Project: Radio Frequency Identification (RFID) used in Cell Phones

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Introduction

The purpose of this project is to describe and analyze the use of Radio Frequency Identification (RFID) Technology using Electronic Product Code (EPC) in Cell Phone Technology.

Acronyms

EPC	Electronic Product Code
RFID	Radio Frequency Identification
SCM	Supply Chain Management
ONS	Object Naming Service
EPCIS	Electronic Product Code Information Service

Table 1. Acronyms

Overview of the Electronic Product Code (EPC) & Radio Frequency Identification (RFID)

Supply Chain Management (SCM) is defined as an attempt to coordinate processes involved in producing, shipping and distributing products, generally performed only by large corporations with large suppliers. Private Trading Exchanges can extend Supply Chain Management to all trading partners regardless of size because they provide a central location to integrate information from all supply chain participants. Over the last few years a new technology involving Radio Frequency Identification (RFID) has evolved which has lot of advantages over the legacy barcode system. To understand the usage of this technology in Supply Chain Management here is an overview of Electronic Product Code (EPC) and Radio Frequency Identification (RFID).

Automatic identification, or auto ID for short, is the broad term given to a host of technologies that are used to help machines identify objects. Auto identification is often coupled with automatic data capture. That is, companies want to identify items, capture information about them and somehow get the data into a computer without having employees type it in. The aim of most auto-ID systems is to increase efficiency, reduce data entry errors, and free up staff to perform more value-added functions, such as providing customer service. There are a

host of technologies that fall under the auto-ID umbrella. These include bar codes, smart cards, voice recognition, some biometric technologies (retinal scans, for instance), optical character recognition, and radio frequency identification (RFID). An RFID system consists of a tag, which is made up of a microchip with an antenna, and an interrogator or reader with an antenna. The reader sends out electromagnetic waves. The tag antenna is tuned to receive these waves. A passive RFID tag draws power from field created by the reader and uses it to power the microchip's circuits. The chip then modulates the waves that the tag sends back to the reader and the reader converts the new waves into digital data. Please see Figure 1

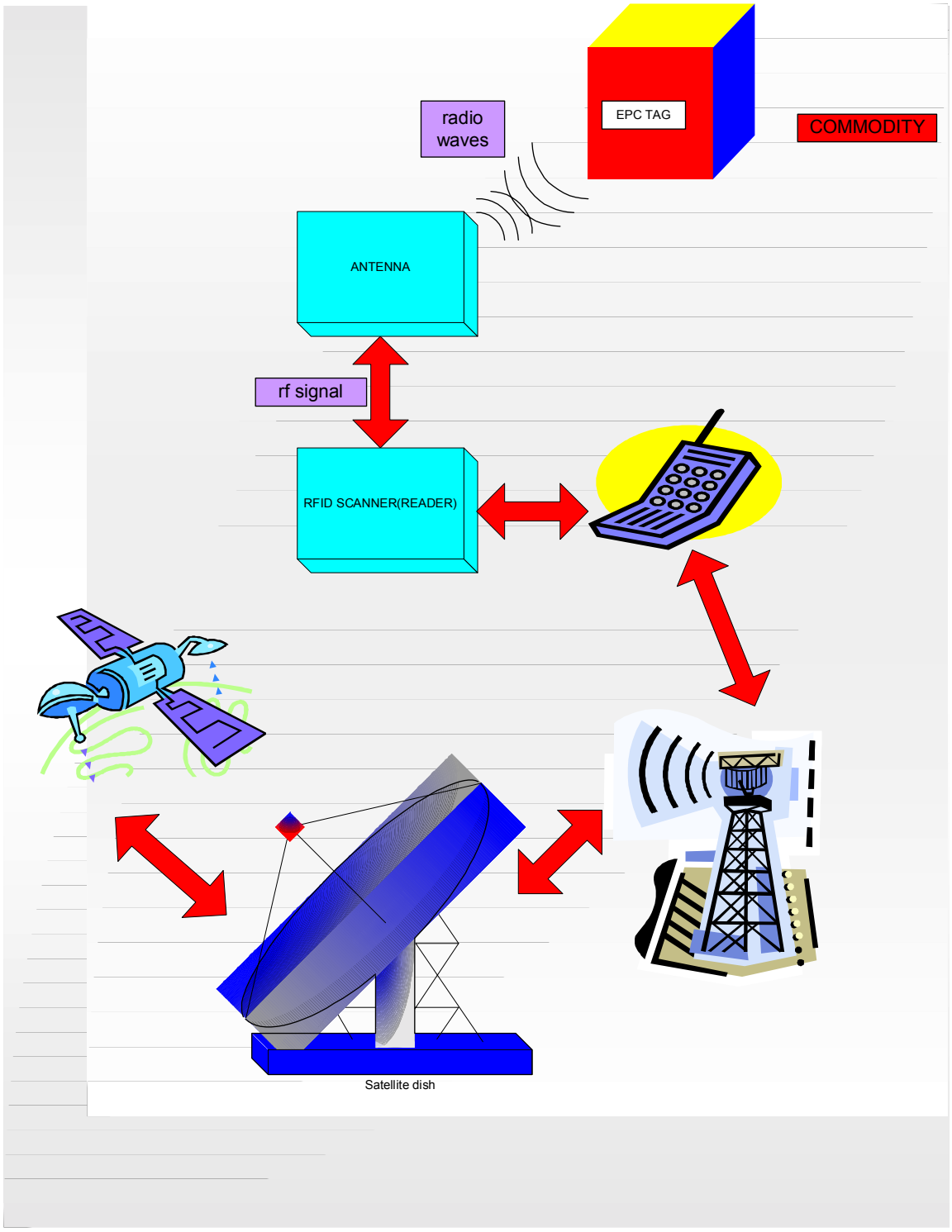


Figure 1. Overview of Using Cell Phones for RFID

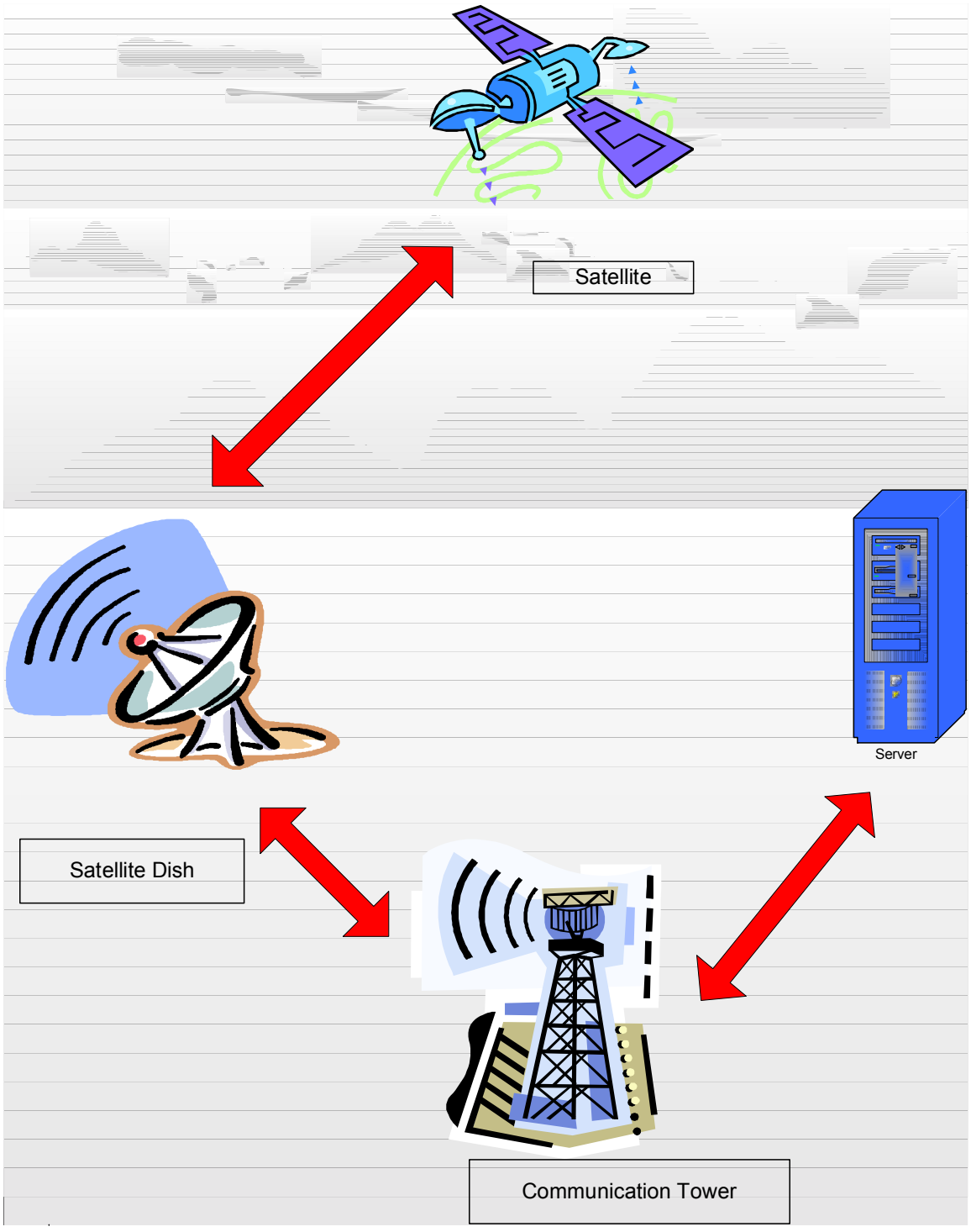


Figure 1a. Overview of Using Cell Phones for RFID

What is Radio Frequency Identification (RFID)?

Radio frequency identification, or RFID, is a generic term for technologies that use radio waves to automatically identify people or objects. There are several methods of identification, but the most common is to store a serial number that identifies a person or object, and perhaps other information, on a microchip that is attached to an antenna (the chip and the antenna together are called an RFID transponder or an RFID tag). The antenna enables the chip to transmit the identification information (Electronic Product Code) to a reader. The reader converts the radio waves reflected back from the RFID tag into digital information that can then be passed on to computers that can make use of it.

What is Electronic Product Code (EPC)?

Electronic Product Code (EPC) is a new industry standard for uniquely identifying any product in the world. The EPC is a number made up of four fields: a header and three sets of data. The header identifies the EPC's version number. The second field of the code identifies the EPC Manager, which is the manufacturer of that particular product. The third field is the Object Class, which refers to the exact type of product. This can include the Stock Keeping Unit, for example, which can identify the exact product stored in the EPC-identified container. The fourth field is the Serial Number, which is the unique identifier of the specific item. Please see the figure below.

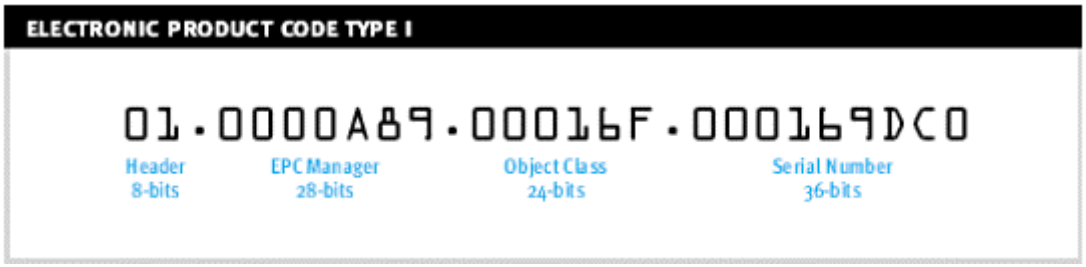
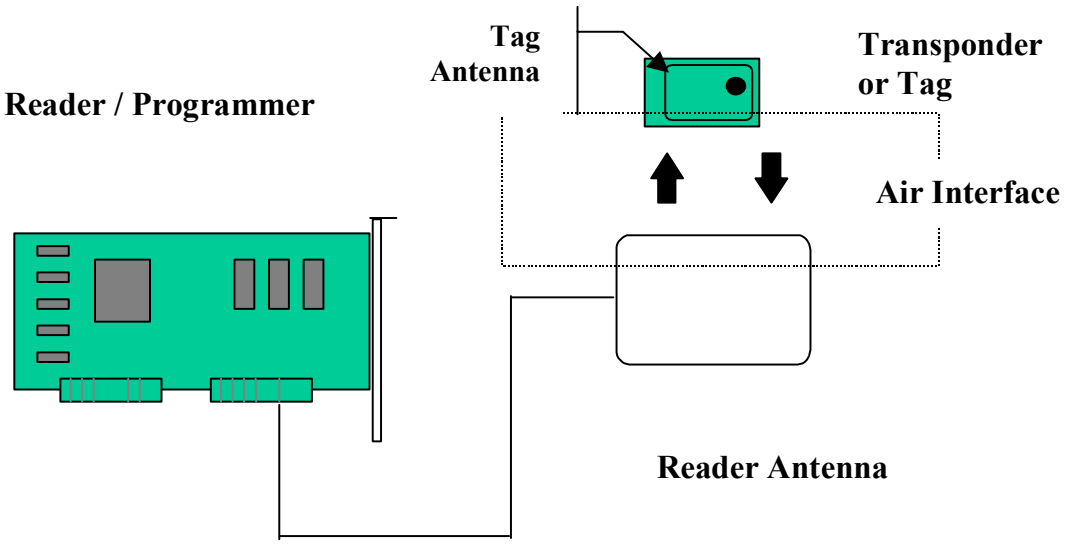


Figure 2. Example Electronic Product Code

The 96-bit EPC number is expected to be the most common Electronic Product Code. The 96-bit EPC provides unique identifiers for millions of companies.

Each manufacturer can have millions of object classes and billions of serial numbers in each class. The 96-bit code is embedded in the RFID chip (smart tag) on individual products. Each smart tag is scanned by a wireless radio frequency "reader", which transmits the product's embedded identity code to the Internet, where the "real" information on the product is kept. The "real" product information is then communicated back from the Internet to provide whatever information is needed about that product. The EPC works together with a Product Markup Language (PML) and an Object Naming Service (ONS).

Figure 3 shows how RFID technology works using Electronic Product Code (EPC).



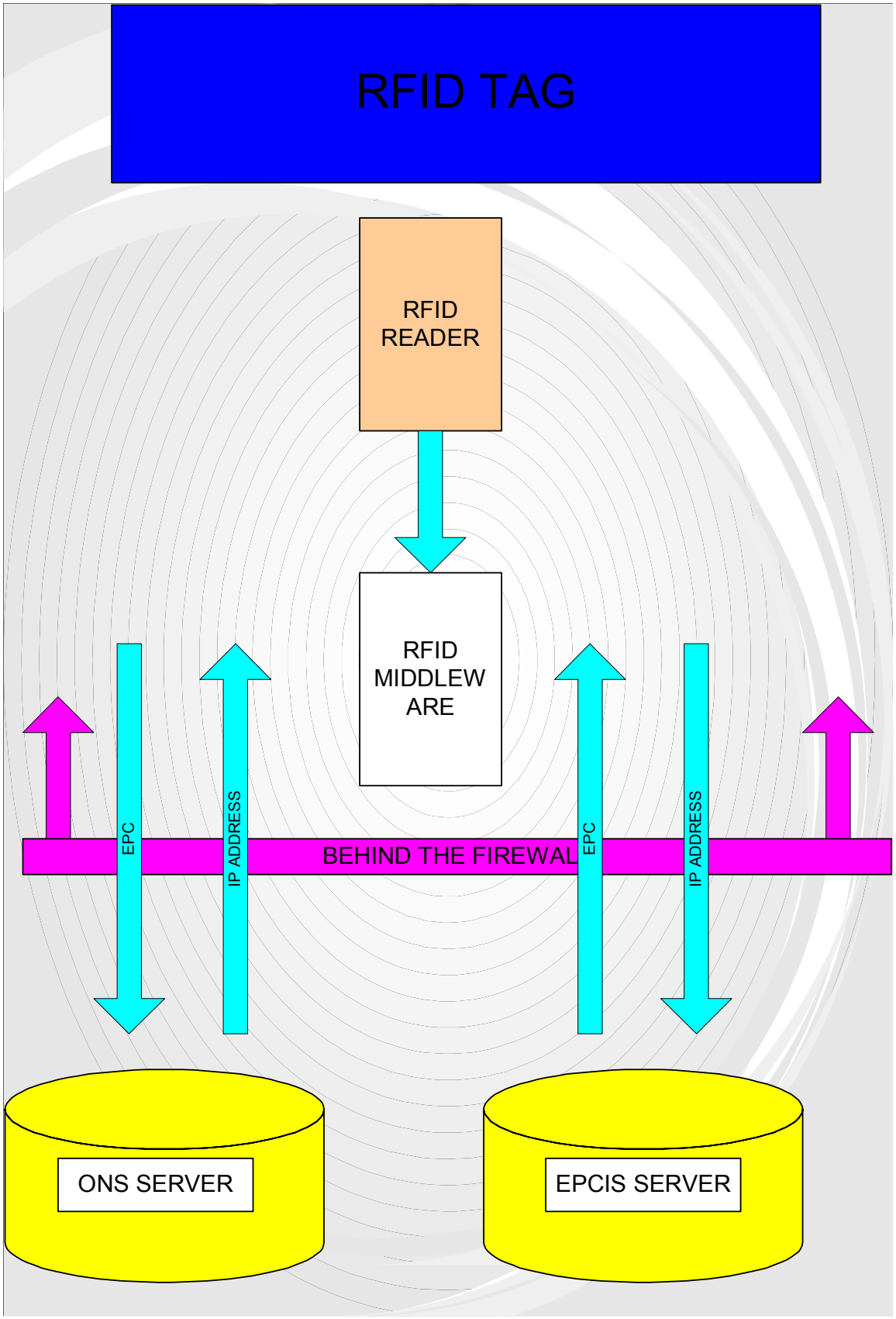
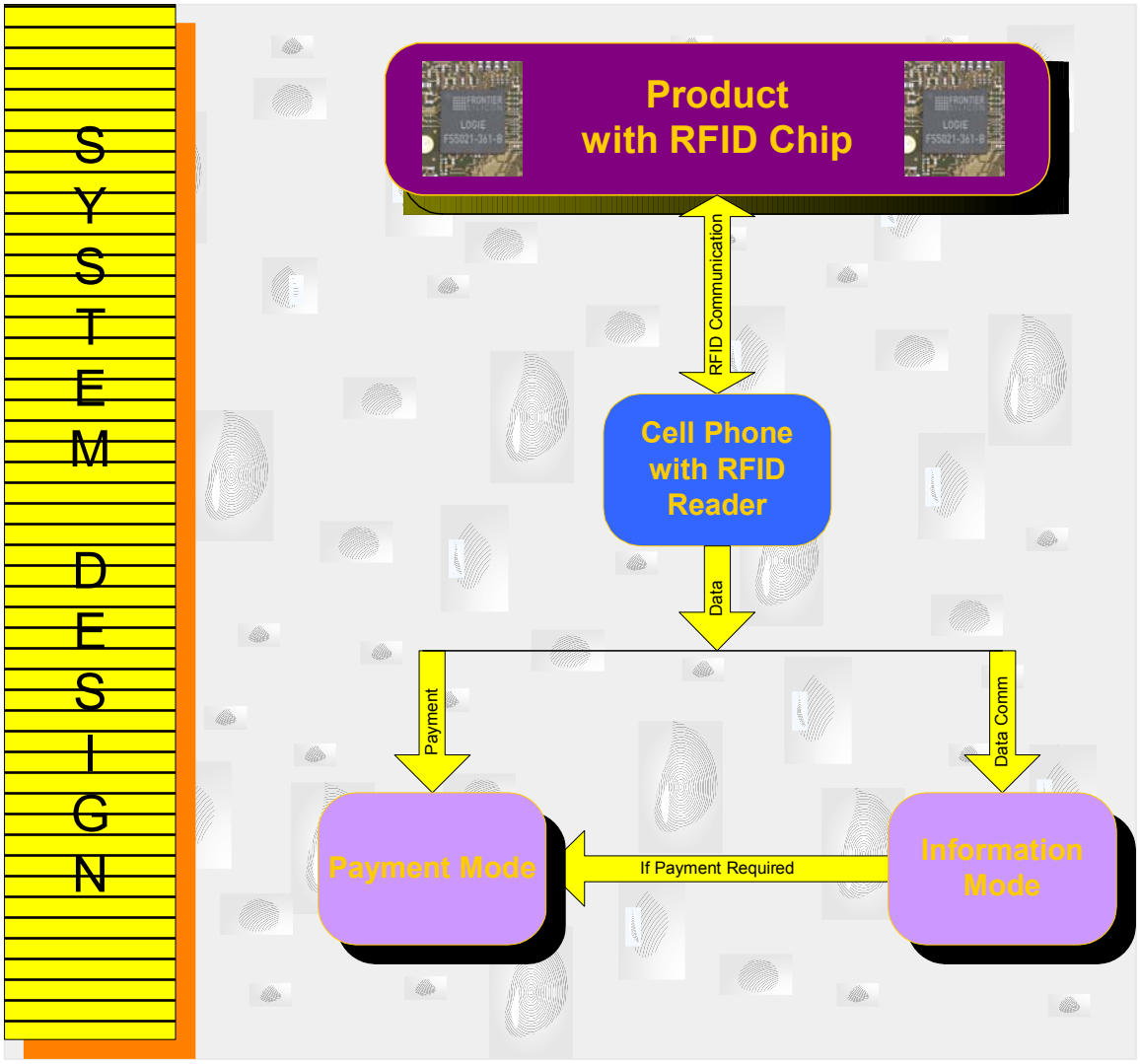

RFID TAG
RFID READER
RFID MIDDLEW ARE
EPC
IP ADDRESS
BEHIND THE FIREWAL
EPC
IP ADDRESS
ONS SERVER
EPCIS SERVER

Figure 3. EPC/RFID Overview

Benefits of using the Electronic Product Code (EPC) & Radio-Frequency Identification (RFID)

- Benefits of Speed:
  - Eliminate lost sales due to low inventories.
  - Speed up store receiving, processing, replenishment and returns processing.
  - Notification of units needed on sales floor upon store receipt.
  - Satisfy customer requests immediately by locating products on sales floor and in the stockroom.
  - Faster and more accurate inventory audits.
  - Increased distribution center efficiency and accuracy.
- Benefits of Visibility:
  - Unit, carton and pallet-level visibility throughout supply chain.
  - Immediate identification of exceptions at various delivery points of goods.
  - Visibility to replenish the right product to the right place at the right time.
  - Block receipt of defective and counterfeit merchandise.
- Benefits of Wireless Transfer
  - Leverage use of existing Cell Phone/Mobile Telecommunication Network
  - Real time availability of information
  - Easy Data visibility



Scope and Objectives

The purpose of this analysis is to demonstrate the high-level system and concept, and also to describe the use of UML in using RFID in a cell phone, which uses EPC and RFID. This system would describe a step-by-step overview of the usage of EPC and RFID technology. This system would describe how RFID Technology could be incorporated into the existing Telecommunication Networks and also some examples would explain how this technology would be helpful for consumers.

The following are the objectives for this analysis:

1. Explain how RFID Technology works.
2. Show how RFID/EPC can be used in the existing cell phone technology.
3. Describe how RFID works with EPC.
4. Show which subsystems should be chosen for Cell Phones.
5. Explain how the various subsystems, specifically EPC and RFID, should interact between each other.

Goals and Scenarios of this study

Goal 1: Product contains RFID Tag having EPC.

Scenario 1.1 RFID Tag embedded on Product.

Scenario 1.2 EPC on RFID Tag.

Goal 2: EPC communicates with the RFID Reader

Scenario 2.1 RFID Reader has an antenna embedded on it.

Scenario 2.2 RFID Reader sends out Electromagnetic Waves.

Scenario 2.3 RFID Tag uses the power of the field to supply EPC from RFID Tag.

Goal 3: RFID Reader would transfer required and necessary information to the Communication Tower

Scenario 3.1 EPC information interpreted by RFID Reader.

Scenario 3.2 EPC Transmits information to Communication Tower.

Goal 4: Cell Phone communicates with the Communication Tower

Scenario 4.1 Cell Phone communicates with the communication tower

Scenario 4.2 Cell Phone transfers data to the communication tower

Goal 5: Communication tower communicates with Satellite Dish

Scenario 5.1 Communication tower communicates with Satellite Dish.

Scenario 5.2 Satellite Dish gets the data transferred from the cell phone through communication tower.

Goal 6: Satellite Dish Communicates with Satellite .

Scenario 6.1 Satellite Dish communicates with Satellite.

Scenario 6.2 Satellite Dish transfers data to Satellite

Goal 7: Satellite communicates with Server through Satellite Disih.

Scenario 7.1 Satellite communicates with Satellite Dish.

Scenario 7.2 Satellite transfers data to Satellite Dish.

Scenario 7.3 Satellite Dish transfers data to the cell phone Servers.

Use Case Diagrams

Figure 4 shows a use case of the RFID system. This system shows the necessary boundary and actors in the system.

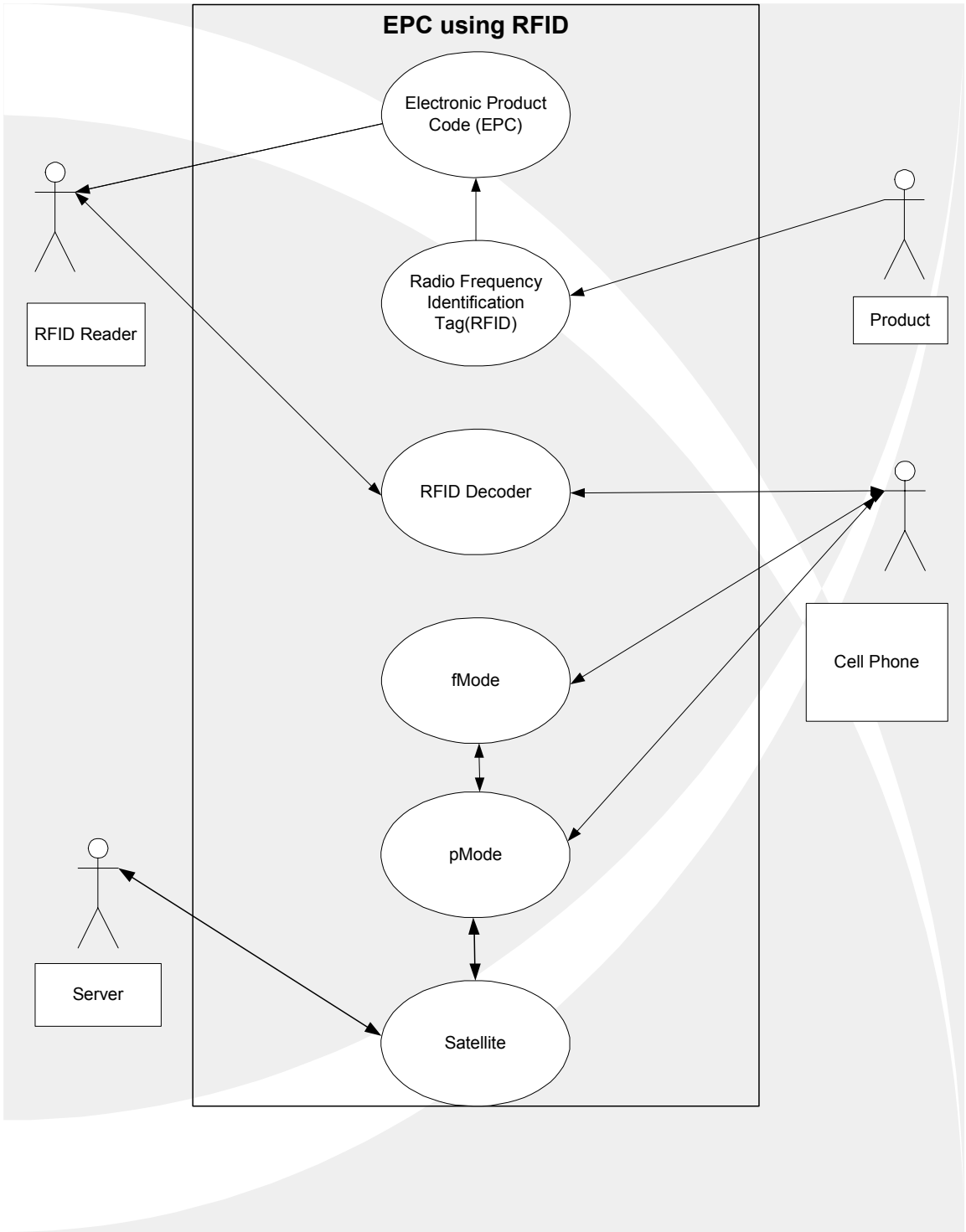


Figure 4. Initial Use Case Diagram

As it can be seen in the Initial Use Case Diagram, a product would have a Radio-Frequency Identification (RFID) Tag attached to it. The RFID Tag would also have an Electronic Product Code (EPC) embedded in it. A RFID Reader would transmit an electronic field which would activate the RFID Tag and allow the EPC to be transmitted. The RFID Reader would then receive the radio waves emitted by the RFID Tag and capture the Electronic Product Code. Once the product code is decoded and matched, it is transferred to the Database using the RFID Reader's Middleware. Once the information is stored, it is then shared with the System Users.

Identify Actors in System

1.) **Product –** This is an item on which the RFID Tag is placed.
2.) **RFID Tag –** This actor is attached to the product and stores the EPC number. It is activated by the electric field produced by the RFID Reader.
3.) **RFID Reader** – This actor transmits an electric field to activate the RFID Tag and retrieve the Electronic Product Code (EPC). The Reader also interacts with the Database to retrieve product information.
4.) **Middleware** – This actor decodes the EPC into the four product fields and performs error-checking on the number.
5.) **Cell Phones**- This actor would act as the middleman between communication between the commodity and the internet as the carrier of the RFID Chip.
6.) **Server** – This would act as the resource for various request which the user would be sending through the cell phone.

Use Case #1: Retrieve Electronic Product Code (EPC)

- *Primary Actor(s):* Product, RFID Reader, RFID Tag, Cell Phone
- *Description:* The RFID Reader communicates with the RFID Tag embedded on the product to retrieve the Electronic Product Code.
- *Preconditions:*

1.) The RFID Reader's power source should be fully charged.
2.) The Product must be within the communication range of the RFID Tag and RFID Reader.

- *Flow of Events:*

1.) RFID Reader is placed within range of RFID Tag.
2.) RFID Tag is activated by electric field created by RFID Reader.
3.) RFID Tag transmits EPC via embedded antenna.
4.) RFID Reader receives the EPC.
5.) Middleware receives EPC information and performs error detection scheme to determine accuracy of information.
    a. If information is accurate, EPC is confirmed.
    b. If inaccurate, the Middleware responds with an invalid flag.
6.) If inaccurate EPC, RFID Reader re-requests the EPC.

- *Post conditions:* The RFID Reader has received an accurate EPC from the product.
- *Assumptions:*

1.) The RFID Reader is functioning properly.
2.) There is a RFID Tag embedded on the product.

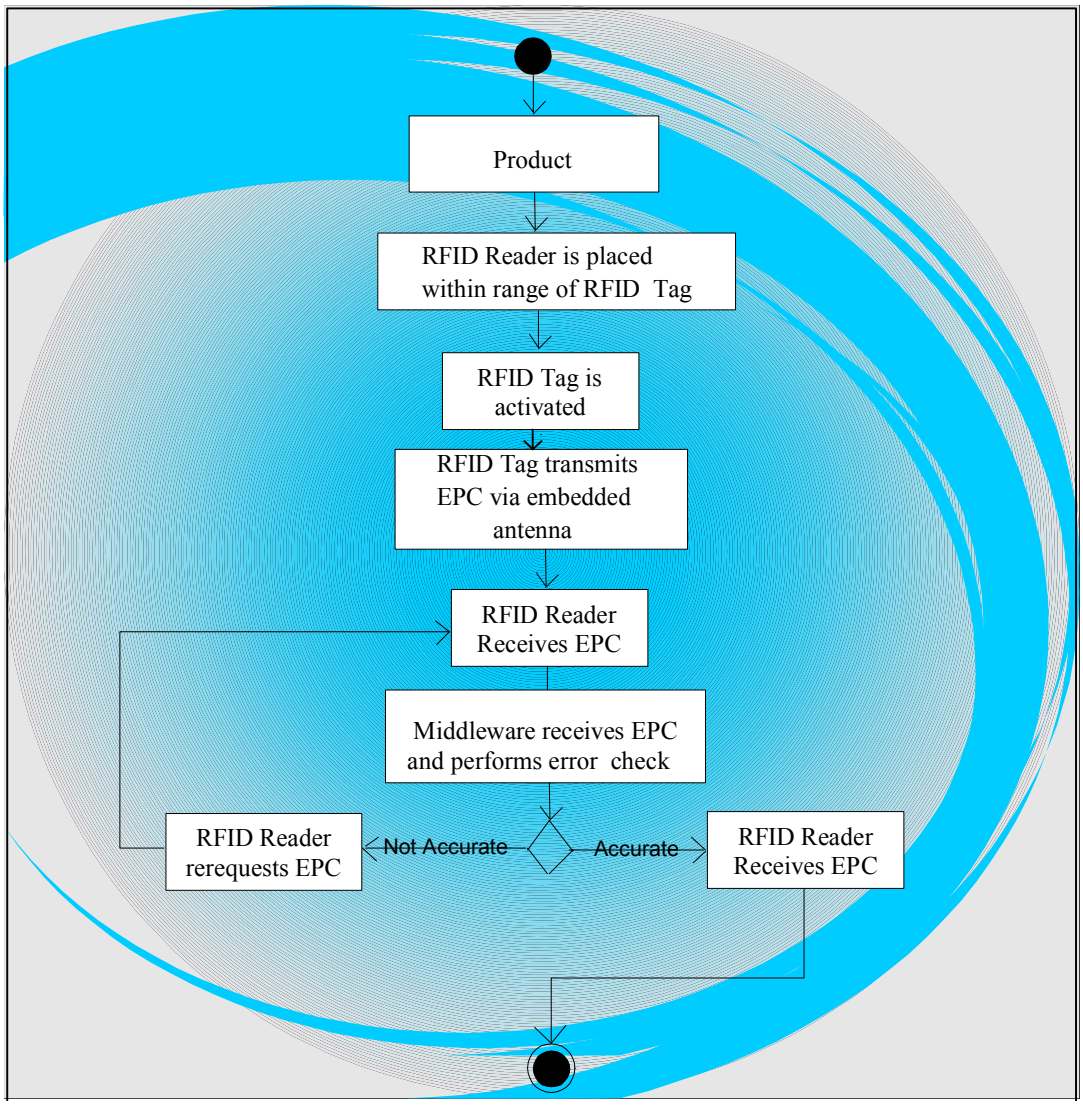


Figure 5. Activity Diagram for Use Case 1

Use Case #2: Decode the Electronic Product Code into the four identifying fields

- *Primary Actor(s):* RFID Reader, Middleware
- *Description:* The Middleware stored on the RFID Reader receives the EPC from the Product and decodes the information into the four product fields.
- *Preconditions:*

  1.) The RFID Reader's Power Source should be fully charged.

  2.) The received EPC should be valid and accurate.

- *Flow of Events:*

  1.) The Middleware receives the EPC from the product.

  2.) The Middleware decodes the first two bits as the Header bits.

  3.) The Middleware decodes the next 28 bits for Manufacturer Information.

  4.) The Middleware decodes the next 24 for Product Identifier.

  5.) The Middleware decodes the last 36 bits for the Serial Number.

- *Post conditions:* The EPC has been correctly decoded into the four identifying fields.

- *Assumptions:* The RFID Reader is functioning properly.

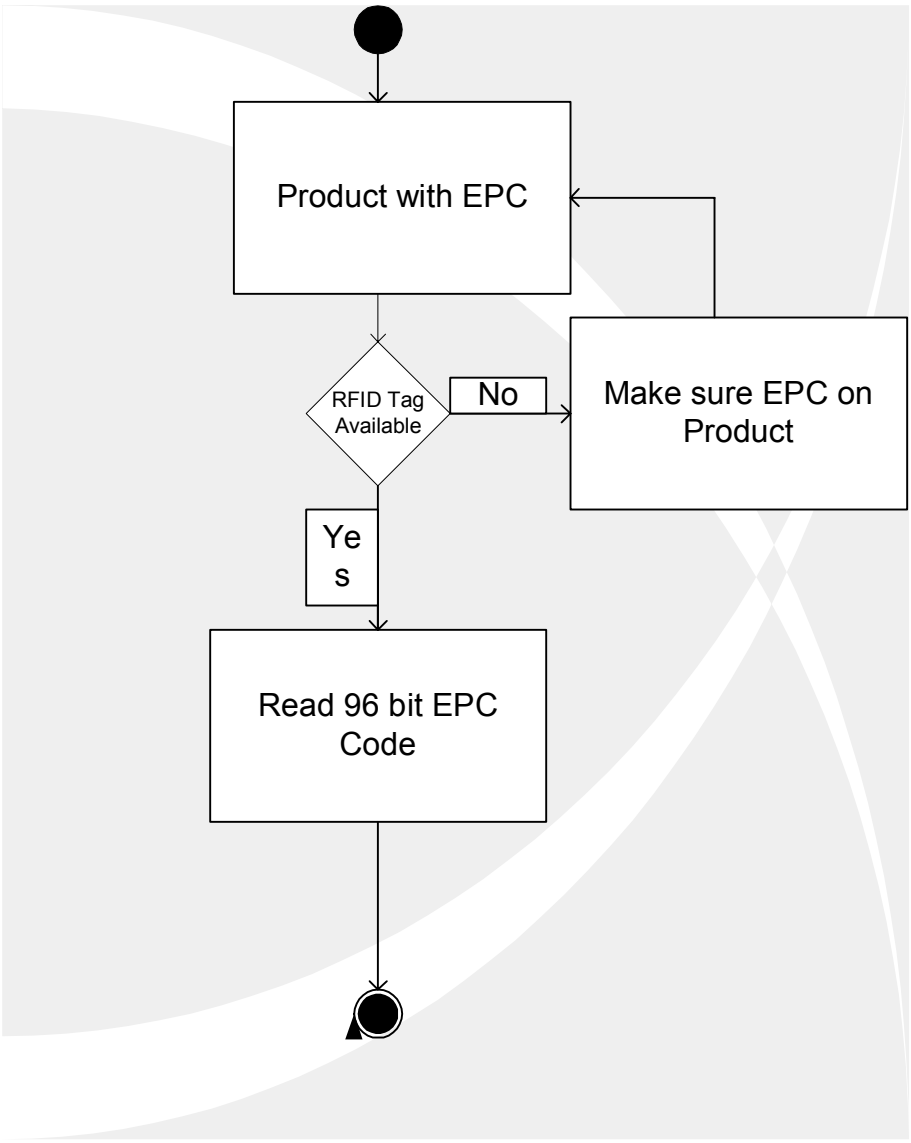


Figure 6. Activity Diagram for Use Case 2

Use Case #3: RFID Reader interacts with Specific Operating System.

- *Primary Actor(s):* RFID Reader, Operating System
- *Description:* Once the EPC has been decoded, depending upon whether information is requested or something needs to paid for.
- *Preconditions:*

1.) The RFID Reader is operational and its power source is fully charged.
2.) The EPC has been decoded properly.

- *Flow of Events:*
  1.) The Middleware receives request for Product Specific Information
  2.) The Middleware connects to the Database.
  3.) The Middleware queries the Database using the four decoded EPC fields.
  4.) The Middleware passes the received Product Information to the RFID Reader.
  5.) The RFID Reader displays that information.
- *Post conditions:* The Product Specific Information has been correctly retrieved from the Database and displayed on the RFID Reader.
- *Assumptions:*
  1.) The Product information is properly updated in the Database.
  2.) The connection between the Middleware and Database is functional.
  3.) The RFID Reader is functioning properly and will correctly display the Information.

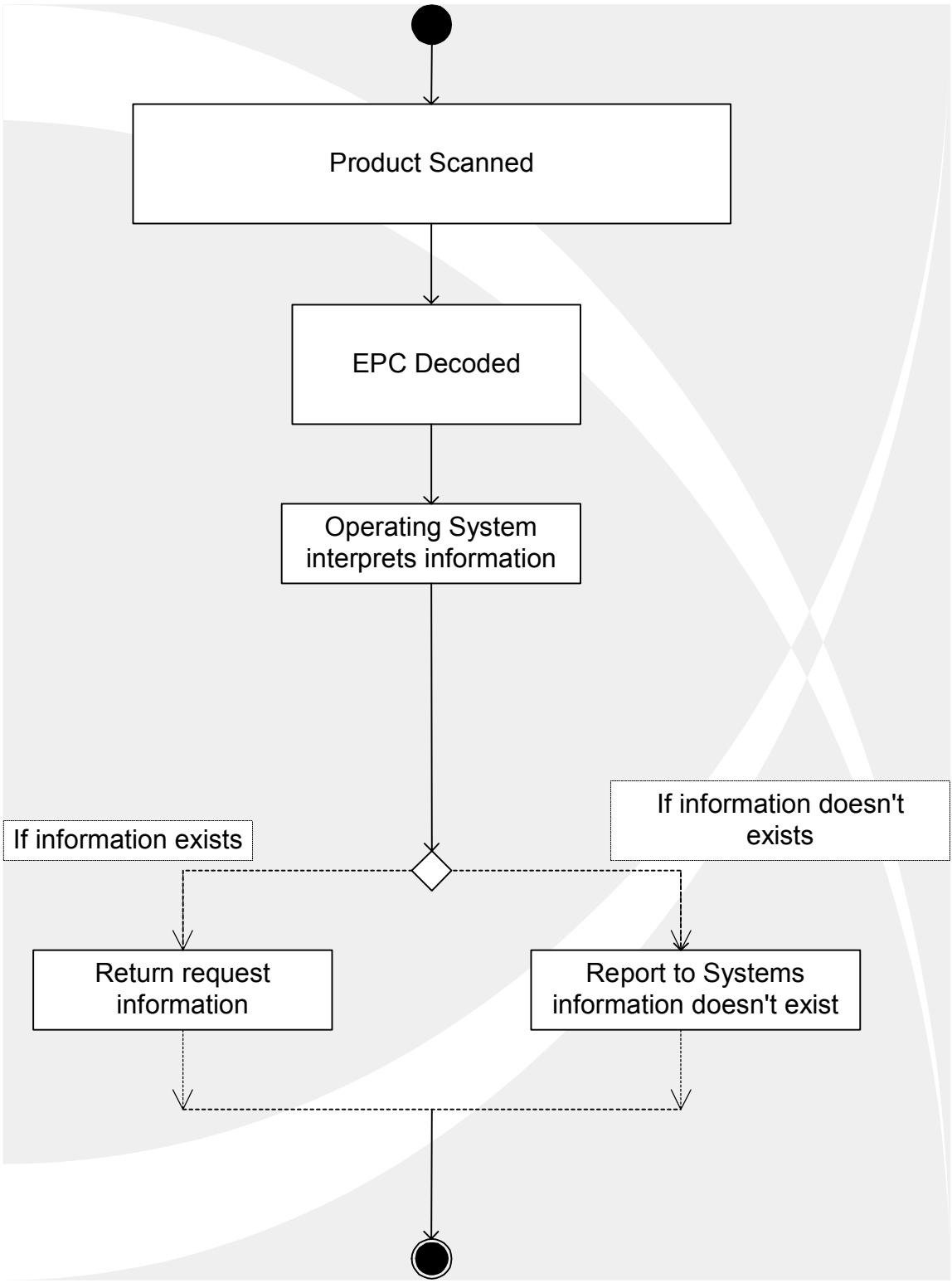


Figure 7. Activity Diagram for Use Cases 3

Use Case #4: Mode Decision

- *Primary Actor(s):* Cell Phone, RFID Chip
- *Description:* Data Decides whether its Financial Mode or Product Mode
- *Preconditions:*

  1.) Data has reached the RFID Chip

  2.) Cell phone is charged.
- *Flow of Events:*

  1.) Data flows from to the RFID Chip.

  2.) Based on certain criteria's it is decided whether its going to be financial mode or product mode.
- *Post conditions:* The System User receives the product tracking information.
- *Assumptions:*

  1.) RFID Chip interacts with the operating system

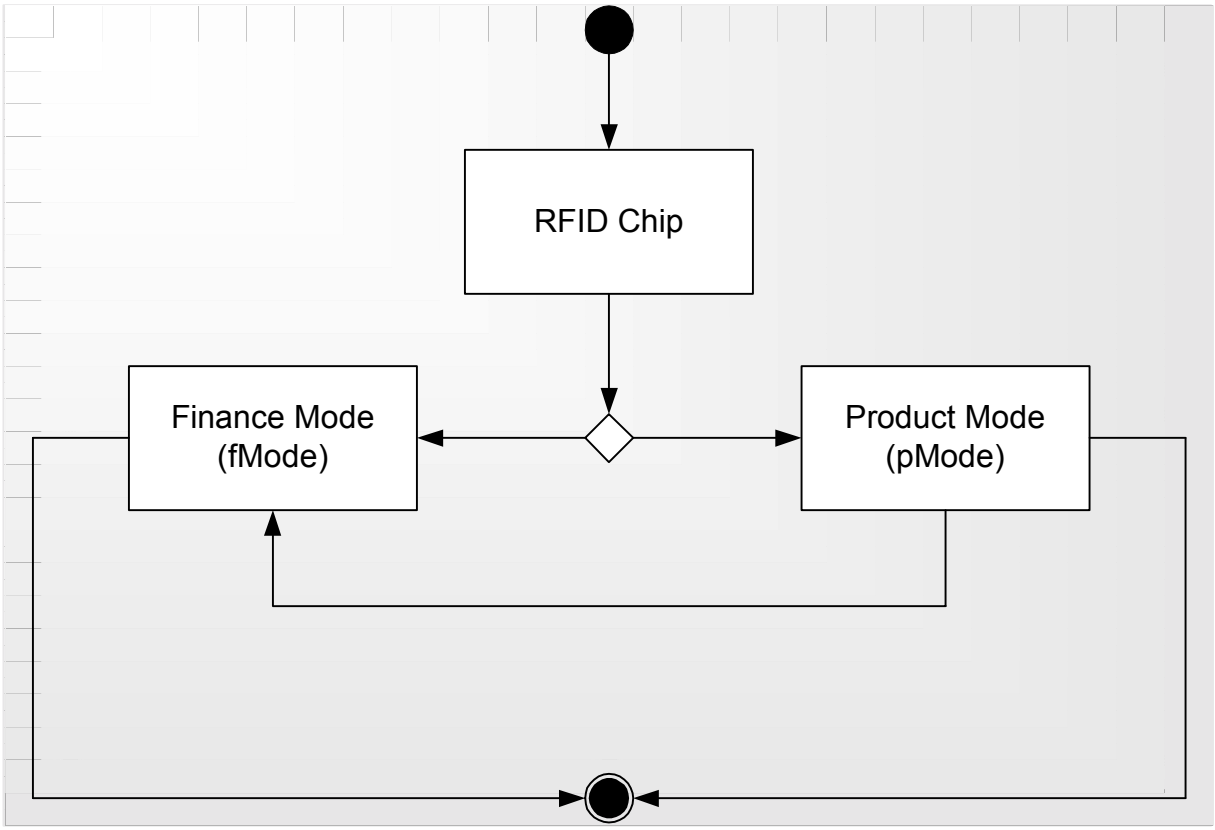
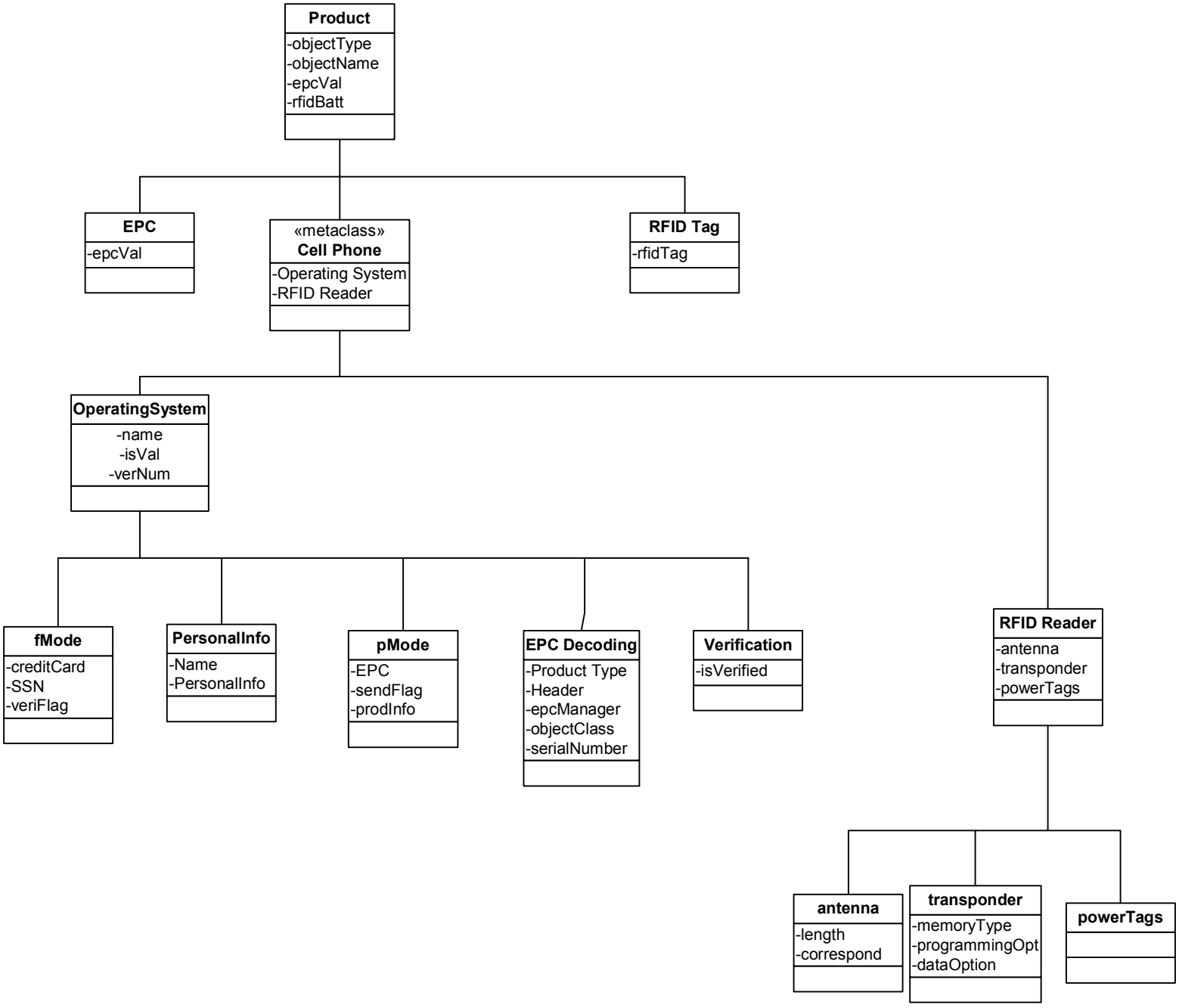


Figure 8. Activity Diagram for Use Case 4

Class Diagram



Class Diagram

Requirements and Specifications

The following Subsystem requirements were generated from the previously outlined Use Cases. They attempt to cover all details necessary for the Radio-frequency Identification System without creating too much detail, which goes beyond the scope of this project.

Subsystem Requirements

Radio-Frequency Identification Tag Requirements:

Index	Requirement
RFT1	Have antenna capable of short-range communication.
RFT2	Communicate to a distance of 3 Meters.
RFT3	Contain permanent memory capable of storing a 96-bit EPC.
RFT4	Contain circuitry capable of generating power from RFID Reader's electronic field.

Table 2. RFID Requirement

Electronic Product Code Requirements:

Index	Requirement
EPC1	Have information length of 96-bits.
EPC2	Contain four fields of information: Header, Manufacturer, Product ID, Item Serial Number.
EPC2.1	Header field must be 2-bits long.
EPC2.2	Manufacturer field must be 28-bits long.
EPC2.3	Product ID field must be 24-bits long.

EPC2.4	Item Serial Number field must be 36-bits long.

Table 3. EPC Requirement

Radio-Frequency Identification Tag Reader Requirements:

Index	Requirement
RFR1	Have rechargeable battery power source.
RFR2	Have on-board memory which can store Product Database.
RFR3	Have I/O capabilities.
RFR3.1	Have I/O port capable of transferring data to and from device.
RFR3.2	Have I/O Antenna capable of communication with RFID Tag.
RFR3.2.1	Antenna must communicate for a distance up to 3 Meters.
RFR4	Have LCD screen capable of displaying formatted information.
RFR5	Have On/Off switch to activate or deactivate power source.
RFR6	Contain Middleware to communicate between Reader and other devices.

Table 4. RFID Tag Requirements

Cell Phone Requirements:

Index	Requirement
CP1	Be able to perform error-checking on Electronic Product Code.
CP2	Be able to communicate with the Satellite Communication Tower.
CP3	Decode Electronic Product Code into four preset fields.

CP4	Have capability & compatibility for having RFID Chip having RFID Reader capability
CP5	Cell Phone operating system shall have two modes
CP6	Cell phone shall have capability of communicating with the RFID Tag
CP7	Cell Phone shall have the capability of being recharged.

Table 5. Cell Phone Requirement

Traceability Matrix

Use Case	Requirements	Description	Components
1. Retrieve Electronic `Product Code	RFT1-3, EPC1-2, RFR3, 5, 6, CP1	The RFID Reader must communicate with the RFID Tag and retrieve the EPC and perform error-checking.	RFID Tag, EPC, RFID Reader, Cell Phone
2. Decode the Electronic Product Code	EPC1-2, CP3, RFR6	Decode the EPC string into the four fields: Header, Manufacturer, Product Identifier, Serial Number	RFID Reader, EPC, Cell Phone
3. Retrieve unique product information	CP4, RFR2, 3.1, 4, 6	Use the decoded EPC fields to access specific information about the product from the database.	Cell Phone, RFID Reader
4. Mode Decision	CP1,3,5,6 ,RFR2, 3.1, 4, 6	Use the decoded EPC fields to access tracking and shipment information about the individual product.	Cell Phone, RFID Reader

Table 7. Traceability Matrix

System State Charts

State Chart #1: Identifying a Product via RFID

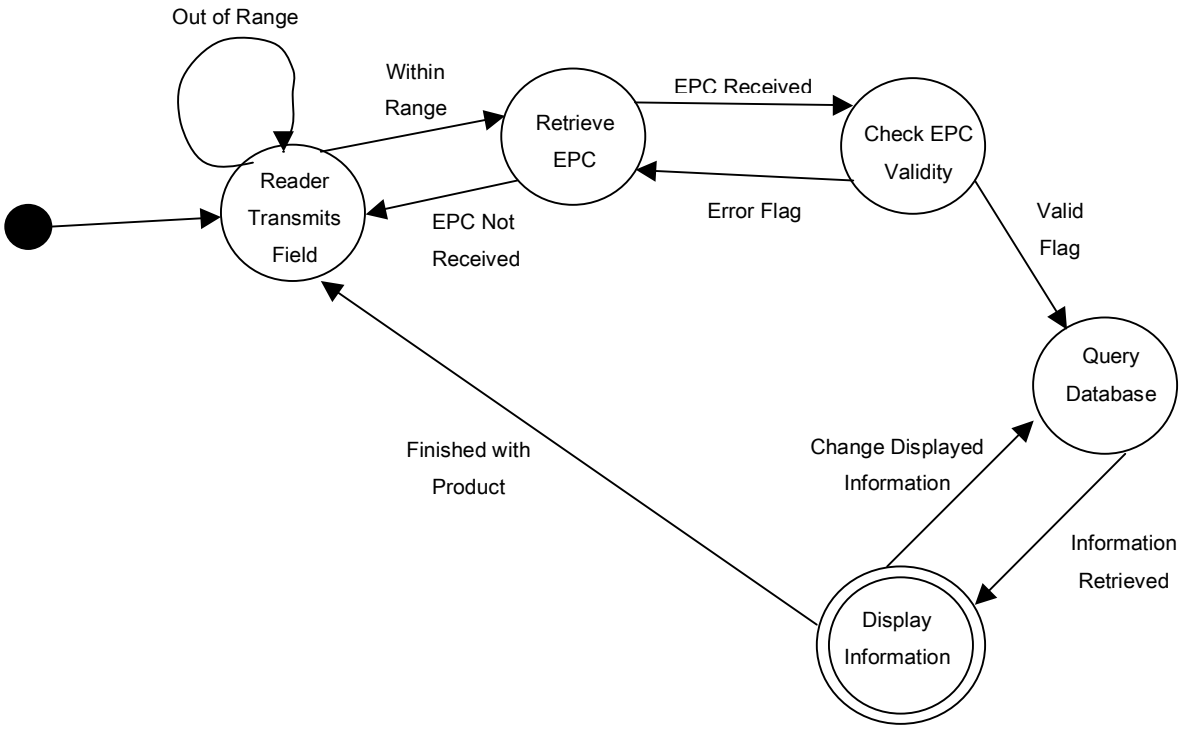


Figure 9. State Chart for Identifying a Product with RFID

State Chart #2: Tracking a Product via EPC

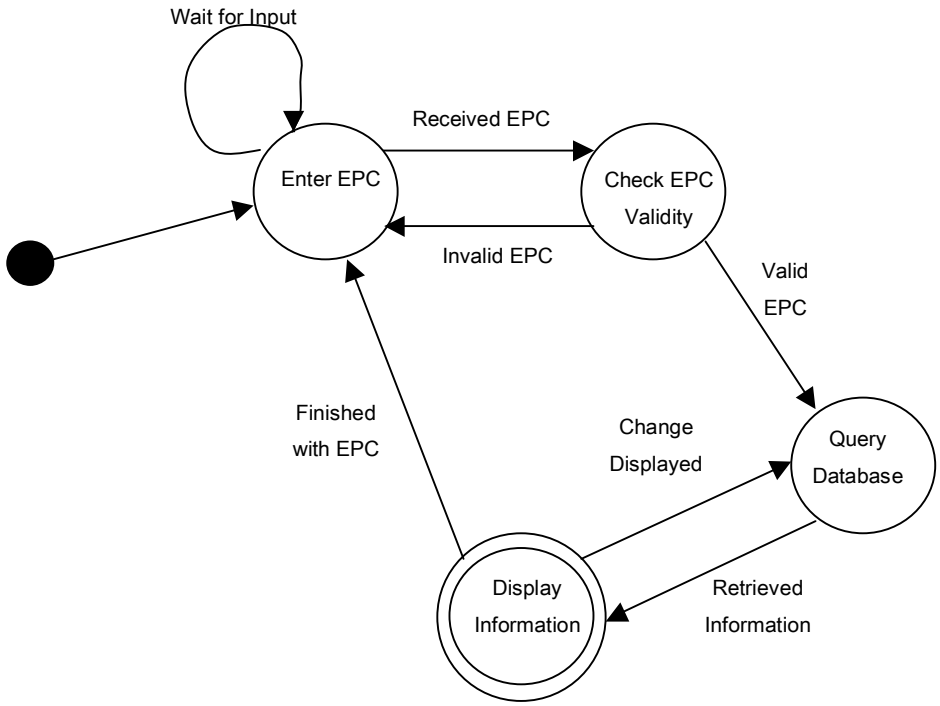


Figure 10. State Chart for Tracking a Product with EPC

Appendix

Following are the appendix for figures and tables.

Appendix A: Figures

Figure #	Figure Description
1	Overview of Using Cell Phones for RFID
1a	Overview of Using cell phones
2	Example of Electronic Product Code
3	EPC/RFID Overview
4	Initial Use Case Diagram
5	Activity Diagram for Use Case 1
6	Activity Diagram for Use Case 2
7	Activity Diagram for Use Case 3
8	Activity Diagram for Use Case 4