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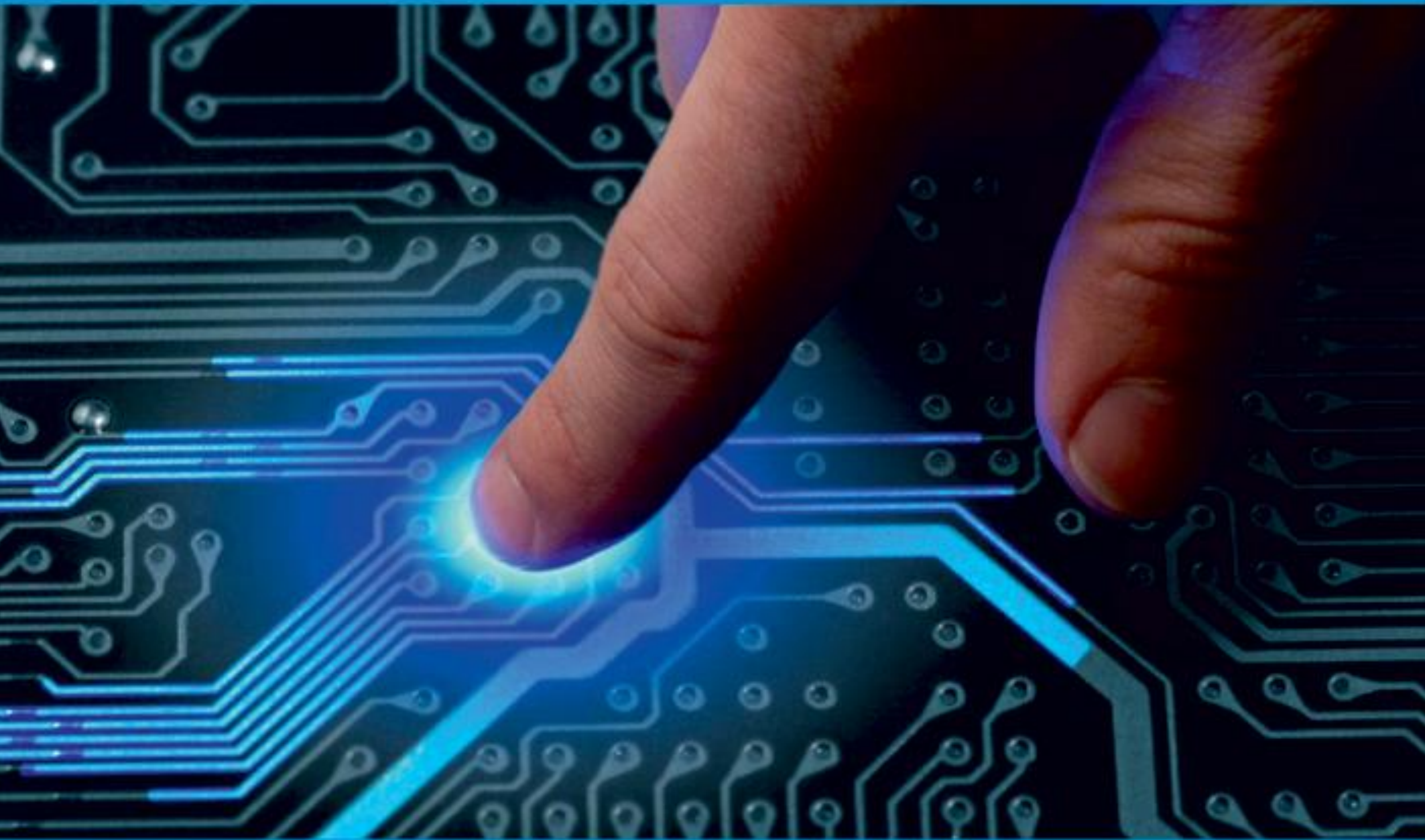

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Review of Wireless Local Area Network (WLAN) Standards and ZIGBEE

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ABSTRACT: The research paper focus on the Wireless LAN standards (WLAN) technologies available under IEEE 11. The paper also focuses on Wireless Sensor Networks (WSN), protocols, and applications. Dramatic advances in communication systems and micro- electro-mechanical systems (MEMS) IC design reduce the cost of the sensor nodes, which in turn enable the use of large scale WSNs for a variety of new monitoring and control applications. For these applications to be viable, the sensed/monitored data must be located. Traditional physical localization techniques are not well suited for these requirements. Including GPS on every device is cost and energy prohibitive for many applications.

KEYWORDS: Wireless LAN (WLAN), Institute of Electrical and Electronics Engineering (IEEE), Wireless Sensor Network (WSN).

I. INTRODUCTION

A wireless local area network (WLAN) [10] [26] links two or more devices using some wireless distribution method. It is used to provides a connection through an access point to the wider internet. This enables users the mobility to move around within a local coverage area and still be connected to the network. Modern WLANs standards are based on IEEE 802.11 standards, marketed under Wi-Fi brand name. Wireless LANs have become popular in the home due to ease of installation, and in commercial complexes offering wireless access to their customer, for free services. There are many wireless network projects are being put up in major cities. An example of Wifi communication is shown in the figure 1 which has Wifi Bridge, Wifi dish, Ethernet, Wifi router, internet service provider in the range for successful internet services.

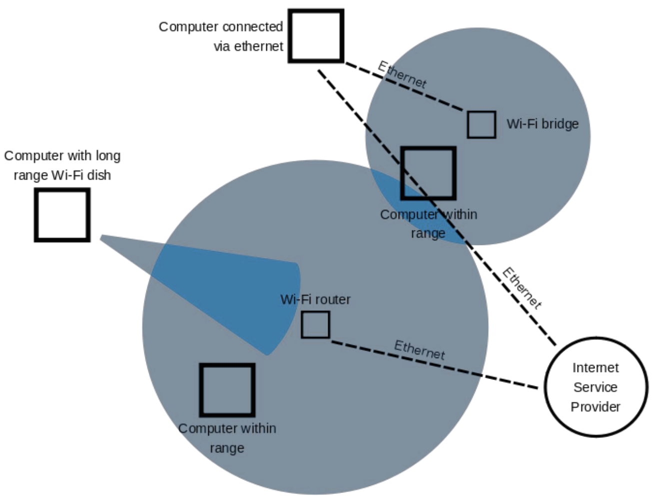

Fig. 1.1 Example Wifi Communication [10]

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Well accepted wireless communication technologies generally operate in frequency bands that are shared among several users, often using different RF schemes. This is true in particular for WiFi, Bluetooth, and more recently ZigBee. They all three operate in the unlicensed 2.4 GHz band, also known as ISM band, which has been key to the development of a competitive and innovative market for wireless embedded devices. But, as with any resource held in common, it is crucial that those technologies coexist peacefully to allow each user of the band to fulfill its communication goals. Despite efforts made by standardization bodies to ensure smooth coexistence it may occur that communication technologies transmitting for instance at very different power levels interfere with each other. In particular, it has been pointed out that ZigBee could potentially experience interference from WiFi traffic given that while both protocols can transmit on the same channel, WiFi transmissions usually occur at much higher power level.

II. TYPES OF WIRELESS LANs

2.1 Peer-to-peer

An ad-hoc network also called WiFi Direct network is a network where stations communicate only peer to peer (P2P). There is no base and no one gives permission to talk. This is accomplished using the Independent Basic Service Set (IBSS).

Fig. 1.2 Peer-to-Peer or ad-hoc wireless LAN

In a Wi-Fi P2P group the group owner operates as an access point and all other devices are clients. There are two main methods to establish a group owner in the Wi-Fi Direct group. In one approach user sets up a P2P group owner manually. This method is also known as Autonomous Group Owner (autonomous GO). In the second method also called negotiation-based group creation two devices compete based on the group owner intent value. The device with higher intent value becomes a group owner and the second device becomes a client. Group owner intent value can depend on whether the wireless device performs a cross-connection between an infrastructure WLAN service and a P2P group, remaining power in the wireless device, whether the wireless device is already a group owner in another group and/or received signal strength of the first wireless device. A peer-to-peer (P2P) network allows wireless devices to directly communicate with each other. Wireless devices within range of each other can discover and communicate directly without involving central access points. This method is typically used by two computers so that they can connect to each other to form a network. If a signal strength meter is used in this situation, it may not read the strength accurately and can be misleading, because it registers the strength of the strongest signal, which may be the closest computer.

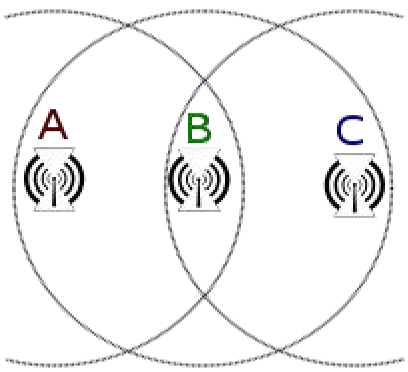

Fig. 1.3 Hidden node problem: Devices A and C are both communicating with B, but are unaware of each other

IEEE 802.11 defines the physical layer (PHY) and MAC (Media Access Control) layers based on CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance). The 802.11 specification includes provisions designed to minimize

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collisions, because two mobile units may both be in range of a common access point, but out of range of each other. The
802.11 has two basic modes of operation: ad hoc mode and infrastructure mode. In ad hoc mode, mobile units transmit directly peer-to-peer. In infrastructure mode, mobile units communicate through an access point that serves as a bridge to a wired network infrastructure. Since wireless communication uses a more open medium for communication in comparison to wired LANs, the 802.11 designers also included shared-key encryption mechanisms: Wired Equivalent Privacy (WEP), Wi-Fi Protected Access (WPA, WPA2), to secure wireless computer networks.

2.2 Bridge

A bridge can be used to connect networks, typically of different types. A wireless Ethernet bridge allows the connection of devices on a wired Ethernet network to a wireless network. The bridge acts as the connection point to the Wireless LAN.

III. WIRELESS SENSOR NETWORKS (WSN)

The availability of low cost, low power, and miniature embedded processors, radios, and sensors, integrated on a single chip, is leading to the use of wireless communications and computing for interacting with the physical world in many civilian and military applications. The resulting systems, called Wireless Sensor Networks (WSN). The advances in the integration of complex wireless integrated products and the increase in performance and functionality of the design tools, the requirements and properties of a single device (sensor node) are well understood. Yet it is not simple and straightforward to implement WSN concepts into a functional prototype system or even a commercial product. A wireless sensor network (WSN) consists of an array of sensors, of diverse types, interconnected by a wireless communication network. Sensor data is shared between these sensor nodes and used as input to a distributed estimation system whose function is to extract the relevant information from the available data. Fundamental design objectives of sensor networks include reliability, accuracy, flexibility, cost effectiveness and ease of deployment. Each node has one or more sensing unit, an embedded processor, and low-power radios. The nodes act as information sources, sensing and collecting data samples from their environment.

They perform routing functions, creating multi-hop wireless networking fabric that conveys data samples to other sensor nodes. Nodes can also act as information sinks, receiving dynamic configuration information from other nodes or external entities. The rapid deployment, self-organization and fault tolerance characteristics for WSNs make them promising for a number of military and civilian applications [1]. Wide varieties of these applications have been enabled by the promise of inexpensive networks of wireless sensors The solution is cooperative localization such that sensors work together in a peer- to-peer manner to make measurements and then form a map of the network forming local coordinate systems.

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as pressure, temperature, sound etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on. The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transreceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting.

A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced wireless mesh network with multihop technique. The propagation technique between the hops of the network can be flooding or routing.

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3.1. Applications

- **Area Monitoring**
  Area monitoring is a common application of WSNs. In area monitoring, the WSN is deployed over a region where some phenomenon is to be monitored. A military example is the use of sensors to detect enemy intrusion; a civilian example is the geo-fencing of gas or oil pipelines. When the sensors detect the event being monitored (heat, pressure), the event is reported to one of the base stations, which then takes appropriate action (e.g., send a message on the internet or to a satellite). Similarly, wireless sensor networks can use a range of sensors to detect the presence of vehicles ranging from motorcycles to train cars.

- **Environmental/Earth Monitoring**
  The term Environmental sensor networks, has evolved to cover many applications of WSNs to earth science research. This includes sensing volcanoe, oceans, glaciers forests etc. Some of the major areas are listed below.
- **Forest Fire Detection**

  A network of Sensor Nodes can be installed in a forest to detect when a fire has started. The nodes can be equipped with sensors to measure temperature, humidity and gases which are produced by fire in the trees or vegetation. The early detection is crucial for a successful action of the firefighters; thanks to Wireless Sensor Networks, the fire brigade will be able to know when a fire is started and how it is spreading.

- **Air Pollution Monitoring**
  Wireless sensor networks have been deployed in several cities (London, Stockholm, or Brisbane) to monitor the concentration of dangerous gases for citizens. These can take advantage of the ad-hoc wireless links rather than wired installations, which also make them more mobile for testing readings in different areas. There are various architectures that can be used for such applications as well as different kinds of data analysis and data mining that can be conducted.

- **Landslide Detection**
  A landslide detection system, makes use of a wireless sensor network to detect the slight movements of soil and changes in various parameters that may occur before or during a landslide. And through the data gathered it may be possible to know the occurrence of landslides long before it actually happens.

- **Machine Health Monitoring**
  Wireless sensor networks have been developed for machinery condition-based maintenance (CBM) as they offer significant cost savings and enable new functionalities. In wired systems, the installation of enough sensors is often limited by the cost of wiring. Previously inaccessible locations, rotating machinery, hazardous or restricted areas, and mobile assets can now be reached with wireless sensors.

- **Data Logging**
  Wireless sensor networks are also used for the collection of data for monitoring of environmental information. This can be as simple as the monitoring of the temperature in a fridge to the level of water in overflow tanks in nuclear power plants. The statistical information can then be used to show how systems have been working. The advantage of WSNs over conventional loggers is the "live" data feed that is possible.

- **Industrial sense and control applications**
  In recent research a vast number of wireless sensor network communication protocols have been developed. While previous research was primarily focused on power awareness, more recent research have begun to consider a wider range of aspects, such as wireless link reliability, real-time capabilities, or quality-of-service. These new aspects are considered as an enabler for future applications in industrial and related wireless sense and control applications, and partially replacing or enhancing conventional wire-based networks by WSN techniques.

- **Water/Wastewater Monitoring**

  There are many opportunities for using wireless sensor networks within the water/wastewater industries. Facilities not wired for power or data transmission can be monitored using industrial wireless I/O devices and sensors powered using solar panels or battery packs and also used in pollution control board.

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- **Agriculture**

  Using wireless sensor networks within the agricultural industry is increasingly common; using a wireless network frees the farmer from the maintenance of wiring in a difficult environment. Gravity feed water systems can be monitored using pressure transmitters to monitor water tank levels, pumps can be controlled using wireless I/O devices and water use can be measured and wirelessly transmitted back to a central control center for billing. Irrigation automation enables more efficient water use and reduces waste

.

- **Greenhouse Monitoring**

  Wireless sensor networks are also used to control the temperature and humidity levels inside commercial greenhouses. When the temperature and humidity drops below specific levels, the greenhouse manager must be notified via e-mail or cell phone text message, or host systems can trigger misting systems, open vents, turn on fans, or control a wide variety of system responses.

- **Structural Monitoring**
  Wireless sensors can be used to monitor the movement within buildings and infrastructure such as bridges, flyovers, embankments, tunnels etc. enabling Engineering practices to monitor assets remotely without the need for costly site visits, as well as having the advantage of daily data, whereas traditionally this data was collected weekly or monthly, using physical site visits, involving either road or rail closure in some cases. It is also far more accurate than any visual inspection that would be carried out.

- **Passive localization and tracking**
  The application of WSN to the passive localization and tracking of non-cooperative targets (i.e., people not wearing any tag) has been proposed by exploiting the pervasive and low-cost nature of such technology and the properties of the wireless links which are established in a meshed WSN infrastructure.

- **Smart Home Monitoring**
  Monitoring the activities performed in a smart home is achieved using wireless sensors embedded within everyday objects forming a WSN. State changes to objects based on human manipulation are captured by the wireless sensors network enabling activity-support services.

IV. WIRELESS LAN STANDARDS

A **wireless local area network** (**WLAN**) links two or more devices using some wireless distribution method (typically spread-spectrum or OFDM radio), and usually providing a connection through an access point to the wider internet. This gives users the mobility to move around within a local coverage area and still be connected to the network. Most modern WLANs are based on IEEE 802.11 standards, marketed under the Wi-Fi brand name. **IEEE 802** refers to a family of IEEE standards dealing with local area networks and metropolitan area networks. More specifically, the IEEE 802 standards are restricted to networks carrying variable-size packets. The services and protocols specified in IEEE 802 map to the lower two layers (Data Link and Physical) of the seven-layer OSI networking reference model. In fact, IEEE 802 splits the OSI Data Link Layer into two sub-layers named Logical Link Control (LLC) and Media Access Control (MAC), so that the layers can be listed like this

- Data link layer LLC Sublayer MAC Sublayer
- Physical layer

The IEEE 802 family of standards is maintained by the IEEE 802 LAN/MAN Standards Committee (LMSC). The most widely used standards are for the Ethernet family, Token Ring, Wireless LAN, Bridging and Virtual Bridged LANs.

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Table 1 WLAN standards

Name	Description
IEEE 802.1	Bridging (networking) and Network Management
IEEE 802.2	LLC (Logical Link layer)
IEEE 802.3	Ethernet
IEEE 802.4	Token Bus
IEEE 802.5	Defines the MAC layer for a Token Ring
IEEE 802.6	MANs (DQDB)
IEEE 802.7	Broadband LAN using Coaxial Cable
IEEE 802.8	Fiber Optic TAG
IEEE 802.9	Integrated Services LAN (ISLAN or isoEthernet
IEEE 802.10	Interoperable LAN Security
IEEE 802.11	Wireless LAN (WLAN) & Mesh (Wi-Fi certification)
IEEE 802.12	100 Base VG
IEEE 802.13	Unused
IEEE 802.14	Cable Modems
IEEE 802.15 **IEEE 802.15.1**	Wireless PAN Bluetooth certification

IEEE 802.15.2 **IEEE 802.15.3** **IEEE 802.15.4** **IEEE 802.15.5** **IEEE 802.15.6**	IEEE 802.15 and IEEE 802.11 coexistence High-Rate wireless PAN Low-Rate wireless PAN (e.g., ZigBee, Wireless HART, MiWi, etc.) Mesh networking for WPAN Body area network
IEEE 802.16 **IEEE 802.16.1**	Broadband Wireless Access (WiMAX certification) Local Multipoint Distribution Service
IEEE 802.17	Resilient packet ring
IEEE 802.18	Radio Regularity Tag
IEEE 802.19	Coexistence TAG
IEEE 802.20	Mobile Broadband Wireless Access
IEEE 802.21	Media Independent Handoff
IEEE 802.22	Wireless Regional Area Network
IEEE 802.23	Emergency Services Working Group
IEEE 802.24	Smart Grid Tag
IEEE 802.25	Omni-Range Area Network

Standard	Bluetooth	UWB	ZigBee/CC2500	Wi-Fi
IEEE Spec	802.15.1	802.15.1a	802.15.4	802.11a/b/g
Frequency band	2.4 GHz	3.1-10.6 GHz	868/915 MHz, 2.4 GHz	2.4 GHz, 5 GHz
Max signal rate	1 mbps	110 Mb/s	250 kb/s	54 mb/s
Nominal Range	10 m	10 m	10-100 m	100 m
Nominal TX power	0-10 dBm	-41.3 dBm/MHz	(-25) – 0 dBm	15 – 20 dBm
Number of RF Channel	79	(1-15)	1/10; 16	14 (2.4 GHz)
Channel	1 MHz	500 MHz – 7.5 GHz	0.3/0.6 MHz; 2 MHz	22 MHz

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Bandwidth				
Modulation type	GFZSK	BOSK, QPSK	BPSK (+ASK), Q-QPSK	BPSK, QPSK ,COFDM, CCK, M-QAM
Spreading	FHSS	DS-UWB, MB-OFDM	DSSS	DSSS, CCK, OFDM
Coexistence Mechanism	Adaptive Freq. Hopping	Adaptive Freq. Hopping	Dynamic freq. Selection	Dynamic freq. Selection, transmit power control (802.11 h)
Basic cell	Pico net	Pico net	Star	BSS
Extension of the basic cell	Scattemet	Peer-to-peer	Cluster tree, Mesh	ESS
Max number of cell nodes	8	8	> 65000	2000
Encryption	ED stream cipher	AES block cipher (CTR, counter mode)	AES block cipher (CTR, counter mode)	RC4 stream cipher (WEP), AES block cipher
Authentication	Shared secret	CBC-MAC (CCM)	CBC-MAC (ext. of CCM)	WPA2 (802.11i)
Data protection	16-bit CRC	32-bit CRC	16-bit CRC	32-bit CRC

V. CONCLUSION

In the paper a review is carried out various wireless technologies for WSN and WLAN standards. A comparison of several Wireless protocols available, on the basis of their Frequency band, Max signal rate, Nominal Range, Nominal TX power, Number of RF Channel, Channel Bandwidth, Modulation type, Spreading, Coexistence Mechanism, Basic cell, Extension of the basic cell, Max number of cell nodes, Encryption, Authentication, Data protection. As it can be seen, the table presents technologies where the throughput is high. However, in an attempt to make the WMSM nodes wireless, this is not the only consideration. It is also noted, that the protocols presented above consume a considerable amount of power. Bluetooth however, has the feature of low power and hence is explored further. Also, a new and emerging protocol defined as ZigBee, which is known for its extremely low power protocol consumption stack and investigated as it is supported by the transceiver used to implement the WMSM in the present work.

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