. The essence is to keep readers abreast on the various available WCT and thereafter make choices suitable to them after weighing the options of cost, transmission range and compatibility. These mediums are mainly communications channels between users and the LDS. WCT channels under considerations in this paper are: Bluetooth, wireless fidelity (Wi-Fi), Radio Frequency (RF), Global System for Mobile Communication (GSM) and Internet of Things (IOT).

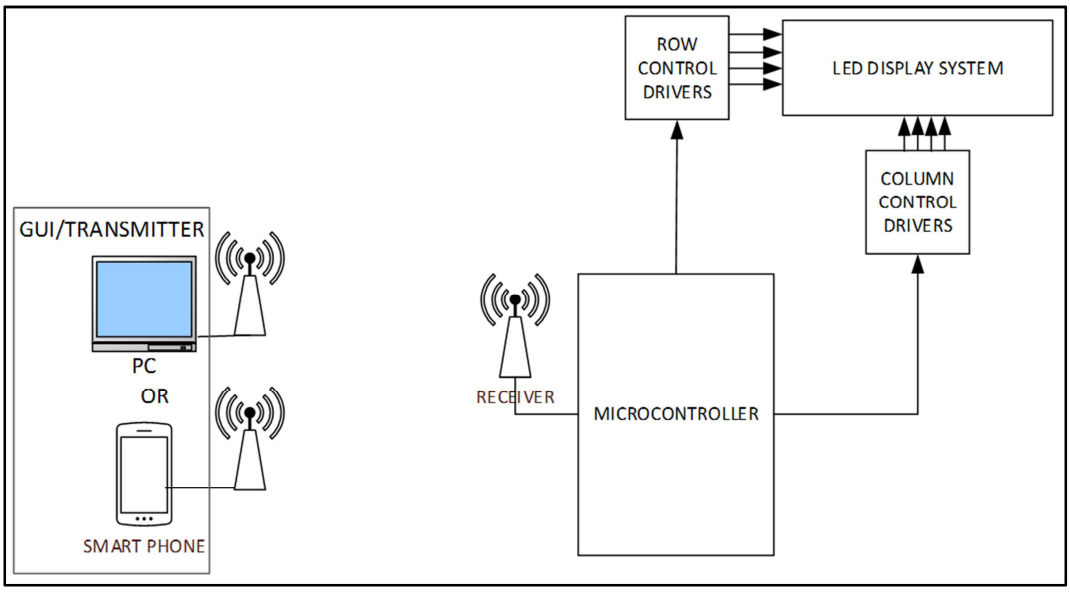

Figure 1. *System Overview of an LDS based on WCT.*

2. Wireless Communication Techniques Used with LED Display Systems

2.1. Bluetooth

Bluetooth in recent times have found great applications in wireless technology. The use of Bluetooth modules has helped seamless updating of LDS [6]. The system block diagram of a typical Bluetooth based LDS. Some unique features of Bluetooth module are that with it, it becomes easy for a user to update the display board with his Bluetooth enabled mobile android phone. An android app from MIT app inventor is used as an interface between the user's phone and the Bluetooth module [7]. HC-05 and HC-06 are common Bluetooth modules used for LDS. Bluetooth technology is inexpensive, fast and also simple to install, has a frequency band of 2.4 gigahertz (GHz) at a data rate of 1megabyte per seconds (Mbps) [8] as seen in Table 1 and as well consumes less power of about 0.3 W as seen in Table 8 and Figure 4 [9]. However, Bluetooth is faced with the limitation of short transmission range of about 7- 9 m as seen in Table 7 and Figure 3.

Table 1. *Bluetooth characteristics.*

References	Frequency Band	Typical network join time	Transmission Range	Data Rate	Size (protocol)	Bandwidth (minimum)	Physical/MAC layers	Current	Voltage
[10-11, 8, 9],	2.4GHz	3 –5 sec	7-9 m	1Mbps	250kb	15MHz (dynamic)	IEEE 802.15.1	60mA	5 V

2.2. Wireless Fidelity (WI-FI)

WI-FI I is another wireless communication medium for updating and sending information to LDS. A WI-FI transceiver (which could serve both as a transmitter and receiver) when interfaced with a personal computer (PC) or a WI-FI enabled mobile phone can be used to update an LDS [12].

WI-FI is a Wireless technology of radio waves that provides network connectivity to devices by emitting frequencies between 2.4GHz- 5GHz based on the amount of data on the network. [13]. WI-FI is cost effective, less complex and simple to use coupled with the fact that nearly all smart phone devices which are WI-FI enabled are equally cheap and affordable [14]. Unlike Bluetooth, WI-FI has a longer transmission range of 75 – 90 m higher than Bluetooth as shown in Figure 3 with typically 1 seconds as its network join time and sends data at a faster rate of 11Mbps at a minimum bandwidth of 22 megahertz (MHz) as shown in Table 2. Using WI-FI to update or send information to a LDS require a mobile application to serve as a user interface.

Despite its unique characteristics, WI-FI consumes more power as it requires six times more power compared to Bluetooth to operate effectively [8, 15].

Table 2. *WI-FI characteristics.*

References	Frequency Band	Typical network join time	Transmission Range	Data Rate	Size (protocol)	Bandwidth (minimum)	Physical/MAC layers	Current	Voltage
[8, 12, 16]	2.4GHz-5GHz	1 sec	75-90 m	11Mbps	1Mb	22MHz (static)	IEEE 802.11	400mA	5 V

2.3. Radio Frequency (RF)

Another wireless communication medium used for LDS is RF. RF is a wireless technology with a frequency band of between 3kilohertz (KHz) to 3 GHz [17]. It has both a transmitter and a receiver module with the transmitter attached to the PC where the information will be sent through the GUI and the receiver is attached to the LDS which receives the sent message and displays it on the LDS with the help of shift registers. It has a longer transmission range of 800 – 1100 meter (m) compared to Bluetooth and WI-FI as shown in Figure 3. It has a data transmission rate of 250kps to 2Mbps and consumes less power as shown in Table 3, Table 8 and Figure 4 and equally has a faster typical network join time as shown in Table 9 and Figure 5. RF is mainly used with a PC for creating the GUI using visual basic and access software [3, 18] and as well have a smaller bandwidth of 3MHz. Commonly used RF module is the NRF24I0 series transceiver [19].

Table 3. *Radio Frequency characteristics.*

References	Frequency Band	Typical network join time	Transmission Range	Data Rate	Size (protocol)	Bandwidth (minimum)	Current	Voltage
[3, 18]	3kHz -3GHz	30ms	800-1100 m	250kps - 2Mbps	32kb	3MHz (static	45-155mA	5 V

2.4. Global System for Mobile Communication (GSM)

The GSM is another medium of sending information to an LDS through a short message service (SMS) from a mobile phone with the GSM module acting as the communication channel. When a message is to be displayed on the LDS, such message is sent as an SMS from the user's mobile phone. The GSM module with an assigned subscriber identification module (SIM) card mounted on it, which is attached to the LDS receives the SMS, and sends the strings via Universal Asynchronous Receiver/Transmitter (UART) to the master unit of the LDS controller [20].

The mobile phone sending the SMS is the transmitter while the GSM module attached to the LDS system is serves as the receiver [21]. This method is user friendly as it does not require a special GUI to be designed to send messages but rather uses the default SMS application on the users' mobile phone. GSM based method has a wider transmission range as its range is almost limitless as long as the GSM module is within the specified frequency band of 900 – 1880MHz as shown in Table 4. Which many a time is a serious challenge that makes it ineffective especially fin some remote regions in most developing countries in Africa. GSM module consumes more power of about 8 W; it requires 3.7 – 4 V at exactly 2A of start current (as shown in Table 4) which on many cases makes it very tedious to handle.

Table 4. *GSM characteristics.*

References	Frequency band	Typical join time	Data rate	bandwidth	current	Voltage
[22-25]	900MHz – 1880 MHz	2- 10 sec	9.68kbps (2G) – 1Gbps (4G)	1880MHz	2A (maximum)	3.7 – 4 V

2.5. Internet of Things (IOT)

IOT is the interconnection and control of devices over the internet. In recent years, IOT has gained popularity and has found useful applications in homes and industries. Researchers have also tried to update and control LDS using IOT [26, 27].

The main component of an IOT based LDS is the espressif (ESP) WI-FI BLUETOOTH low energy (BLE) node microcontroller unit (nodeMCU) series modules such as ESP 32-family and ESP 8266. The Wi-Fi router on the module enables it to connect the LDS to the internet while BLE enabled modules enables it to be connected to mobile phone operated GUI [28].

IOT based LDS consumes less power of about 0.5 W, is cost effective with just about $6 (₦ 2,700 Nigerian Naira) as shown in Figure 2 and Table 6, it has wider variations of input/output peripherals such as UART, serial peripheral interface (SPI), I2C, analog/digital converters (ADC) capacitive touch etc. [28]. It has a broader transmission range since its operational connection is over the internet with a data rate of 1 – 11Mbps on a 2.4GHz frequency band as shown Table 5. IOT based LEDS is not effective in areas that are out of network coverage and it requires a strong internet connection for its operation.

Table 5. *IOT Characteristics.*

References	Frequency band	Typical join time	Data rate	bandwidth	current	VOLTAGE
[26, 28, 29, 30, 31]	2.4GHz	1 sec	1 - 11Mbps	15 – 22 MHz	500mA	3.3V

Table 6. *Cost comparison (in Nigerian Naira (₦)).*

References	Bluetooth	WI-FI	RF	GSM	IOT
[32, 33]	3, 500	24,302	6,373.34	4, 500	2,700

Table 7. *Transmission Range in meters (Maximum).*

Bluetooth	WI-FI	RF	GSM	IOT
9	100	1100	∞	∞

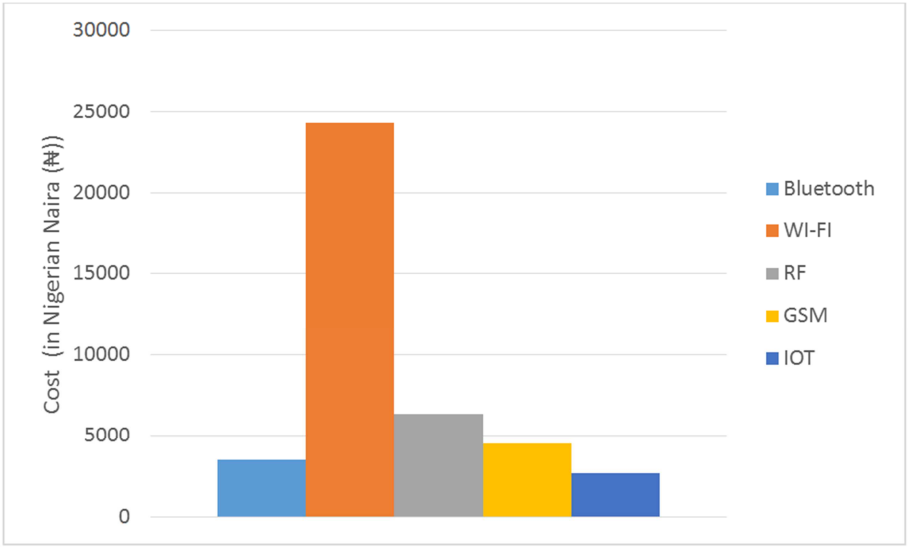

Figure 2. *Cost characteristics of LDS wireless communication techniques.*

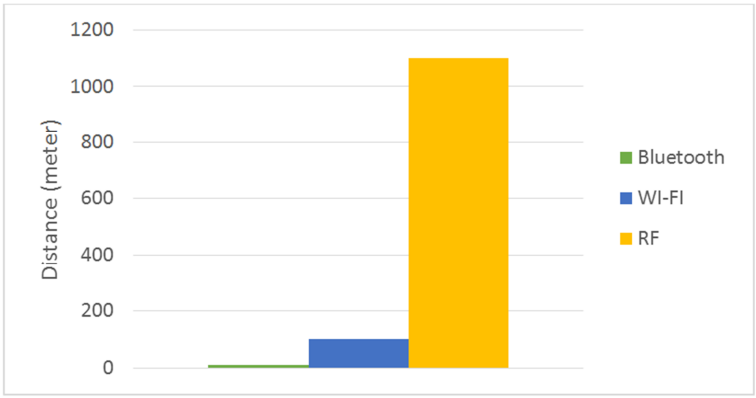

Figure 3. *Transmission Range.*

Table 8. *Maximum Power Requirement in Watts (W).*

Bluetooth	WI-FI	RF	GSM	IOT
0.3	2	0.8	8	1.7

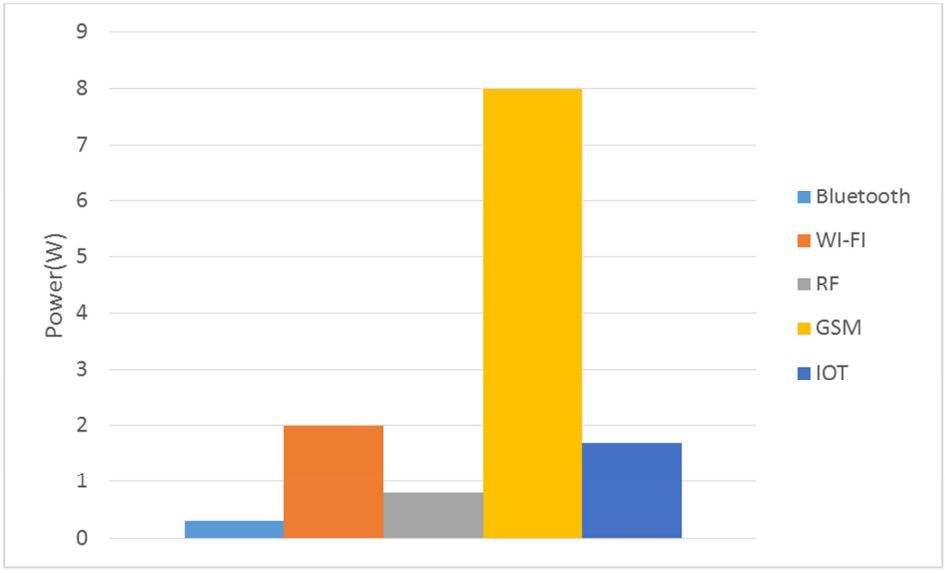

Figure 4. *Maximum Power Requirement.*

Table 9. *Average Typical join Time (in seconds).*

Bluetooth	WI-FI	RF	GSM	IOT
4	1	0.03	6	1

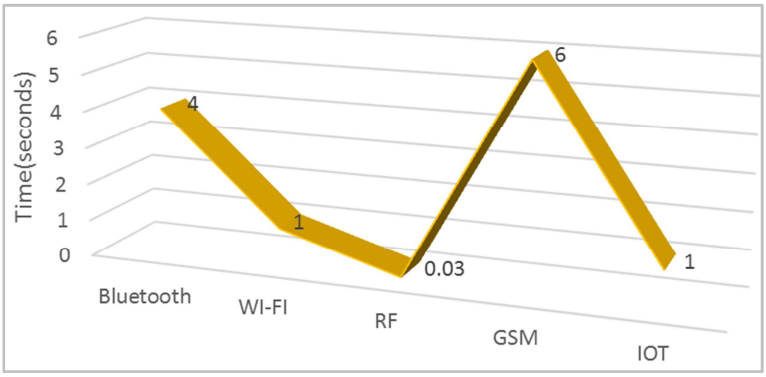

Figure 5. *Average typical join time.*

3. Conclusion

Haven explored extensively the characterization of various existing wireless communication technique for sending and updating information to a LDS, researchers and hobbyists can weigh their options and consider which technique to employ based cost, power consumption frequency band, transmission range and typical join.

There are still areas yet to explore such as voice command technique which is still a virgin area up for researchers to explore.

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