Lecture 42: RFID and NFC systems: Working principle and applications

Wireless Technologies

DI05011011: Mobile Communication

Agenda for Today

- 1. Introduction to RFID
- 2. Components of an RFID System
- 3. Active vs. Passive RFID Tags
- 4. Operating Frequencies of RFID
- 5. Working Principle of RFID
- 6. Applications of RFID
- 7. Introduction to NFC
- 8. NFC Operating Modes
- 9. Applications of NFC
- 10. Comparison: RFID vs NFC
- 11. Summary and Next Steps

Introduction to RFID

- **RFID (Radio Frequency Identification)** uses electromagnetic fields to automatically identify and track tags attached to objects.
- It acts like a wireless barcode but does not require direct line-of-sight.
- An RFID tag can hold unique identification data (like a serial number) and other information.
- Widely used to track inventory, animals, vehicles, and assets.

Components of an RFID System

- An RFID system consists of three main components:
- **1. RFID Tag (Transponder):** Attached to the object. Contains a microchip (to store data) and an antenna (to transmit/receive).
- **2. RFID Reader (Interrogator):** A device that transmits a radio signal to the tag and receives the data back.
- **3. Backend System/Database:** A computer system that processes the data received from the reader to take actionable decisions (e.g., deducting inventory).

Types of RFID Tags

- **Passive Tags:**
- - Have no internal power source (no battery).
- - Draw power from the electromagnetic energy transmitted by the RFID reader.
- - Short read range (up to a few meters).
- - Cheaper, smaller, and have a long operational life.
- **Active Tags:**
- - Have their own battery.
- - Can broadcast their signal continuously.
- - Long read range (up to 100 meters or more).
- - Larger, more expensive, and limited by battery life.

Working Principle of Passive RFID

- 1. The **Reader** continuously emits radio waves through its antenna.
- 2. When a **Passive Tag** enters the field, its antenna picks up the energy.
- 3. This energy induces a small current that powers up the microchip inside the tag.
- 4. The microchip retrieves its stored ID data.
- 5. The tag transmits the data back to the reader using a technique called **Backscatter Modulation**.
- 6. The reader decodes the signal and sends the ID to the database.

Applications of RFID

- **Supply Chain & Logistics:** Tracking pallets and cartons in warehouses.
- **Retail:** Anti-theft systems and automated checkout (e.g., Decathlon stores).
- **Toll Collection:** FASTag in India uses passive RFID.
- **Access Control:** Employee ID cards to open doors.
- **Animal Tracking:** Implantable chips for pets and livestock.

Introduction to NFC

- **NFC (Near Field Communication)** is a specialized subset of RFID technology.
- Operates specifically at the **13.56 MHz** frequency.
- Designed for extremely short-range communication (usually **under 4 centimeters** or 1.5 inches).
- Unlike standard RFID, NFC is designed for **secure, two-way communication** between complex devices like smartphones.

NFC Operating Modes

- NFC devices (like smartphones) can operate in three distinct modes:
- **1. Reader/Writer Mode:** The phone acts like an RFID reader to read a passive NFC tag (e.g., tapping a smart poster to get a URL).
- **2. Peer-to-Peer (P2P) Mode:** Two active NFC devices exchange data (e.g., Android Beam sharing a contact).
- **3. Card Emulation Mode:** The phone pretends to be a passive NFC smart card. Used for contactless payments (Apple Pay, Google Pay) or transit passes.

Working Principle and Security of NFC

- NFC uses **magnetic induction** to couple devices.
- **Security advantage of short range:** Because the range is ¡ 4cm, it is very difficult for a hacker to intercept or eavesdrop on the signal without being physically noticed.
- **Secure Element (SE):** When used for payments, NFC relies on a highly secure hardware chip (Secure Element) inside the phone to store credit card tokens securely.
- Transactions are encrypted and often require biometric authentication (Face ID/Fingerprint).

Applications of NFC

- **Contactless Payments:** Tap-to-pay via smartphones or contactless credit cards.
- **Transit Systems:** Tapping your phone for Metro or Bus tickets.
- **Device Pairing:** Tapping a phone to a Bluetooth speaker to instantly pair them without menus.
- **Smart Posters/Tags:** Tapping a museum exhibit for information or an NFC tag at home to automate smart home settings.
- **Digital Identity:** Mobile passports and digital driver's licenses.

Comparison: RFID vs. NFC

- — Feature — RFID — NFC —
- — :— — :— — :— —
- — **Range** — Up to 100 meters (Active) — Less than 4 cm —
- — **Communication** — Mostly one-way (Tag to Reader) — Two-way (Peer-to-Peer) —
- — **Multiple Items**— Can read hundreds of tags at once — Usually one-to-one interaction —
- — **Primary Use** — Asset tracking, Logistics, Tolls — Payments, Pairing, Access —
- — **Frequency** — LF, HF, UHF — 13.56 MHz (HF) only —

Lecture Summary

- RFID is a technology using RF fields to identify and track tags.
- Passive RFID tags draw power from the reader, while active tags have batteries.
- NFC is a subset of RFID operating at 13.56 MHz with a range of under 4 cm.
- NFC supports three modes: Reader/Writer, Peer-to-Peer, and Card Emulation.
- RFID dominates supply chains and tracking, while NFC dominates secure mobile payments.

Next Lecture Preview

- In our next lecture, we will look at a technology designed for the Internet of Things (IoT) and smart homes:
- **Zigbee:**
- - Basic concepts and IEEE 802.15.4 standard.
- - Mesh networking capabilities.
- - Why use Zigbee instead of Wi-Fi for smart home sensors?