

# Chapter 06

## CS596 IoT IoT Introduction

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## CS596 IoT Introduction

### Ch-6 IoT RF Technologies-1

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## Class-6 Outline

- RF
- NFC
- Bluetooth
- WiFi
- RFIC
- WiFi
- 6LoPAN
- ZigBee
- Z-Wave
- RFIC

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## Wireless Transmission Frequencies

1GHz to 40GHz	<ul style="list-style-type: none"><li>‣ Referred to as microwave frequencies</li><li>‣ Highly directional beams are possible</li><li>‣ Suitable for point to point transmissions</li><li>‣ Also used for satellite communications</li></ul>
30MHz to 1GHz	<ul style="list-style-type: none"><li>‣ Suitable for omnidirectional applications</li><li>‣ Referred to as the radio range</li></ul>
$3 \times 10^{11}$ to $2 \times 10^{14}$	<ul style="list-style-type: none"><li>‣ Infrared portion of the spectrum</li><li>‣ Useful to local point-to-point and multipoint applications within confined areas</li></ul>

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## Antennas



- Electrical conductor or system of conductors used to radiate or collect electromagnetic energy
- Radio frequency electrical energy from the transmitter is converted into electromagnetic energy by the antenna and radiated into the surrounding environment
- Reception occurs when the electromagnetic signal intersects the antenna
- In two way communication, the same antenna can be used for both transmission and reception

Source: W. Stalling

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## Radiation Pattern

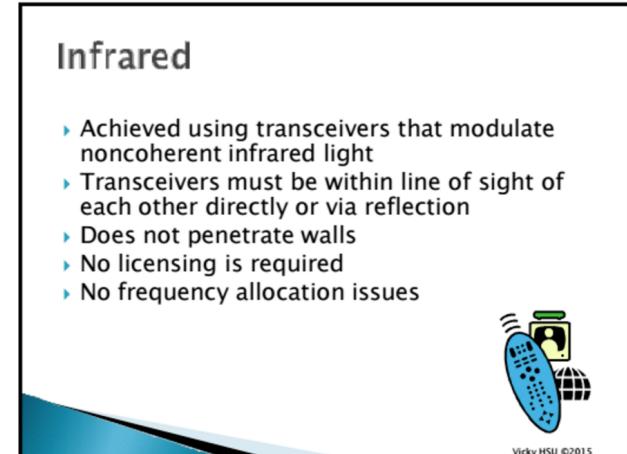
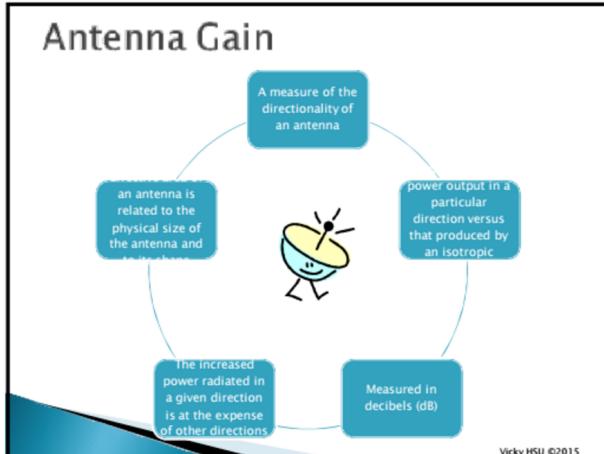
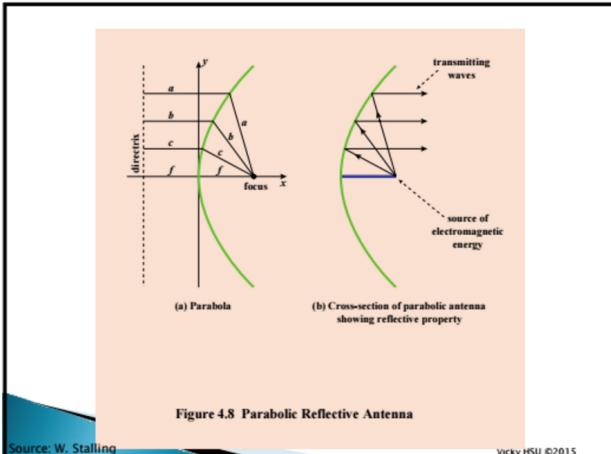
- Power radiated in all directions
  - Does not perform equally well in all directions
- Radiation pattern
  - A graphical representation of the radiation properties of an antenna as a function of space coordinates
- Isotropic antenna
  - A point in space that radiates power in all directions equally
  - Actual radiation pattern is a sphere with the antenna at the center



in  
with

Source: W. Stalling

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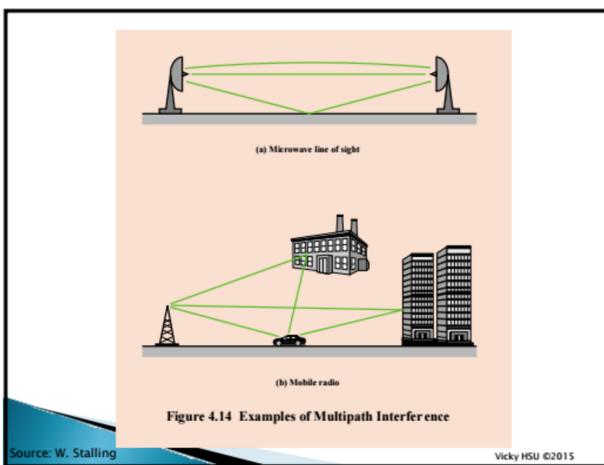
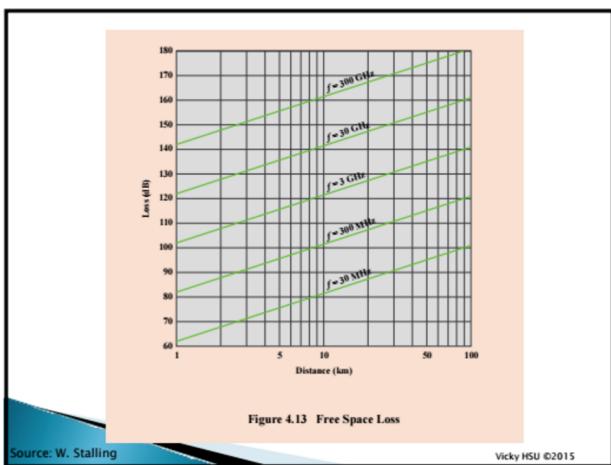
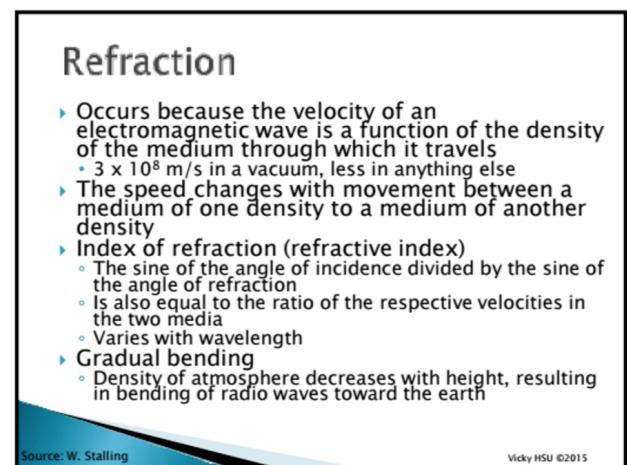
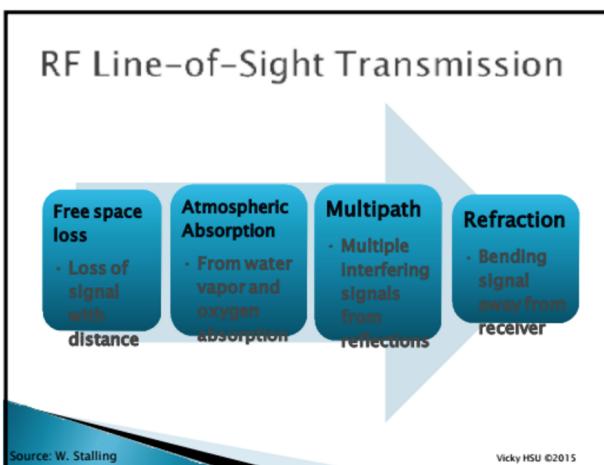


Band	Frequency Range	Free-Space Wavelength Range	Propagation Characteristics	Typical Use
ELF (extremely low frequency)	30 to 300 Hz	10,000 to 1000 km	GW	Power line frequencies; used by some home control systems.
MF (medium frequency)	300 to 3000 kHz	1000 to 100 km	GW	Used by the telephone system for analog subscriber lines.
VLF (very low frequency)	3 to 30 kHz	100 to 10 km	GW; low attenuation day and night; high atmospheric noise level	Long-range navigation; submarine communication
LF (low frequency)	30 to 300 kHz	10 to 1 km	GW; higher power than VLF; absorption in daytime	Long range navigation; marine communication radio beacons
MF (medium frequency)	300 to 3000 kHz	1,000 to 100 m	GW and night SW; attenuation low at night, high in day atmospheric noise	Maritime radio; direction finding; AM broadcasting.
HF (high frequency)	3 to 30 MHz	100 to 10 m	SW; quality varies with time of day, season, and frequency	Amateur radio; military communication
VHF (very high frequency)	30 to 300 MHz	10 to 1 m	LOS; increasing because of temperature inversion; cosmic noise	VHF television; FM broadcast and two-way radio; AM aircraft communication; aircraft navigational aids
UHF (ultra high frequency)	300 to 3000 MHz	100 to 10 cm	LOS; cosmic noise	Ultra television; cellular telephony; microwave links; personal communications systems
SHF (super high frequency)	3 to 30 GHz	10 to 1 cm	LOS; rainfall attenuation above 10 GHz; attenuation due to oxygen and water vapor	Satellite communication; radar; terrestrial microwave links; wireless local loop
EHF (extremely high frequency)	30 to 300 GHz	10 to 1 mm	LOS; atmospheric attenuation due to oxygen and water vapor	Experimental; wireless local loop; radio astronomy
Infrared	300 GHz to 400 THz	1 mm to 770 nm	LOS	Infrared LANs; consumer electronic applications
Visible light	400 THz to 900 THz	770 nm to 330 nm	LOS	Optical communication

Table 4.5  
Frequency Bands

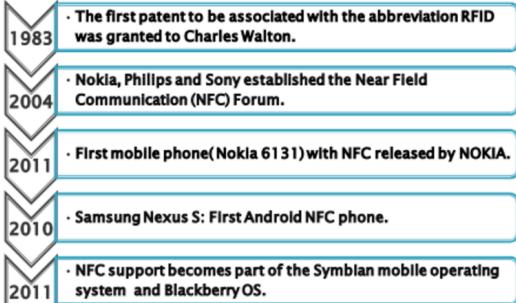
(Table can be found on page 136 in textbook)

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- ## What Is NFC?
- NFC trademark logo
- NFC or Near Field Communication is a short range high frequency wireless communication technology.
  - NFC is mainly aimed for mobile or handheld devices.
  - A radio communication is established by touching the two phones or keeping them in a proximity of a few centimeters (up to 10 cm).
  - It allows for simplified transactions, data exchange, and wireless connections between two devices.
  - Allows communication between
    - Two powered (**active**) devices
    - Powered and non self-powered (**passive**) devices
- Source:NFC Forum, IEEE, Akamai
- Vicky HSU ©2015

## History of NFC



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## Features

- NFC is an extension of **Radio frequency identification (RFID)** technology that combines the interface of a smartcard and a reader into a single device. This allows **two-way communication** between endpoints, where earlier systems were one-way only.
- It operates within the globally available and unlicensed radio frequency band of **13.56 MHz**, with a bandwidth of **14 kHz**.
- Working distance with compact standard antennas: up to **10 cm**.
- Supported data rates: **106, 212 and 424 Kbit/s**
- For two devices to communicate using NFC, one device must have an NFC **reader/writer** and one must have an **NFC tag**

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## NFC Reader

Usually a microcontroller-based (for example NFC enabled phones) with an integrated circuits that is capable of generating radio frequency at 13.56 MHz with other components such as encoders, decoders, antenna, comparators, and firmware designed to transmit energy to a tag and read information back from it by detecting the backscatter modulation. The reader continuously emits RF carrier signals, and keeps observing the received RF signals for data.

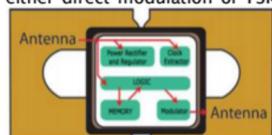


An NFC Reader  
(A Smartphone)

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## NFC Tag

An RFID device incorporating a silicon memory chip connecting to external antenna. Tag does not have its own power source (**passive**). The passive tag absorbs a small portion of the energy emitted by the reader (phone), and starts sending modulated information when sufficient energy is acquired from the RF field generated by the reader. Data modulation (modulation for 0s and 1s) is accomplished by either direct modulation or FSK or Phase modulation.



Following figure shows the internal hardware of NFC tag where we can see its memory, logic etc.

Source:NFC Forum, IEEE, Akshay

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## Operation Of NFC

- NFC has two communicative terminals :The **INITIATOR** is the one who wishes to communicate and starts the communication. The **TARGET** receives the initiator's communication request and sends back a reply



- NFC employs two different coding to transfer data. If an active device transfers data at 106 Kbit/s, a **Modified Miller** coding with 100% modulation is used. In all other cases **Manchester coding** is used with a modulation ratio of 10%.

Source:NFC Forum, IEEE, Akshay

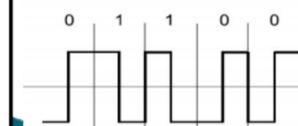
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## Operation Of NFC

### Manchester Coding

### Modified Miller Coding

- A low-to-high transition expresses a 0 bit, whereas a high-to-low transition stands for a 1 bit.

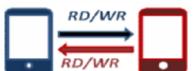


Source:NFC Forum, IEEE, Akshay

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## Operation Of NFC

There are two mode of communication



**Passive Communication Mode:** The Initiator device provides a carrier field and the target device answers by modulating existing field. In this mode, the Target device may draw its operating power from the Initiator-provided electromagnetic field.

**Active Communication Mode:** Both Initiator and Target device communicate by alternately generating their own field. A device deactivates its RF field while it is waiting for data. In this mode, both devices typically need to have a power supply.

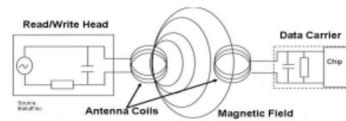
Source:NFC Forum, IEEE, Akshay

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## Operation Of NFC

- NFC devices communicate via **magnetic field induction**, where two loop antennas are located within each other's **near field**, effectively forming an **air-core transformer**.

- The reader continuously generates an RF carrier sine wave (at **13.56 MHz**), watching always for modulation to occur. Detected modulation of the field would indicate the presence of a tag.



Source:NFC Forum, IEEE, Akshay

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## Operation Of NFC

- A tag enters the RF field generated by the reader. Once the tag has received sufficient energy to operate correctly, it divides down the carrier and begins clocking its data to an output transistor, which is normally connected across the coil inputs.

- The tag's output transistor shunts the coil, sequentially corresponding to the data which is being clocked out of the memory array.

- Shunting the coil causes a momentary fluctuation (dampening) of the carrier wave, which is seen as a slight change in amplitude of the carrier.

- The reader peak-detects the amplitude modulated data and processes the resulting bit stream according to the encoding and data modulation methods used.

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## Comparison With Existing Technologies

	NFC	RFID	Wi-Fi	Bluetooth
Set-up time	<0.1ms	<0.1ms	>0.5s	>6 sec
Range	Up to 10cm	Up to 3m	Up to 5m	Up to 30m
Usability	Human centric Easy, intuitive, fast	Item centric Easy	Data centric Easy	Data centric Medium
Selectivity	High, given, security	Partly given Line of sight		Who are you?
Use cases	Pay, get access, share, initiate service, easy set up	Item tracking	Control & exchange data	Network for data exchange, headset
Consumer experience	Touch wave, simply connect	Get information	Easy	Configuration needed

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## Operating Modes of NFC devices



### Reader/writer mode

The NFC device is capable of reading NFC Forum-mandated tag types, such as a tag embedded in an NFC smart poster



### Peer-to-Peer mode

Two NFC devices can exchange data. For example, you can share Bluetooth or Wi-Fi link set-up parameters or you can exchange data such as virtual business cards or digital photos.



### Card Emulation mode

The NFC device appears to an external reader much the same as a traditional contactless smart card. This enables contactless payments and ticketing by NFC devices without changing the existing infrastructure.

Source:NFC Forum, IEEE, Akshay

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## Specifications

The NFC Forum has issued various specifications to date:

Specification	Purpose
NFC Data Exchange Format (NDEF)	Defines a common data format between NFC-compliant devices and tags
Record Type Definition (RTD)	Specifies rules for building standard record types. Five specific RTDs (Text, URI, Smart Poster, Generic Control, and Signature) are used to build standard record types
Logical Link Control Protocol (LLCP)	Defines a protocol to support peer-to-peer communication between two NFC-enabled devices
Connection Handover	Defines how to establish a connection using other wireless communication technologies
Operations Specifications for Four Tag Types (1/2/3/4)	Enable core interoperability between tags and NFC devices

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## Benefits of NFC

NFC provides a range of benefits to consumers and businesses, such as:

- **Versatile:** NFC is ideally suited to the broadest range of industries, environments, and uses
- **Open and standards-based:** The underlying layers of NFC technology follow universally implemented ISO, ECMA, and ETSI standards
- **Technology-enabling:** NFC facilitates fast and simple setup of wireless technologies, (such as Bluetooth, Wi-Fi, etc.)
- **Inherently secure:** NFC transmissions are secure due to short range communication
- **Interoperable:** NFC works with existing Contactless card technologies
- **Security-ready:** NFC has built-in security abilities to support secure applications



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## Application of NFC



Source:NFC Forum, IEEE, Akshay

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## Application of NFC

### Smart Posters

- An object that has, affixed to or embedded in it, one or more readable NFC tags with NDEF messages stored in them.
- Each tag is read when an NFC device is held close to it
- "N-Mark" shows touch point
- Not only a paper poster on the wall
- Billboard, garment tag, magazine page, even a three-dimensional object



The Smart Poster record defines a URI plus some added metadata about it

NDEF Message	
Sp (Smart Poster)	application/vcard
URI	Action Configuration vCard data

Source:NFC Forum, IEEE, Akshay

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## Application of NFC

### NFC and Mobile Payment

A customer makes his payment through mobile phone using NFC

- ▶ NFC phone will open wallet application
  - Wallet will display product cost when user clicks "Buy"
- ▶ At check out, wallet will display all credit/debit cards in wallet for payment
- ▶ Customer will select card for payment
- ▶ Wallet will show the confirmation page with the check out basket
- ▶ Wallet will connect to retailer back end for authorization and display tracking information



Source:NFC Forum, IEEE, Akshay

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## Application of NFC

### Peer-to-peer

- **Connection Handover:** A handover use case is the exchange of configuration information via the NFC link to easily establish a connection over (for e.g. Bluetooth or Wi-Fi) and carry the information to be shared. Connection can be set between NFC devices
- Home computer components      \* In-car devices
- Home entertainment systems      \* Headsets and handsets
- Cameras and printers      \* Secure WLAN modem set-up
- If the amount of information is relatively small (up to one kilobyte), it is possible to use NFC to transmit the data itself (e.g. electronic business cards, contacts).



Speakers (touch to connect)



GPS On  
Bluetooth On  
Launch Map Application

Smart Tags

Source:NFC Forum, IEEE, Akshay

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## Application of NFC

- Asset Management – Use NFC phones to read smart tags per product for inventory
- Remote worker reporting – Remote workers confirm locations visited and tasks completed
- Access – Ensure secure building area access for personnel with NFC device and contactless reader
- Maps – An interactive NFC Smart Poster map allows the user to download the map, get additional information on relevant services, and access coupons, etc.
- Parking – Use NFC to authenticate parking entry and keep record.
- Meal orders – Customers order their meals by touching NFC Smart Posters.

Source:NFC Forum, IEEE, Akshay

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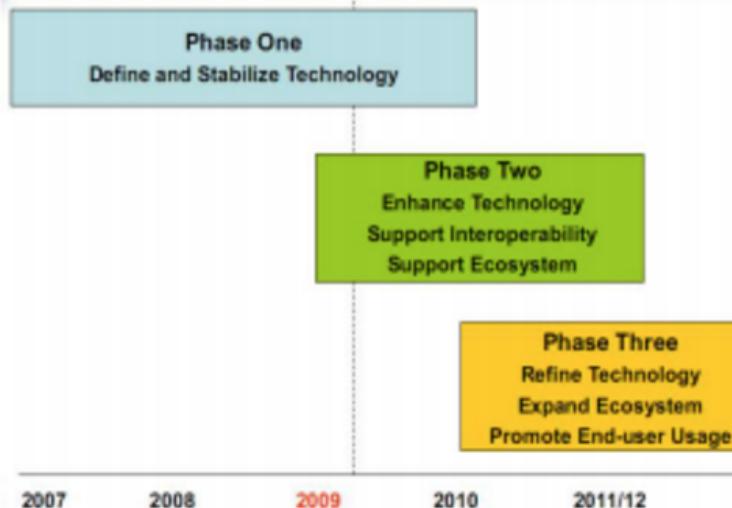
# *Evolution and Future of NFC*

## NFC Forum

The NFC Forum is a non-profit industry association to advance the use of NFC short-range wireless interaction in consumer electronics, mobile devices and PCs.

The NFC Forum promotes implementation and standardization of NFC technology to ensure interoperability between devices and services. In September 2008, there were over 150 members of the NFC Forum.

## NFC Projected Development



Source:NFC Forum etc

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