
 Marmara University, 2021

# Wireless and Mobile Networks


Subject 4  
Wireless Personal Area Networks

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Associate Professor


 Contents


- Wireless Personal Area Networks (WPANs)
- The Bluetooth Technology
- Introduction to WSN
- Introduction to ZigBee
- Emerging WPAN Technologies

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 WIRELESS PERSONAL AREA NETWORKS (WPANS)


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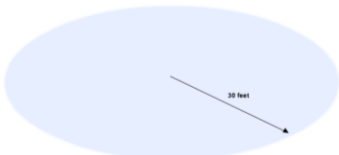
 Wireless Personal Area Networks (WPANs)



W P A N


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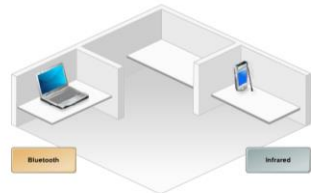
Wireless Personal Area Networks (WPANs) 



W P A N

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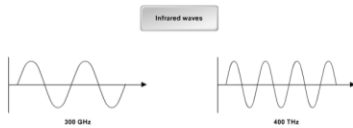
Wireless Personal Area Networks (WPANs) 



Bluetooth Infrared

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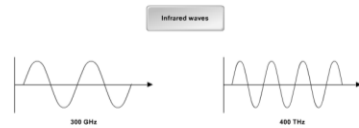
## Infrared Waves



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## Infrared Waves

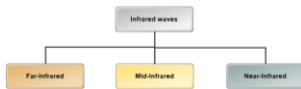


Wavelengths range from  
1 mm to 750 nm

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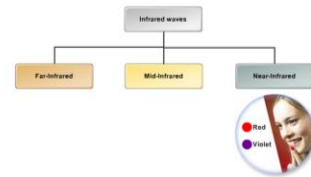
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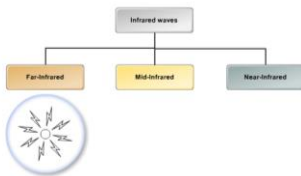
## Infrared Waves



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## Infrared Waves



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## Infrared Communication



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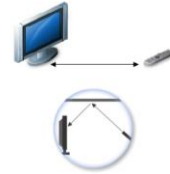
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## Infrared Communication



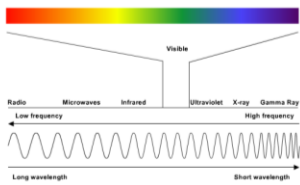
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## Infrared Communication



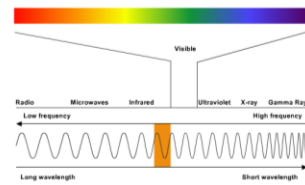
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## Infrared Communication



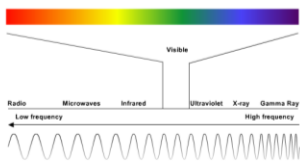
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## Infrared Communication



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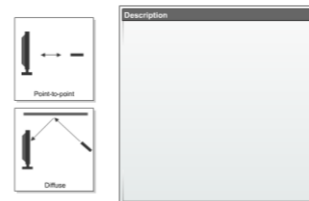
## Infrared Communication



*Wireless infrared communication  
is also referred to as wireless  
optical communication*

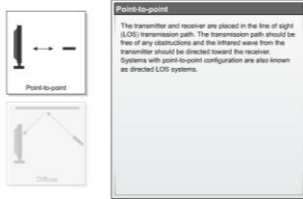
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## Infrared Configuration



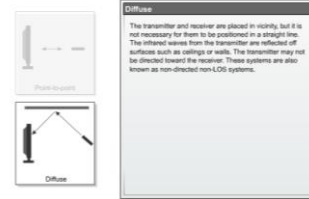
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## Infrared Configuration



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## Infrared Configuration



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## Infrared Devices



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## Infrared Devices



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## Infrared Devices



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## Infrared Devices



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## Infrared Devices

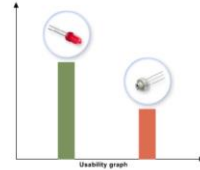


**Laser Diode**

- More focused beam
- More efficient

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## Infrared Devices



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## Infrared Devices



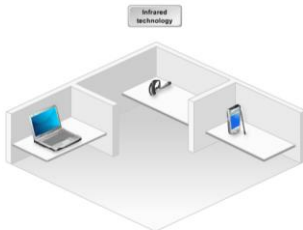
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## Applications of Infrared Technology



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## Applications of Infrared Technology



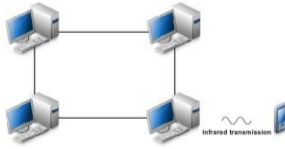
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## Applications of Infrared Technology



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## Applications of Infrared Technology



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## Applications of Infrared Technology



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## THE BLUETOOTH TECHNOLOGY



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## Bluetooth



*The IEEE standardized Bluetooth as IEEE 802.15.1, but no longer maintains the standard.*

**Bluetooth SIG** (Special Interest Group) is the standards organization that oversees the development of Bluetooth standards and the licensing of the Bluetooth technologies and trademarks to manufacturers.

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## Bluetooth



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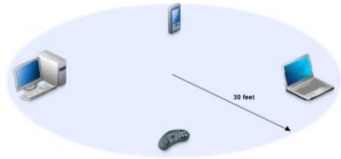
## Bluetooth



2.4 GHz

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## Bluetooth



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## Bluetooth



*Bluetooth devices operate at very low power levels of approximately 2.5 milliwatts*

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## Evolution of Bluetooth

managed by the **Bluetooth Special Interest Group (SIG)**



Latest version is 4.0 in 2010 with addendums in 2011, 2012, and 2013.

Revealed version is **Bluetooth 5**, in June 16, 2016, designed for **IoT**

Updated and most common version is 4.2 in 2014, Dec. 2

Updated version is 4.1 in 2013, December 4.

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## Competing Technologies

		ZigBee	Bluetooth technology	802.11b	802.11g	802.11a	802.11n	UWB
Throughput	Mbps	0.03	1-3	11	54	54	200	200
Max range	ft	75	30	200	200	150	150	30
Sweet spot	Mbps-ft	.03@75	1-3@10	24@200	24@200	36@100	100@100	200@10
Service	bps-kb	530	314M	251G	251G	1.13T	3.14T	62G
Power	mW	30	100	750	1000	1500	2000	400
BW	MHz	0.6	1	22	20	20	40	500
Spectral efficiency	bit/s/MHz	0.05	1	0.5	2.7	2.7	5	0.4
Power efficiency1	mW/Mbps	1000	100	68	19	27	10	2
Power efficiency2	mW/GB	2211	67	46	12	18	7	1.3
TTTB	Time	3.1 day	2.2 hr	12 min	2.5 min	2.5 min	40 sec	40 sec
Price	US\$	\$2	\$3	\$5	\$9	\$12	\$20	\$7

<http://www.bluetooth.com/Pages/Competing-Tech.aspx>

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## Bluetooth Network Types



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## Bluetooth Network Types



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## Bluetooth Network Types



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## Bluetooth Network Types



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## Bluetooth Network Types



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## Bluetooth Network Types



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## Bluetooth Network Types



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## Bluetooth Network Types



*The bridge node can act as a slave in one piconet and a master in another*

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## Bluetooth Connectivity



Inquiry  
Paging

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## Bluetooth Connectivity



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## Bluetooth Connectivity



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## Bluetooth Connectivity



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## Bluetooth Connectivity



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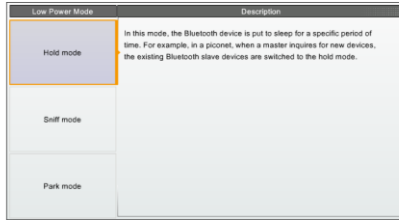
## Low Power Modes in Bluetooth



Low Power Mode	Description
Hold mode	
Sniff mode	
Park mode	

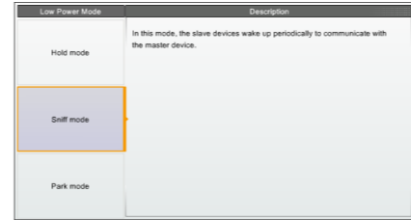
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## Low Power Modes in Bluetooth



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## Low Power Modes in Bluetooth



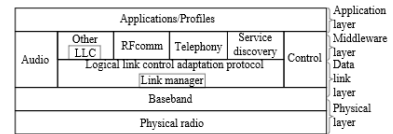
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## Low Power Modes in Bluetooth



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## Bluetooth Protocol Stack

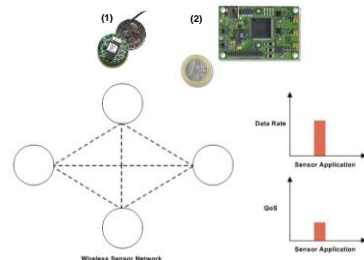


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## INTRODUCTION TO WSN

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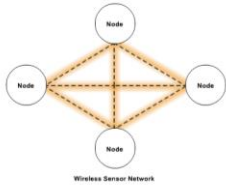
## Wireless Sensor Networks



(1) Source: <https://www.comsys.rwth-aachen.de/teaching/ss-13/wireless-sensor-networks-lab/>  
 (2) Source: <http://www.itp-microelectronics.com/en/solutions/wireless-sensor-networks.html>

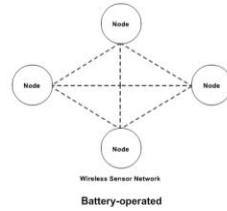
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## Wireless Sensor Networks



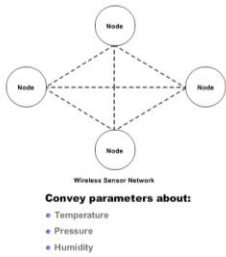
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## Wireless Sensor Networks



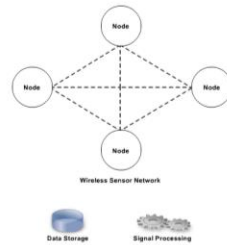
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## Wireless Sensor Networks



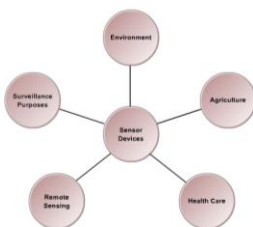
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## Wireless Sensor Networks



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## Wireless Sensor Networks



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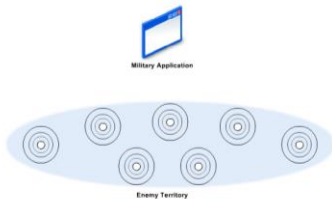
## Wireless Sensor Networks



**Wireless sensor networks  
are widely used in  
military applications**

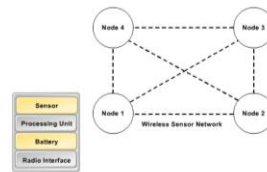
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## Wireless Sensor Networks



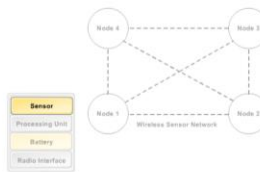
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## Communication in a Wireless Sensor Network



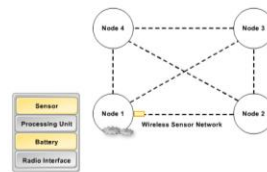
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## Communication in a Wireless Sensor Network



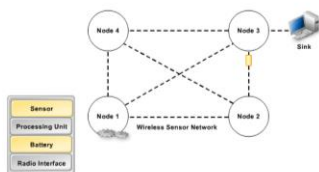
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## Communication in a Wireless Sensor Network



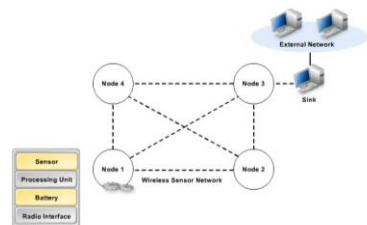
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## Communication in a Wireless Sensor Network



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## Communication in a Wireless Sensor Network



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## Features of WSN



Feature	Description
Collaboration	
Redundancy	
Scalability	
Many-to-one communication	

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## Features of WSN



Feature	Description
Collaboration	Nodes in the wireless sensor network collaborate with each other for passing on information instead of competing with each other. For example, if a node cannot communicate directly to the sink, it can use the help of other nodes to transmit the information.
Redundancy	
Scalability	
Many-to-one communication	

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## Features of WSN



Feature	Description
Collaboration	
Redundancy	Wireless sensor networks involve a number of sensor nodes. Therefore, even if a node fails, the other nodes can take over.
Scalability	
Many-to-one communication	

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## Features of WSN



Feature	Description
Collaboration	
Redundancy	
Scalability	Wireless sensor networks are very easy to configure. Therefore, more sensor nodes can be added as and when needed.
Many-to-one communication	

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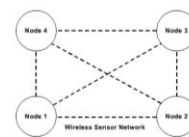
## Features of WSN



Feature	Description
Collaboration	
Redundancy	
Scalability	
Many-to-one communication	Nodes in a wireless network transmit information to the sink. This is an example of many-to-one communication. This feature further enhances the redundancy of wireless sensor networks.

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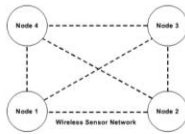
## Advantages of WSN



Greater coverage

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## Advantages of WSN

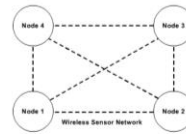


Accuracy

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## Advantages of WSN

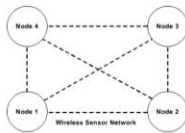


Redundancy

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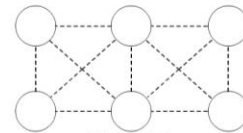
## Advantages of WSN



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## Advantages of WSN

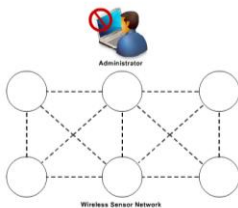


Wireless sensor networks  
form a network on their own

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## Advantages of WSN

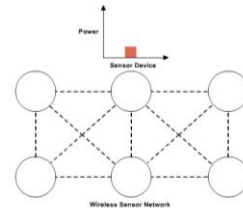


Wireless Sensor Network

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## Advantages of WSN



Sensor devices have a  
battery life of up to a year

Now, there are batteries  
living up to 10 years!

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## INTRODUCTION TO ZIGBEE

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## IEEE 802.15.4



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## IEEE 802.15.4



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## IEEE 802.15.4



Frequency Band	Region
2.400 - 2.484 GHz	Worldwide
902 - 928 MHz	North America
868.0 - 868.6 MHz	Europe

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## ZigBee



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## ZigBee



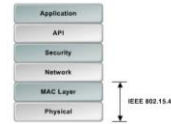
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## ZigBee



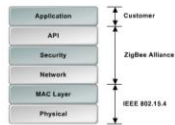
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## ZigBee



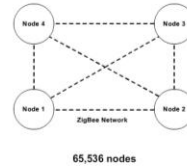
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## ZigBee



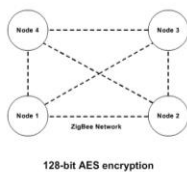
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## ZigBee



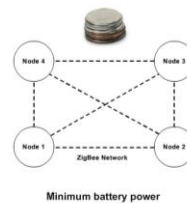
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## ZigBee



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## ZigBee



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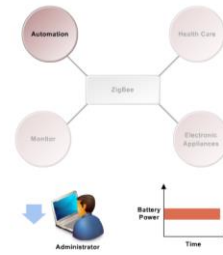


## ZigBee Applications



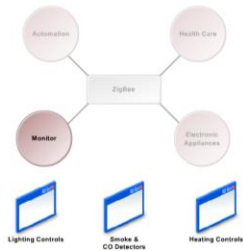
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## ZigBee Applications



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## ZigBee Applications



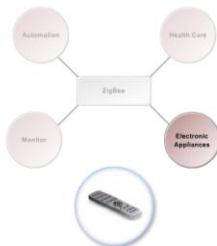
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## ZigBee Applications



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## ZigBee Applications




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## EMERGING WPAN TECHNOLOGIES



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### Ultra-Wideband




WPAN

Ultra-wideband

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### Ultra-Wideband




WPAN

480 Mbps

3.1 to 10.6 GHz UWB spectrum

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### Ultra-Wideband




Transmitter

WPAN

Receiver

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### Ultra-Wideband



Transmitter


WPAN

Receiver

38 Picoseconds

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### Ultra-Wideband



Transmitter


WPAN

Receiver

> 300 MHz

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### Ultra-Wideband



Transmitter

WPAN

Receiver

Transmitter 1

Transmitter 2

Transmitter 3

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## Ultra-Wideband



*UWB pulses are  
virtually untraceable*

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## WiMedia Alliance



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## WiMedia Alliance



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## WiMedia Alliance



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## WiMedia Alliance



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## WiMedia Alliance



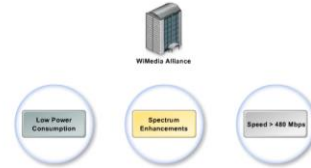
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## WiMedia Alliance



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## WiMedia Alliance



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## UWB Applications



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## UWB Applications



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## UWB Applications



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## UWB Applications



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## UWB Applications



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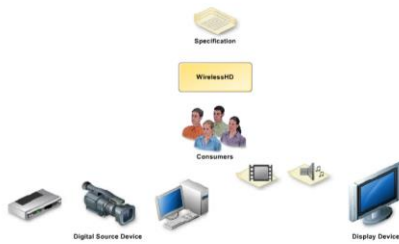
## WirelessHD



*Next generation of  
interoperable multi-gigabit wireless  
high definition digital interface*

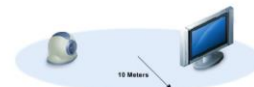
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## WirelessHD



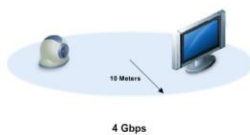
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## WirelessHD



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## WirelessHD

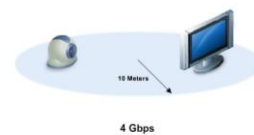


- 7 GHz channel in the 60 GHz radio band
- allows theoretical data rates as high as 25 Gbit/s
- digital transmission of high-definition video and audio and data signals, essentially making it equivalent of a wireless HDMI.

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## WirelessHD

**HOMEWORK: Wireless Gigabit Alliance**



- 7 GHz channel in the 60 GHz radio band
- allows theoretical data rates as high as 25 Gbit/s
- digital transmission of high-definition video and audio and data signals, essentially making it equivalent of a wireless HDMI.

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