Mobile Tagging (2)

CSE 162 – Mobile Computing

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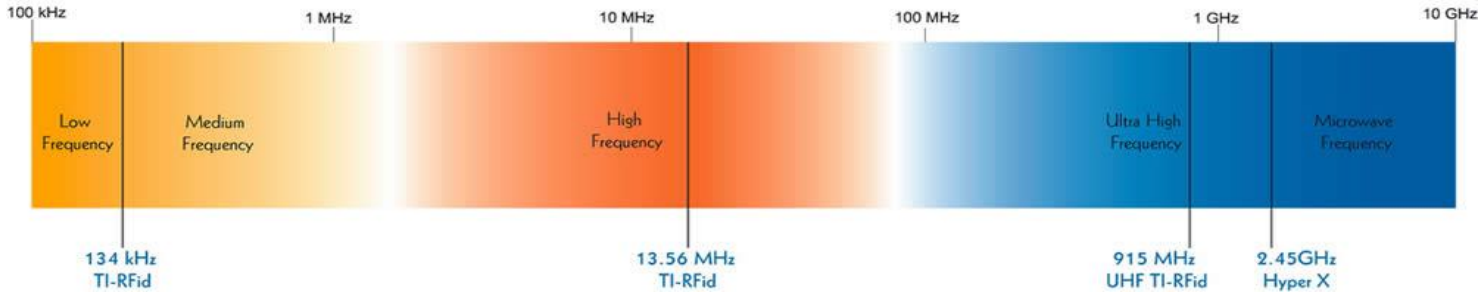
Recap: RFID vs. Bar Codes

	Manual Process	**Bar Code**	**RFID**
Data Accuracy	Least Accurate	Most Accurate	**More Accurate**
Data Collection Time/Labor	Most Time/Labor	Some Time/Labor	**Least Time/Labor**
Data Input Time/Labor	Most Time/Labor	Some Time/Labor	**Least Time/Labor**
Equipment Costs (tags, readers/scanners)	N/A	Some	**More**
Ability to Track Assets Out of Line of Sight	No	No	**Yes**
Amount of Data Storage on Tag	N/A	Less	**More**
Ability to Exchange Information Two Ways	No	No	**Yes**
Ability to Reprogram Tags	N/A	No	**Yes**

Limitations of RFID

- Scanning single vs multiple items
  - An RFID reader can scan all tags within its range.
  - Doesn’t work well if you’re only trying to scan specific items.
  - Special protocols or barriers needed to solve the problem
  - Barcode: scan one item at a time.
- Material limitations
  - RFID tags are very specific to the type of material
  - E.g., metal will deactivate the RFID antenna.
  - E.g., Liquid products affect the reliability of the signal: that’s why RFID not used in grocery stores
- Cost Comparison
  - A typical barcode label costs a few cents each, while an RFID tag can run from one dollar or up.
  - RFID readers are also more expensive than barcode scanners.

Recap: Frequencies



- Low Frequency (LF)
  - 125 KHz or 134KHz
  - Shorter read-range and read-rate
  - Less sensitive to interference
- High Frequency (HF)
  - 13.56 MHz
  - Greater read-range & higher read-speed than LF
- Ultra-High Frequency (UHF)
  - 860 to 930 MHz
  - Same cost as HF
  - Faster Data Transfer
  - Limited read ability
- **Microwave**
  - **2.45GHz or 5.8GHz**
  - **Highest data read speed**
  - **Most expensive**
  - **Limited read range (3ft)**

More about Microwave RFID

- Almost all microwave tags use 2.45 GHz.
- Expensive because the production volume is low.
- High data throughput because of more bandwidths
- Passive microwave tags have the same read range of about 3 feet.
- The semi-passive microwave tags have a read range of about 100 feet, while the active microwave tags have read range of about 350 feet.

Factors that influence microwave rfid ranges

- Reflections and interferences
  - Reflected and transmitted EM waves interfere with each other
  - Destructive interference leads to nulls in the EM field
  - Less severe is High and Low frequency bands
- Eddy Current Losses
  - losses in conducting surfaces are proportional to frequency
- Absorption by non-conductors
  - Nonconductors with a high dielectric constant can cause severe performance degradation, yet have little impact on low-frequency RFID.
  - E.g., LF or HF tags are preferred for animal tagging or those involving humans.

Eddy current loss

- When a time-varying magnetic field is applied to a magnetic material, an emf is induced in the material itself according to Faraday's Law of Electromagnetic induction.
- Since the magnetic material is a conducting material, these EMFs circulate current within the body of the material.

- The eddy current power loss in a magnetic material is given by the equation shown below:

$$P_e = K_e B_m^2 t^2 f^2 V \qquad \text{watts}$$

Collision Avoidance in RFID

- Tag collision
- Reader collision

Tag Collision Avoidance

Tag Collision Problem

When multiple tags are in range of the reader:

- All the tags will be excited at the same time.
- Makes it very difficult to distinguish between the tags.

Tag Collision Problem

- Collision avoidance mechanisms:
  - Probabilistic: Tags return at random times.
  - Deterministic: Reader searches for specific tags.

- Several approaches
  - Aloha algorithm
  - Tree algorithm
  - Memoryless protocol
  - Contactless protocol

Tag Collision avoidance: ALOHA

- Tags detect when a collision has occurred, and attempt to resend after waiting a random interval.

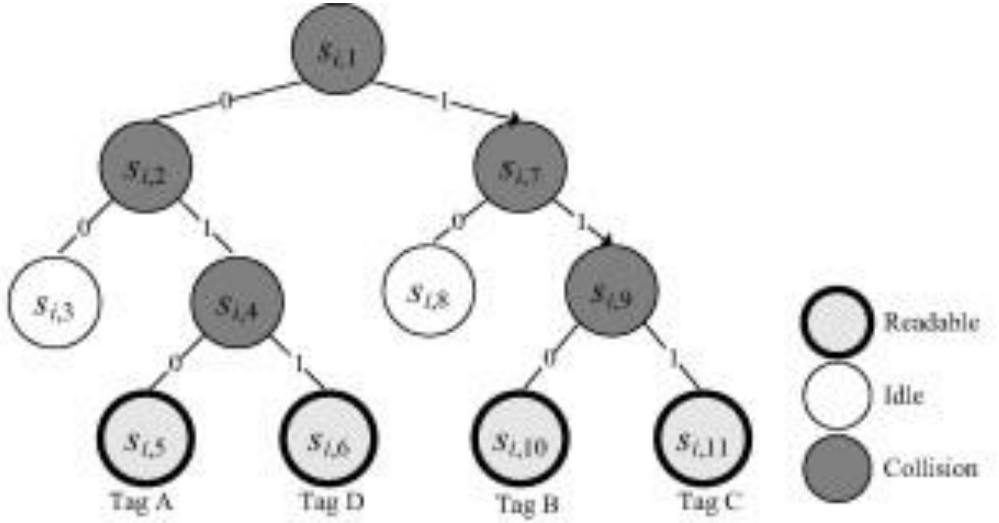
- Pros: simple
- Cons: when tags are dense, the network can reach congestion collapse.

Tree Algorithm

- Reader queries for tags
- Reader informs in case of collision and tags generates 0 or 1 randomly
- If 0 then tag retransmits on next query
- If 1 then tag becomes silent and starts incrementing its counter (which is initially zero)
- Counter incremented every time collision reported and decremented every time identification reported
- Tag remains silent till its counter becomes zero

Example

- Reader informs tags in case of collision and tags generate 0 or 1
- If 0 then tag retransmits on next query, else tag becomes silent and starts a counter. Counter incremented every time collision reported and decremented otherwise.



(a) Application of binary tree algorithm in frame f_i

Slot	Counter value					Responding tag	Feedback message
	Reader	Tag A	Tag B	Tag C	Tag D		
1	0	0	0	0	0	A,B,C,D	Collision
2	1	0	1	1	0	A,D	Collision
3	2	1	2	2	1		Idle
4	1	0	1	1	0	A,D	Collision
5	2	0	2	2	1	A	Readable
6	1		1	1	0	D	Readable
7	0		0	0		B,C	Collision
8	1		1	1			Idle
9	0		0	0		B,C	Collision
10	1		0	1		B	Readable
11	0			0		C	Readable
12	-1						Terminate

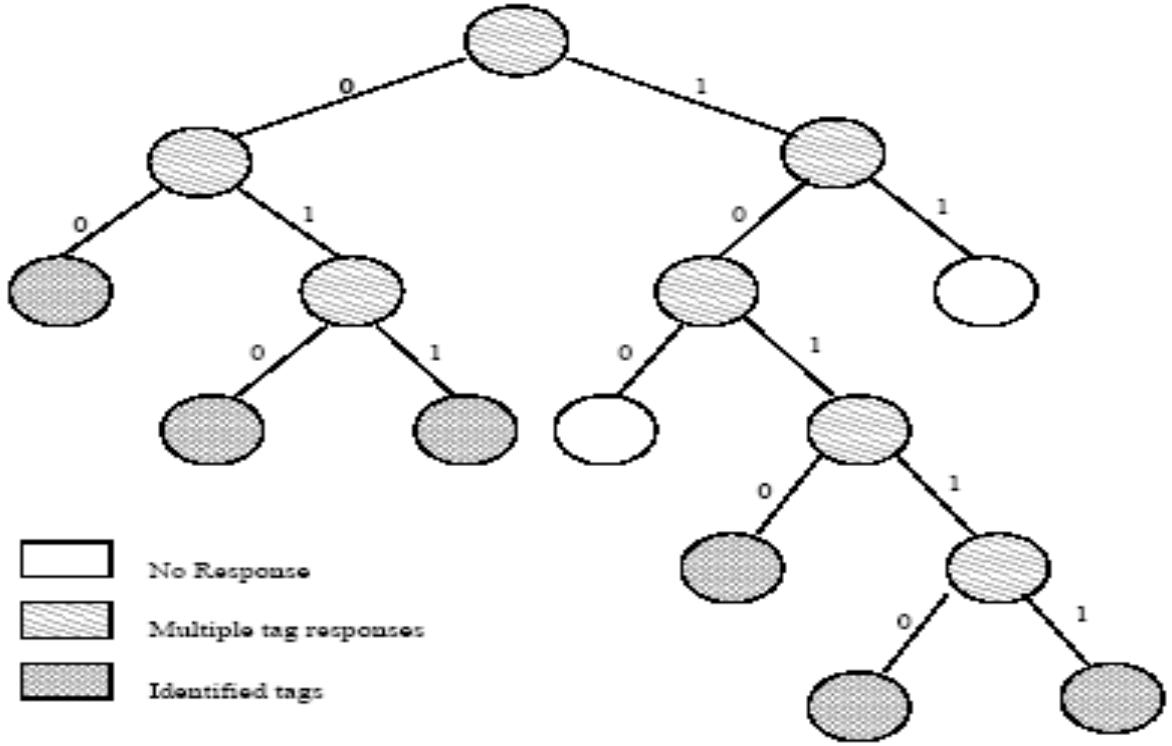
Memoryless Protocol

- Assumption: tagID stored in *k* bit binary string
- Algorithm
  - Reader queries for prefix *of length p*
  - In case of collision queries prefix of length p+1

Memoryless Protocol – Example

- Reader queries for prefix of length *p*
- In case of collision, reader queries for prefix of length p+1
- Example: consider tags with prefixes: 00111, 01010, 01100, 10101, 10110 and 10111

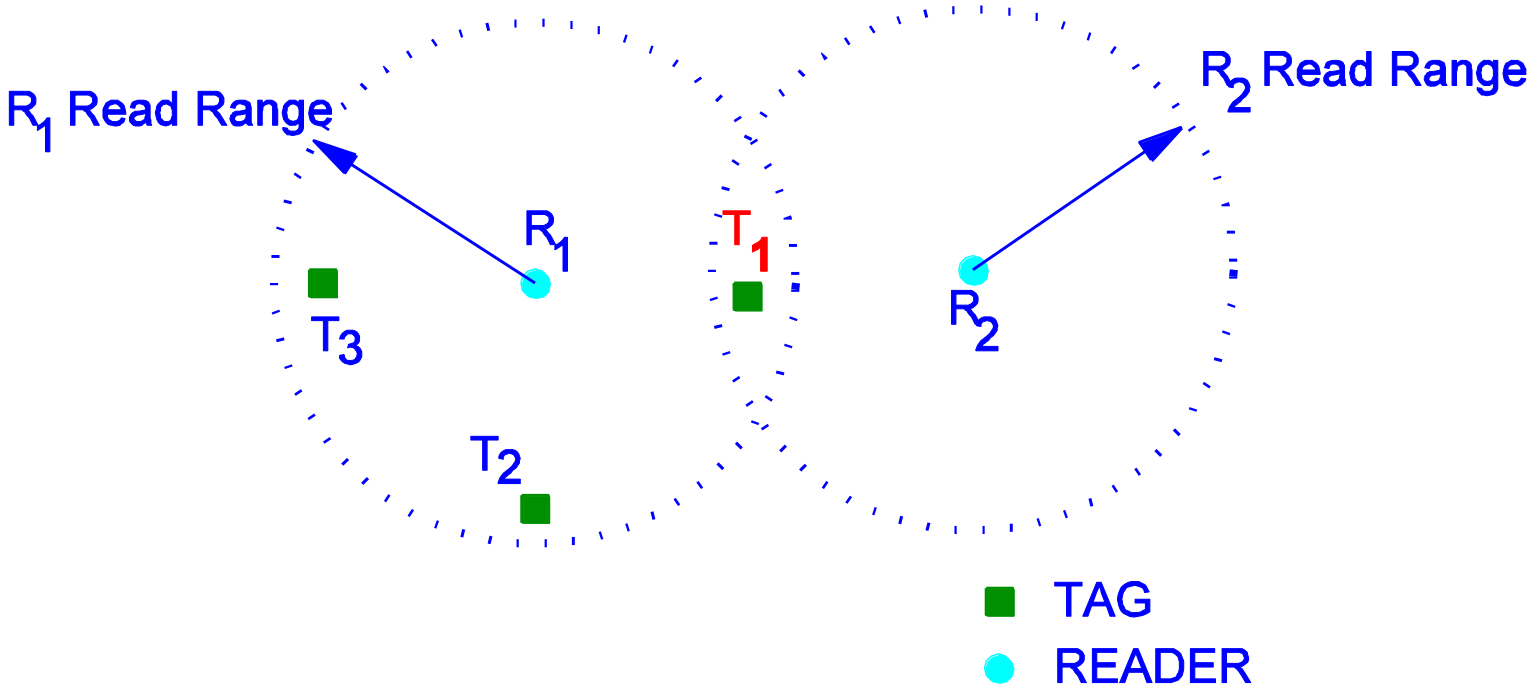
Step	Query Prefix	Response
1	0	Collision
2	1	Collision
3	00	00111 (Identified)
4	01	Collision
5	10	Collision
6	11	No Response
7	010	01010 (Identified)
8	011	01100 (Identified)
9	100	No Response
10	101	Collision
11	1010	10101 (Identified)
12	1011	Collision
13	10110	10110 (Identified)
14	10111	10111 (Identified)



Reader Collision Avoidance

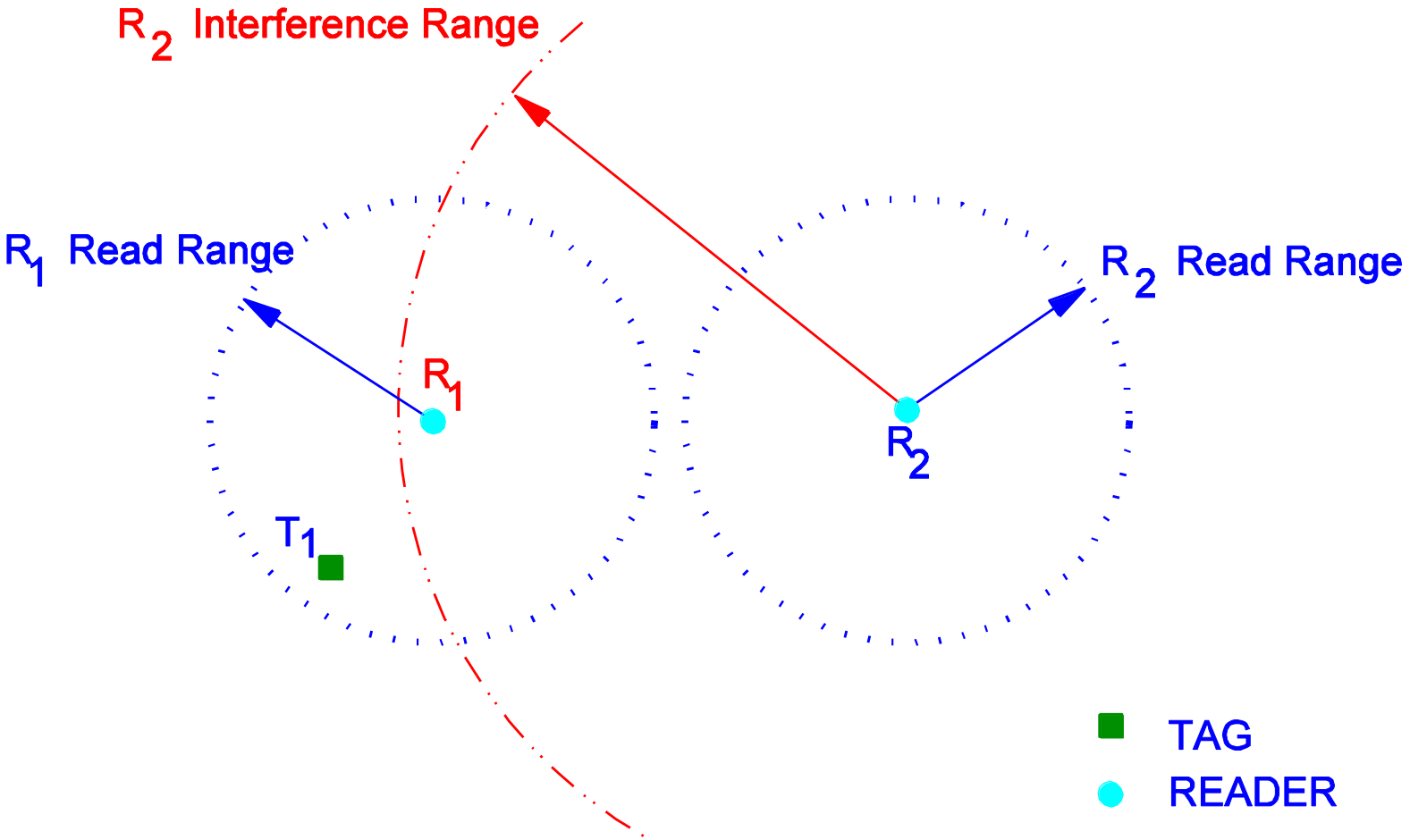
Reader Collision Problem

- Hidden Terminal



Reader Collision Problem

- Reader to Reader Interference:



Existing Solutions

- **TDMA :** Interfering readers transmit in different timeslot
  - Time synchronisation required
  - Timeslot distribution is inefficient in a mobile network
- **CSMA :** Sense channel before transmitting
  - RFID suffer from hidden terminal
  - Collision happen at the tags and hence collision detection is not possible by carrier sensing at the readers alone

Existing Solutions

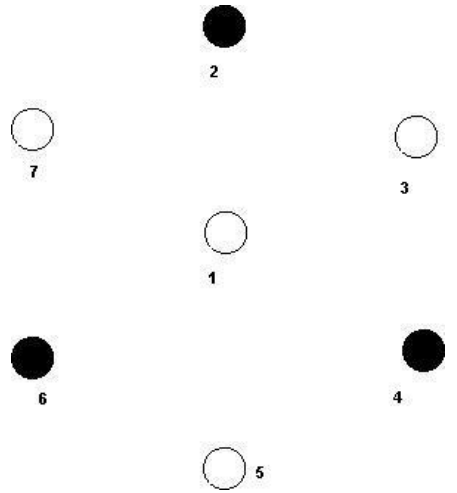
- **FDMA :** Interfering readers transmit at different frequency
  - Adding tuning circuitry to the tags will increase the cost

- **CDMA :**
  - Requires complex circuitry at tags which will increase the cost of passive tags

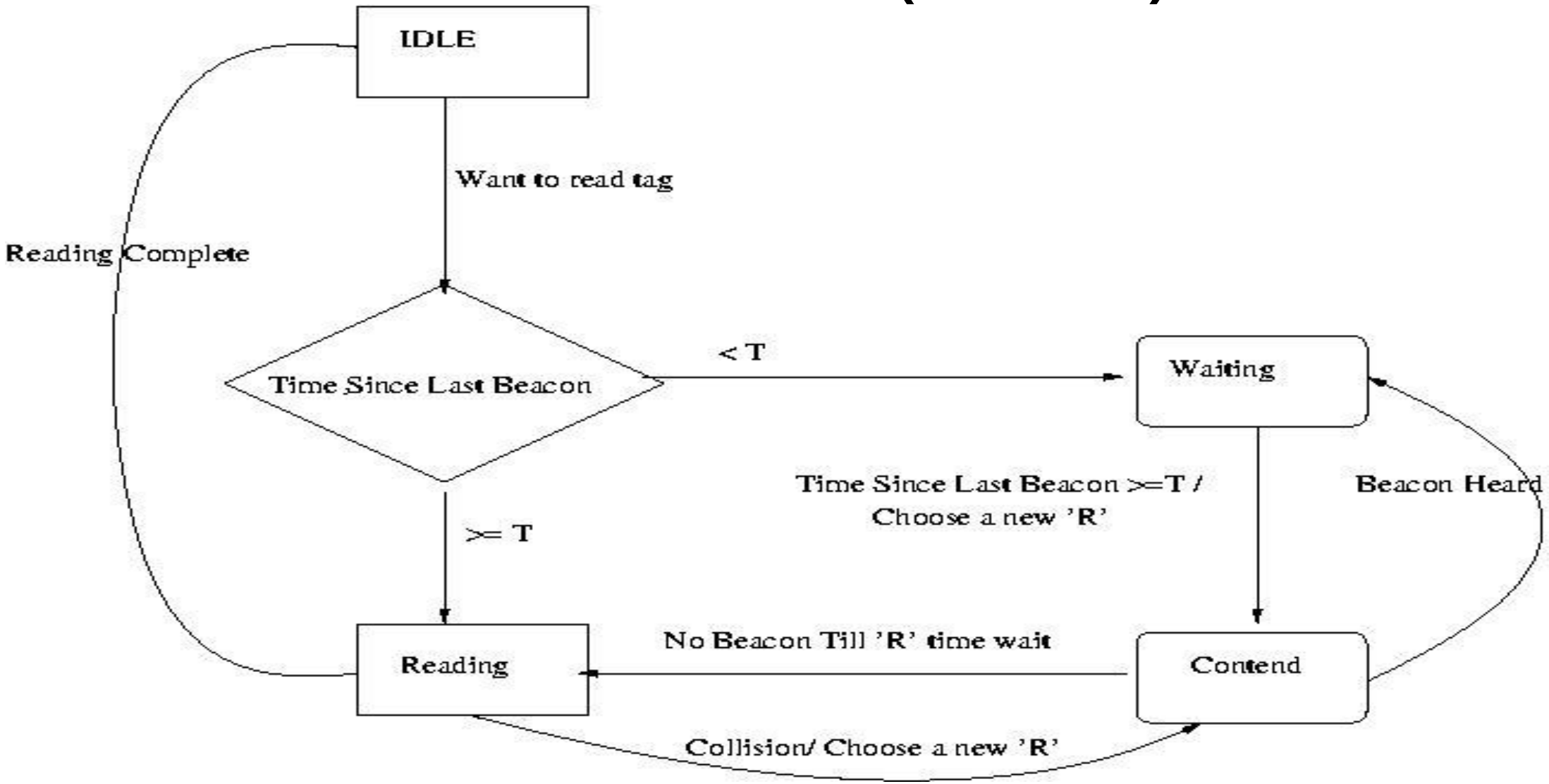
Reader-Reader Collision avoidance: Beacon based solution

- A reader while reading tag, periodically sends a beacon on the control channel

- Assumptions
  - The range in the control channel is sufficient for a reader to communicate with all the possible readers that might interfere in the data channel



Beacon based solution (contd.)



Near Field Communication (NFC)

What is NFC?

- NFC or Near Field Communication is a type of High frequency RFID
- NFC is mainly aimed for mobile or handheld devices.
- 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

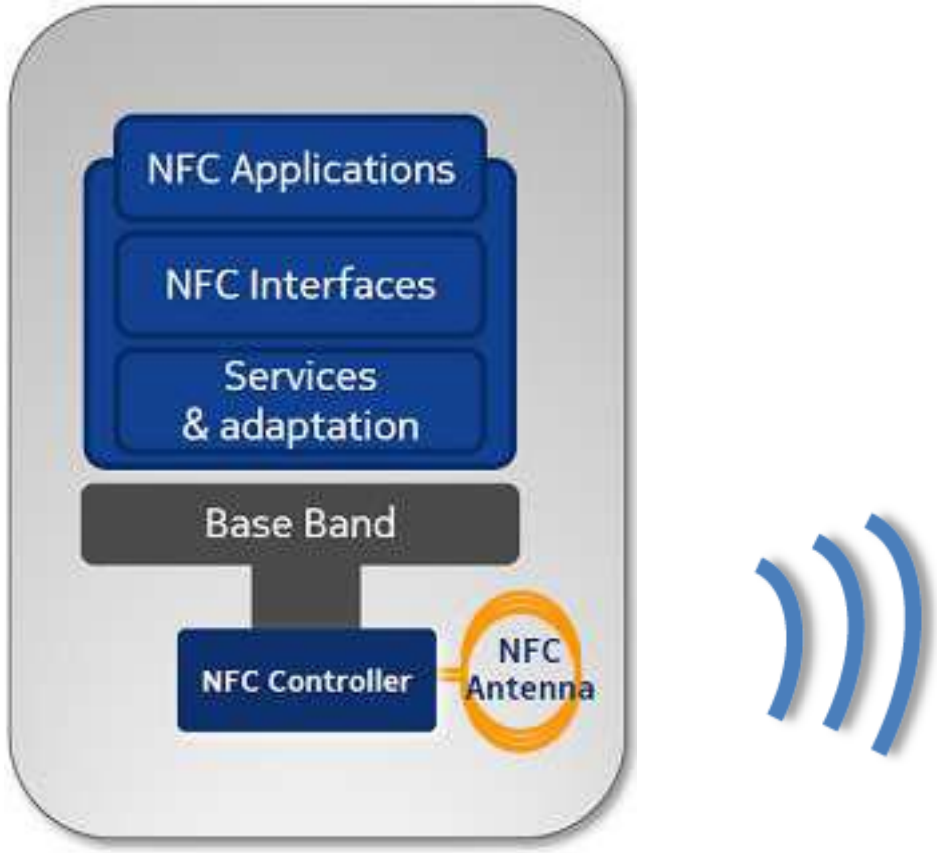
Features

- NFC is an extension of **Radio frequency identification (RFID)** technology
- 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**

NFC Reader

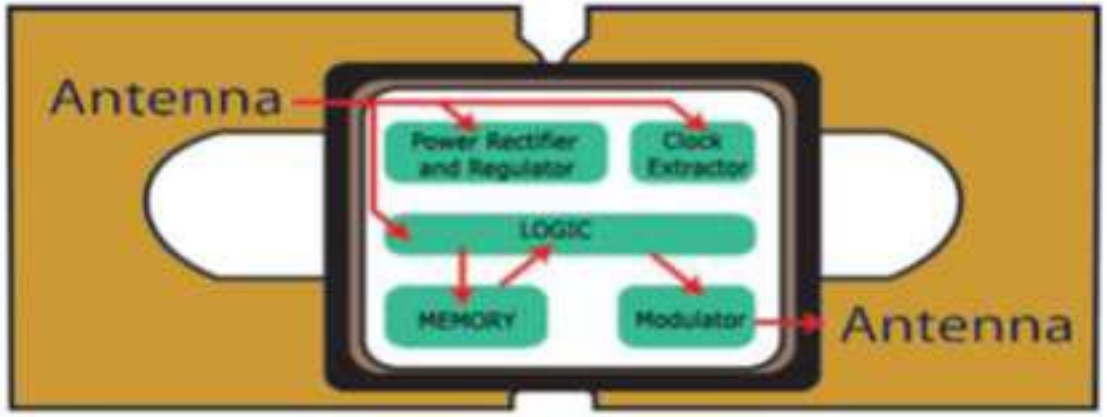
- Usually a microcontroller-based (e.g., smartphones) with an integrated NFC circuits

- The reader continuously emits RF carrier signals, and keeps observing the received RF signals for data



NFC Tag

- 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.



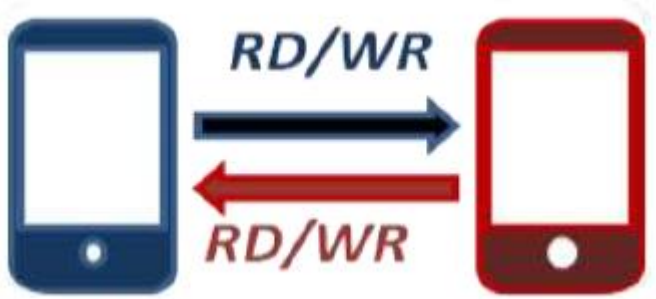
Operation Of NFC

- 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

Communication modes Of NFC

- **Passive Communication Mode**
- The Initiator device provides a carrier field and the target device answers by modulating existing field.

- **Active Communication Mode**
- Both Initiator and Target device communicate by alternately generating their own field.



Operating Modes of NFC devices

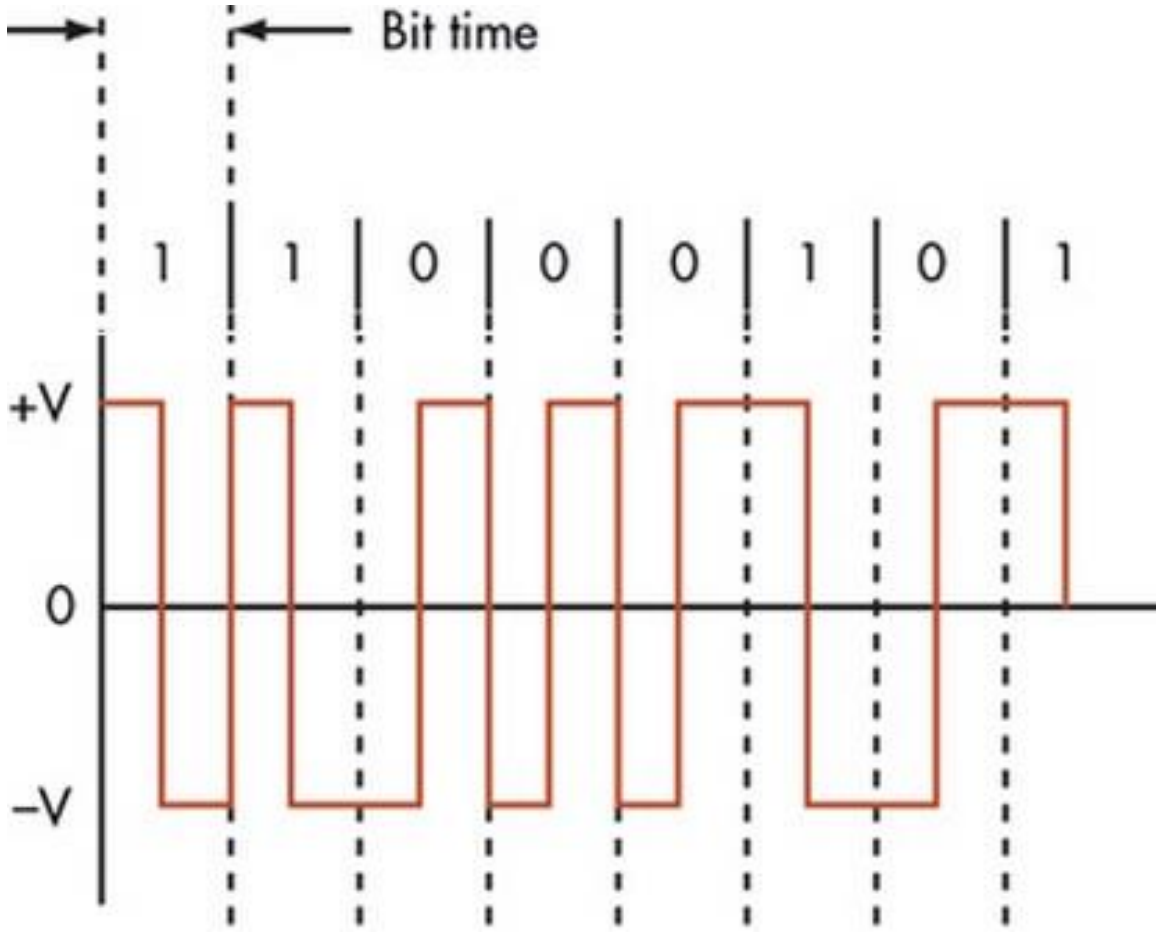
- **Reader/writer mode**
  - the NFC device is capable of reading NFC Forum-mandated tag types, such as a tag embedded in an NFC smart poster

- **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.

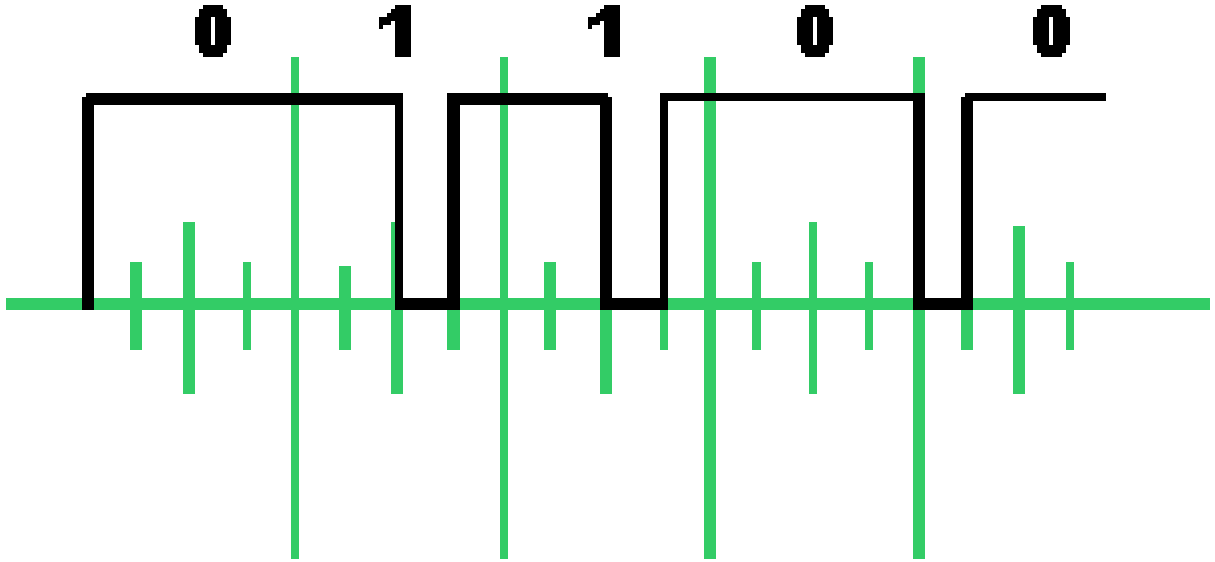
NFC Manchester Coding

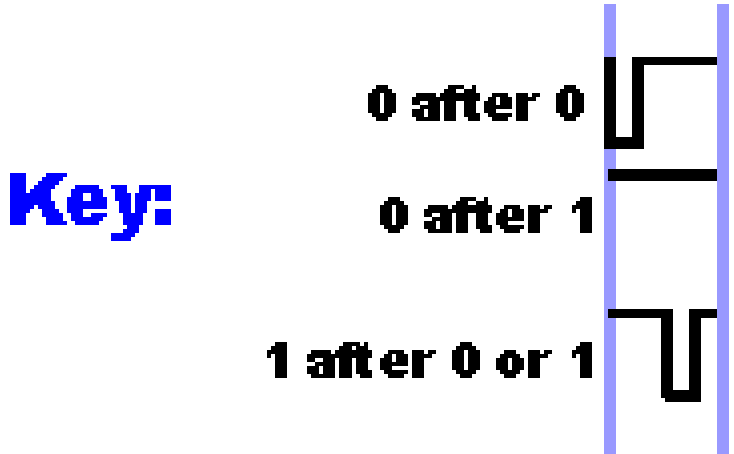
- High to Low transition is mapped as binary logic-1
- Low to High transition is mapped as binary logic-0
- Transition occurs exactly in the middle of bit period.



Modified Miller Coding

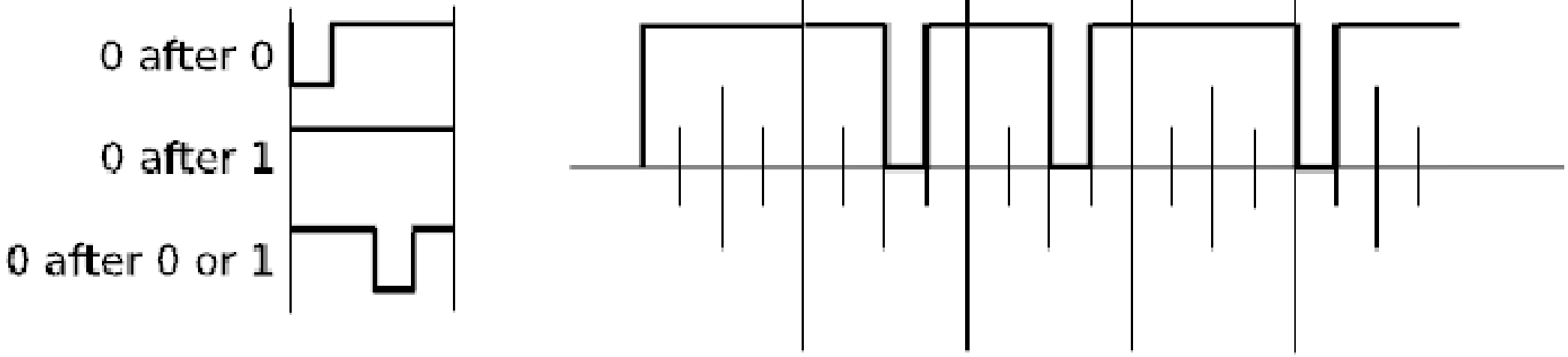
- A high or "1" is always encoded in the same way, but a low or "0" is encoded differently dependent upon what preceded it.
- Pros
  - Has fewer transitions. This characteristic saves bandwidth
  - Easy to implement in the hardware



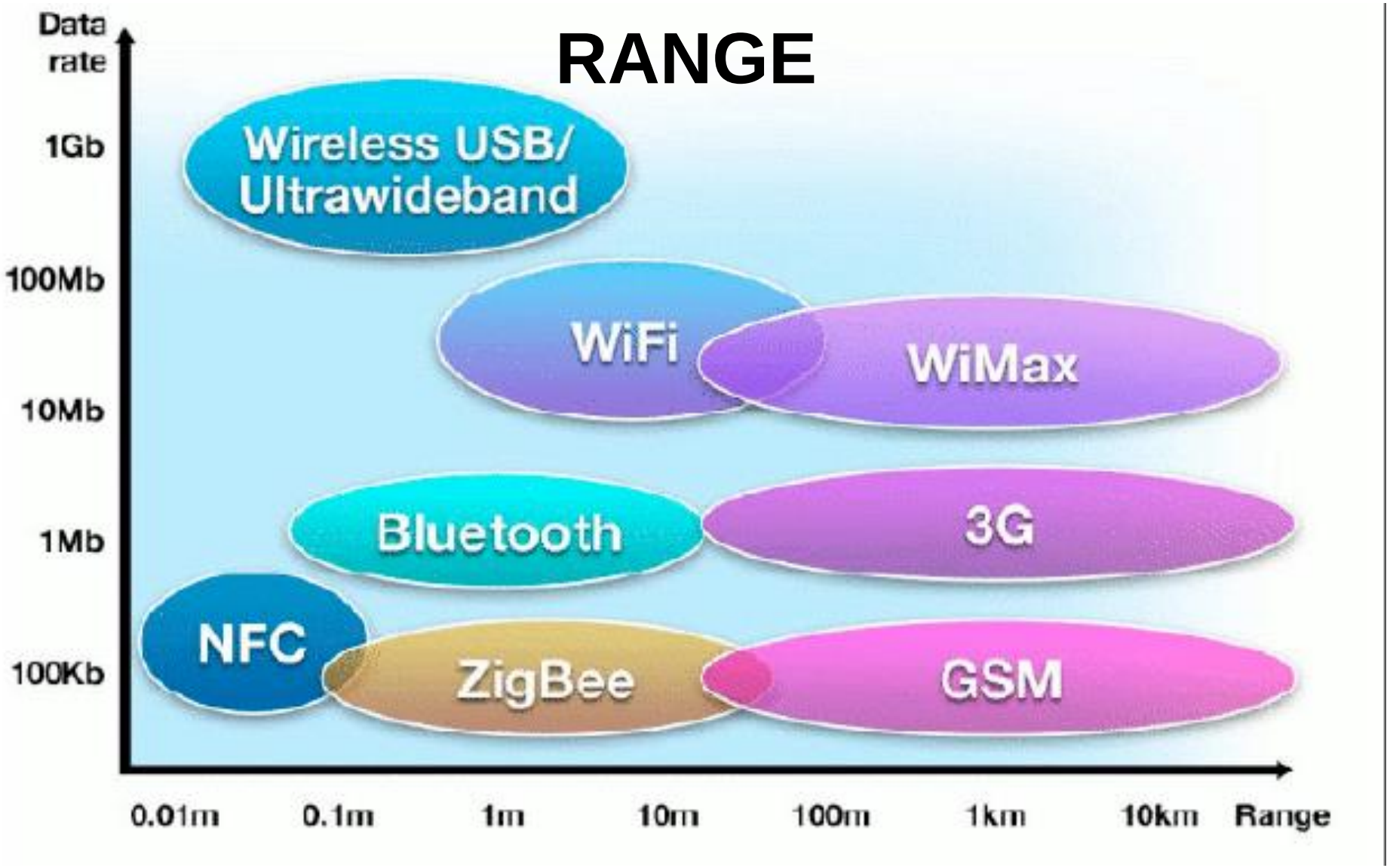


Exercise

- Decode the signal modulated in modified miller code



DATA RATE & RANGE



NFC Applications

BEFORE & AFTER

PREVIOUSLY USED METHODS

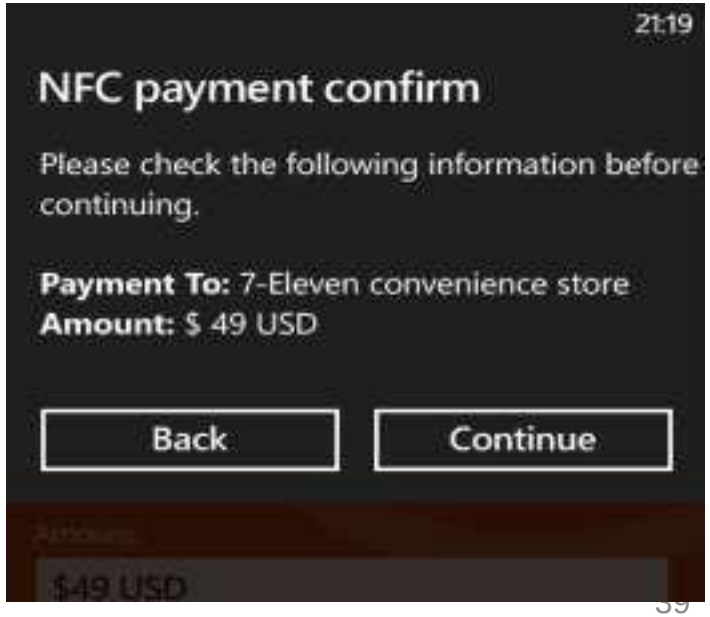
CURRENT & FUTURE METHODS

Smart Posters

- An object that has, affixed to or embedded in it, one or more readable NFC tags
- Each tag is read when an NFC device is held close to it
- “N-Mark” shows touch point
- Paper poster, billboard, garment tag, magazine page, even a three-dimensional object

NFC and Mobile Payment

- 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 connect to retailer back end for authorization and display tracking information



NFC P2P applications

- Connection Handover: exchange of configuration information via the NFC link
  - In-car devices
  - Home entertainment systems
  - Headsets and handsets
  - 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)

Smart Tags

NFC Advantages

- Convenience
  - Replacement of wallets
  - Already integrated in many mobile phones
- Versatility
  - Suited for a broad range of applications.
  - Because it allows innovations through the development of software.
  - E.g., bank cards, transit passes, movie passes, reward systems and even keys.
- Security
  - Compared with the traditional wallets, NFC has an additional protection of passwords.
  - Retailers no longer have physical access to your credit card information
  - [Note] Wireless communication can pose new security threats

NFC Disadvantages

- Cost of deployment.
  - NFC is most useful when it can be used everywhere. Business wants to deploy NFC after it’s used everywhere
- Security:
  - Phone hacking and phone viruses can expose important information all in one device.
  - E.g., credit card information, bill payments, social security information, etc.
- Limitations:
  - Short range (< 10 cm), low data rate (106, 212 or 424kbps).