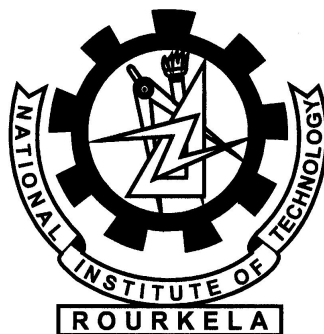


A Tag - Reader Authentication Scheme for RFID Systems

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May, 2015.

A Tag - Reader Authentication Scheme for RFID Systems

*Thesis submitted in partial fulfillment
of the requirements for the degree of*

Master of Technology

in

Information Security

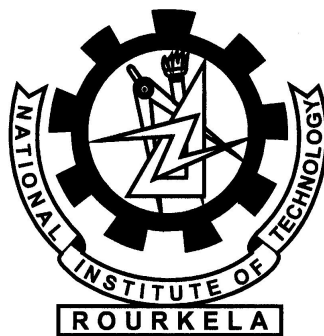
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May, 2015.

Dedicated to my parents and teachers



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Certificate

This is to certify that the work in the thesis entitled ” *A Tag-Reader Authentication Scheme for RFID Systems* ” submitted by *Hakim Singh* is a record of an original research work carried out by him under our supervision and guidance in partial fulfillment of the requirements for the award of the degree of Master of Technology in Computer Science and Engineering, National Institute of Technology, Rourkela. Neither this thesis nor any part of it has been submitted for any degree or academic award elsewhere.

Place: NIT,Rourkela-769008
Date: 30 - 05- 2015

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Hakim Singh

Abstract

Radio frequency Identification(RFID) system is latest a technology. It has been used in various application in the world. Radio frequency identification(RFID) can be used in supply chain management, automated payment systems and other daily application as essential technology to enhance lives of human beings. RFID systems are vulnerable for many malicious attacks against privacy and security. To solve these problems, many authentication protocols based on cryptography scheme have been developed in order to ensure preservation of privacy. However, many of the these approaches cannot fully protect privacy in the presence of malicious readers or insider attacks. Our research work in this thesis mainly focuses on designing secure RFID authentication schemes with untraceability. We observe a number of recent proposed RFID authentication scheme as well as related. Cryptography techniques, and then define the security and privacy requirement for our RFID systems. Our main contribution in this thesis consist proposed RFID authentication.

Generally, the weakness of RFID technology is authentication systems between a reader and a tag become weak. In this thesis, we introduced RFID tag - reader authentication scheme for use under the electronic product code global frame work . Which is more efficient for possible privacy and security threats in RFID system. This scheme is based on 16-bit random number. Random number is generated by 16-bit linear feedback shift register(LFSR). 16-bit Linear feedback shift register(LFSR) is based on polynomial feedback $X^{16} + X^{14} + X^{13} + X^{11} + 1$. We further analysed the RFID system's security strength against various attacking scenarios, such that man in middle attack, eavesdropping, replay attack and mutual authentication.

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List of Acronyms

Acronym	Description
R	Reader
T	Tag
RR	Reader Request
RFID	Radio Frequency Identification
EPC	Electronic Product Code
LFSR	Linear Feedback Shift Register
SV	Seed Value
RNR1	Random Number Reader First
RNT1	Random Number Tag First
PWDL	Password Lower Bits
PWDM	Password Most Significant Bits
RNT2	Random Number Tag Second
RNR2	Random Number Reader second
EPWDLT	Encrypted Password Lower Bits Tag
EPWDMT	Encrypted Password Most Significant Bits Tag
EPWDLR	Encrypted Password Lower Bits Reader
EPWDMR	Encrypted Password Most significant Bits Reader

Chapter 1

Introduction

RFID Technology

RFID Application

Motivation

Objective of Research

Organization of Thesis

Chapter 1

Introduction

In This chapter describes the overview of the thesis. Part 1.1 describes the background of RFID technology and part 1.2 describes the application of RFID technology. Part 1.3 explains the research issues in RFID sysetms and describes the motivation of my research in part 1.4. The contribution of this thesis gives in part 1.5, and describes the organisation of the thesis in part 1.6.

1.1 RFID Technology

RFID systems is new technology. It is used in identify and track objects automatically through radio waves. It has been considered as a replacement of barcode and given some attractive features (12) (13). RFID systems have three main parts : reader, tags and back-end server. It is called as transponders. Transmitter or receiver is part of a transponder. That is contemplated to gets a needed radio signal and automatically send a response. In its easier implementing, the transponder listens via a radio beacon, and transmits a beacon of its itself as a response. As active tags do not hold to respond on being powered through the reader, active tag are not limited to operating inside the near field. Active tag can be interrogated and reply at forward distances away by the reader, its means that active tags (at a minimum) are able to sending and taking over larger distances Semi-passive tags hold a battery to power the memory circuitry, but depend on the near Field for power the radio circuits during the getting and transmitting of data. As active tags do not hold to respond on being powered through the reader, active tag are not limited to operating inside the near field. Passive tag is called as dead tag. Because passive tag do not have battery. Passive tag have only EPC, 32-bit password and common random number procedure. Battery or other power sources does not in RFID passive tags. In order to passive tags for work, the

antenna and the tag must be near impedance for the reader, as the tags keep an interior power source, and derive its power to send by coupling for the near field of the antenna. So, passive tags must wait for a signal from a reader. Getting power from the reader device is completed by an electromagnetic property. Passive tags do not keep an internal power source, such as batteries. So, they are cheap and small. The microchip inside the tag is able to get power from the reader's interrogation radio signals. All are shown in figure 1.1 (20).

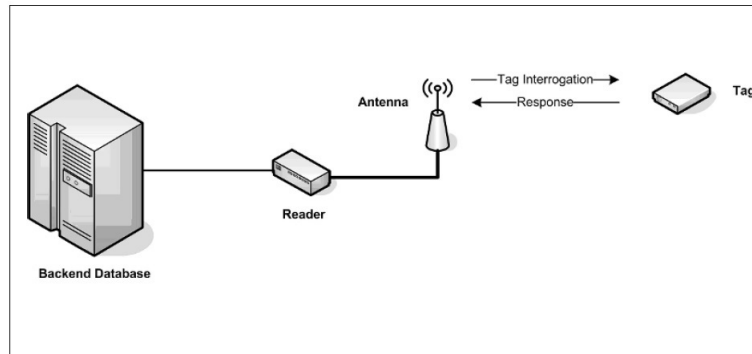


Figure 1.1: RFID Systems Components

1.1.1 RFID Tags

Class of radio devices have units of RFID. It is called as transponders. Transmitter or receiver is part of a transponder. That is contemplated to get a needed radio signal and automatically send a response. In its easier implementing, the transponder listens via a radio beacon, and transmits a beacon of its itself as a response. The transponder listens signal by beacon and after send by beacon of its self. Very difficult process may send a one alphabets or numbers back through the sources, or transmit many characters of numbers and letters. Lastly, blooming process can do a compute or checking system and combined encrypted radio broadcasting to finished eavesdroppers via finding the information being sending class of radio devices have units of RFID. It is called as transponders. Transmitter or receiver is part of a transponder. That is contemplated to get a needed radio signal and automatically send a response. In its easier implementing, the transponder listens via a radio beacon, and transmits a beacon of its itself as a response. As active tags do not hold to respond on being powered through the reader, active tag are not limited to operating inside the near field. Active tag can be interrogated and reply at forward distances away

by the reader, it means that active tags (at a minimum) are able to send and receive over larger distances. Semi-passive tags hold a battery to power the memory circuitry, but depend on the near field for power the radio circuits during the receiving and transmitting of data. As active tags do not have to respond on being powered through the reader, active tags are not limited to operating inside the near field. A passive tag is called a dead tag. Because passive tags do not have a battery. Passive tags have only EPC, 32-bit password and common random number procedure. Battery or other power sources do not exist in RFID passive tags. In order for passive tags to work, the antenna and the tag must be near the reader, as the tags keep an internal power source, and derive their power to send by coupling for the near field of the antenna. So, passive tags must wait for a signal from a reader. Getting power from the reader device is completed by an electromagnetic property. Passive tags do not keep an internal power source, such as batteries. So, they are cheap and small. The microchip inside the tag is able to get power from the reader's interrogation radio signals. A communication session can only be initiated by a reader range between a passive tag and a reader is limited. It is called the near field. While the name implies, the device must be comparatively near the reader in order to work. The near field in brief supplies sufficient power to the tag because it can transmit a reply (15) (17).

- *First is encoding/decoding circuitry*
- *Second is memory*
- *Third is antenna*
- *Last is power supply/communication process*

Passive Tag

A passive tag is called a dead tag. Because passive tags do not have a battery. Passive tags have only EPC, 32-bit password and common random number procedure. Battery or other power sources do not exist in RFID passive tags. In order for passive tags to work, the antenna and the tag must be near the reader, as the tags keep an internal power source, and derive their power to send by coupling for the near field of the antenna. So, passive tags must wait for a signal from a reader. The tag holds an echoic circuit competent of receiving power via the reader's antenna. Getting power from the reader device is completed by an electromagnetic property. Passive tags do not keep an internal power

source, such as batteries. So, they are cheap and small. The microchip inside the tag is able to get power from the reader's interrogation radio signals. A communication session can only be initiated by a reader range between a passive tag and a reader is limited. It called as the near field. While the name implies, the device must be comparatively near the reader in order for work. The near field in brief supplies sufficient power to the tag because it can transmits a reply (6) (16).

In order to passive tags for work, the antenna and the tag must be near impendency for the reader, as the tags keep an interior power source, and derive itself power to send by coupling for the near field of the antenna. The near field gets benefits of electromagnetic cretic and generates a small, less-lived electrical pulse with the passive tag that can power a tag large enough for it to reply.

passive tag do not keep internal power source, such as batteries. So, they are cheap and small. The microchip inside the tag is able to get power from the reader's interrogation radio signals. A communication session can only be initiated by a reader range between a passive tag and a reader is limited (19) (20).

Semi-passive tag and Active Tag

The successively for a passive tag is an active tag. Active tags keep their itself power source, commonly an interior battery. So, active tag hold a battery for power the radio circuitry, active tag can actively send and gets on their itself, without hold to be powered through the near field of the reader's antenna . As active tags do not hold to respond on being powered through the reader, active tag are not limited to operating inside the near field. Active tag can be interrogated and reply at forward distances away by the reader, its means that active tags (at a minimum) are able to sending and taking over larger distances Semi-passive tags hold a battery to power the memory circuitry, but depend on the near field for power the radio circuits during the getting and transmitting of data. As active tags do not hold to respond on being powered through the reader, active tag are not limited to operating inside the near field. Passive tag is called as dead tag. Because passive tag do not have battery. Passive tag have only EPC, 32-bit password and common random number procedure. Battery or other power sources does not in RFID passive tags. In order to passive tags for work, the antenna and the tag must be near impendency for the reader,

as the tags keep an interior power source, and derive itself power to send by coupling for the near field of the antenna. So, passive tags must waiting to a signal by a reader. Getting power by the reader device is completed by an electromagnetic properties . Passive tag do not keep internal power source, such as batteries. So, they are cheap and small. The microchip inside the tag is able to get power from the reader's interrogation radio signals. A communication session can only be initiated by a reader range between a passive tag and a reader is limited. It called as the near field. While the name implies, the device must be comparatively near the reader in order for work. The near field in brief supplies sufficient power to the tag because it can transmits a reply(1) (14).

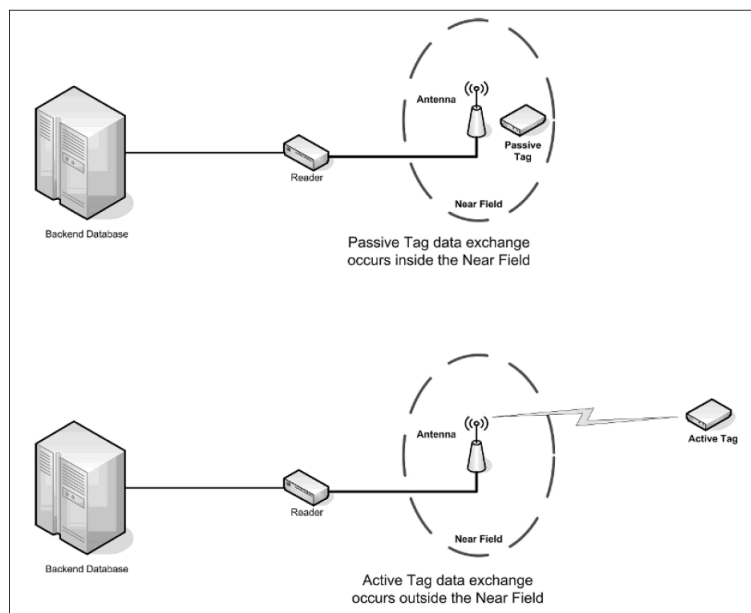


Figure 1.2: RFID Passive and Active Tag Process

1.1.2 RFID Readers

The second component of RFID system is reader. Reader is read the information from the tags and then store in server or database. Reader is depends on distance because when distance is large then we are used high frequency reader and while distance is sort then we are used low frequency reader. As active tags do not hold to respond on being powered through the reader, active tag are not limited to operating inside the near field. Active tag can be interrogated and reply at forward distances away by the reader, its means that active tags (at a minimum) are able to sending and taking over larger distances Semi-passive tags hold a battery to power the memory circuitry, but depend on the near field

for power the radio circuits during the getting and transmitting of data. As active tags do not hold to respond on being powered through the reader, active tag are not limited to operating inside the near field. Passive tag is called as dead tag. Because passive tag do not have battery. Passive tag have only EPC, 32-bit password and common random number procedure. Battery or other power sources does not in RFID passive tags. In order to passive tags for work, the antenna and the tag must be near impendency for the reader, as the tags keep an interior power source, and derive itself power to send by coupling for the Near Field of the antenna. So, Passive tags must waiting to a signal by a reader. Getting power by the reader device is completed by an electromagnetic properties . Passive tag do not keep internal power source, such as batteries. So they are cheap and small. The microchip inside the tag is able to get power from the reader's interrogation radio signals. A communication session can only be initiated by a reader range between a passive tag and a reader is limited. It called as the Near Field. While the name implies, the device must be comparatively near the reader in order for work. The near field in brief supplies sufficient power to the tag because it can transmits a reply.

1.2 RFID Applications

Beginning from the 90s, RFID technology has launched in a variety of commercial products. For example, Wal-Mart has started to require their suppliers to adopt RFID technology in their own smart cards after year 2000. This initiative has been the biggest push for commercial usage of this technology in the recent years. Beside, the massive commercial adoption in the marketplace, such technology has also been applied in military in the United States. In the following section, we presented some common applications for RFID tags and highlighting their security concerns. RFID tags can also store personal information for security check-ins. Another common RFID application is the RFID-enabled vehicle immobilizer in the auto- motive industry. There is an embedded chip in each key that sends out out an 32-bit encrypted radio-frequency signal forming a particular code. With this code, the driver is able to start the car and activate the fuel pump with ease. As a result, this technology has increased anti-theft capability in the automotive industry. For example, an employee carries an ID card, embedded with a RFID chip, could authenticate

his or her identity at the security entry in a facility within a very short period of time. The embedded chips in the new passports store the same personal information as those in the old printed document, including names, nationalities, sex, dates of birth, places of birth, fingerprints, and photos of the passport holders.

1. For instance, pharmaceutical industries in the United States, capturing ten percent of the global market, makes 32 billion dollars. The recent increase of counterfeit or diluted drugs has caught the attention of Food and Drug Administration (FDA). FDA considered this as a threat to public health. Implementation of the RFID technology could immediately improve pharmaceutical supply chain safety through real-time, one, and item-level authentication, from the initial point of manufacturing to the final stage of dispensing drugs to consumers in the pharmacies. This touch-free payment system speeds up transactions, when customers only need to place their credit cards in close proximity to an RFID reader. (7).

2. Many RFID-based payment systems are widely used in our daily life, including RFID- capable credit cards from major credit card association and companies and payment cards in mass transit systems. This touch-free payment system speeds up transactions, when customers only need to place their credit cards in close proximity to an RFID reader. RFID tags can also store personal information for security check-ins. For example, an employee carries an ID card, embedded with a RFID chip, could authenticate his or her identity at the security entry in a facility within a very short period of time. The embedded chips in the new passports store the same personal information as those in the old printed document, including names, nationalities, sex, dates of birth, places of birth, fingerprints, and photos of the passport holders.

3. Another common RFID application is the RFID-enabled vehicle immobilizer in the automotive industry. There is an embedded chip in each key that sends out an 32-bit encrypted radio-frequency signal forming a particular code. With this code, the driver is able to start the car and activate the fuel pump with ease. As a result, this technology has increased anti-theft capability in the automotive industry.

4. RFID tags can also store personal information for security check-ins. For example, an employee carries an ID card, embedded with a RFID chip, could authenticate his or her

identity at the security entry in a facility within a very short period of time. The embedded chips in the new passports store the same personal information as those in the old printed document, including names, nationalities, sex, dates of birth, places of birth, ngerprints, and photos of the passport holders (4) (6) (8).

1.3 Motivation

To address all these objective mentioned below,The research should concern many properties about RFID security and privacy.

Tag authentication is called a tag prove its validity for a reader, while reader authentication is in the opposite way. Mutual authentication is used for tag and reader authentication. In especially, tag authentication is more important because tags are very easier to counterfeit than readers. Authentication is an more effective approach to prevent attacks.

Untraceability means that a tag is both anonymous and indistinguishable to an adversary. Although an RFID tag is vulnerable to compromise, an malicious reader should not identify the communication records of this tag in the past or future session. Thus,a protocol should not leak the identity or internal secret of RFID tags in communication processes.

Performance requirements should be satisfied. Considering the limited storage and computational ability of low-cost tags, cryptographic techniques used in the schemes should be basic and restricted. Besides, a back-end server may deal with a plenty of tags in one RFID system in real world scenarios. Thus,an RFID scheme should also be scalable and especially easy for a server to search the information of a tag in the database for these issues, the thesis focuses on designing secure and untraceable authentication schemes for RFID systems.

1.4 Objectives of Research

The weakness of RFID systems technology, it is high cost. Mutual authentication between a tag and a reader is less.

- To provide more security between reader and tag.
- To prevention Man-in-the-middle attack.

- To prevention Mutual Authentication.

1.5 Organisation of Thesis

The rest of Thesis is organized as follow:

Chapter 2: In this chapter A survey of Tag-reader authentication for RFID systems as reported in the literature is mentioned.

Chapter 3:In this chapter we have shown Proposed authentication scheme and Existing Authentication scheme.

Chapter 4:In this chapter we have shown simulation result and implementation.

Chapter 5:In this chapter we have shown about conclusion and future work.

Chapter 2

Literature Survey

Chapter 2

Literature Survey

Konidala et al. (1) proposed a scheme which is taken large time to mutual authentication. Which is more secure than other scheme. It is not implemented in hardware. Its process completely depend on passwords and access password.

However, due to the wireless nature of communication in RFID, identity theft can be achieved more easily without proper security measurement. Personal information is exposed for hackers, who would break into the devices, snap personal information, and then walk away with it. Unauthorized duplication of passports not only jeopardizes millions of Americans' privacy, it also threatens national security (13).

Peris-Lopez et al. (2) required a Mix Bits function, which needs more iterations to complete. This scheme takes more time for authentication between tag's and reader.

In addition, many public transportation systems are also RFID-ready in major cities around the world, such as Massachusetts Bay Transportation Authority system in Boston, the Easy Card for Taipei Metro system, and Octopus Card in Hong Kong. The adoption of the RFID technology in these markets has made the mass transit systems transforming from a slow cash collection process to a speedy fare scan-and-go process. Vending machines or many marketplaces in the cities can dispense the transit cards providing riders convenient sale methods and locations.

Li et al. (10) proposed a EX-OR approach for an fast implementation of protocol. It takes less time in computation to EX-OR operation. And this scheme is completely depend on EX-OR and random number.

Schulte et al. (14) This scheme is completely based on truncated multipliers. Truncated multiplier takes less time for authentication between tags and reader.

Huang et al. (12) changes the Pad gen function given by Konidala et al. It is more

secure than konidala approach because some modification in the previous approach.

Ko and Hsiao. (13) proposed an efficient array based truncated multiplier. This scheme is implemented in hardware. This is take less time other approach.

Active tags and passive tags hold batteries. The difference both of them is that. Active tags are able to power their memory circuitry and radio circuits. Semi passive tags still need the reader's radio-frequency signals to power their radio circuits. So, Both contain their itself power source. Both of them can communicate with reader in a larger distance compared to passive tags.

Chapter 3

Authentication Scheme

EPC class-1 generation-2 standard

Authentication using Diffie Hellman Algorithm

Proposed Authentication Scheme

Reader Operation

Tag Operation

16-Bit Linear Feedback Shift Register

Chapter 3

Authentication Scheme

3.1 EPC class-1 generation-2 standard

32-bit secure password is kept in the tag's reserved memory if this password is true, then data transmit will be build between tag and reader. Firstly reader send a requests to tag. Tag is created a random number after transmit for reader. The reader computes encrypted password using performing a bit wise exclusive-or between actual password and random number. The encrypted password is send for the tag. The tag calculates encrypted password using performing a bit wise exclusive-or between actual password and random number. The encrypted password using performing a bit wise EX-OR of the gets encrypted password with the original as shown in Fig.3.1 and Fig.3.2. In this approach , both random number transmit in unencrypted form. Man in middle attack is possible to happen by takes exclusive-or operation between the encrypted passwords and random number, that gives actual password and their via unauthorized reader get the tags data. 32-bit secure password is kept in the tag's reserved memory if this password is true, then data transmit will be build between tag and reader. Firstly reader send a requests to tag. Tag is created a random number after transmit for reader. The reader computes encrypted password using performing a bit wise exclusive-or between actual password and random number. The encrypted password is send for the tag.(10).

3.2 Authentication using Diffie Hellman Algorithm

Fig.3.3 and Fig.3.4 explain the proposed scheme communication step between a tag and a reader and the detailed classification of the proposed scheme is as follow.

Step 1: Firstly, reader send a request data for tag.

Step 2: The tag compute the value of R1 by P, Q and PWDL.

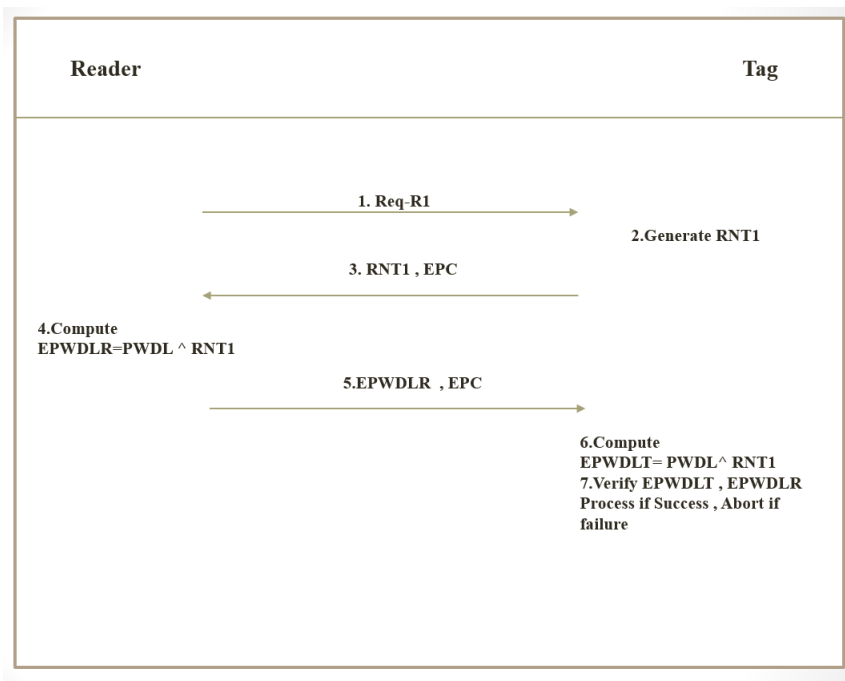


Figure 3.1: Authentication Approach Proposed by EPC Global

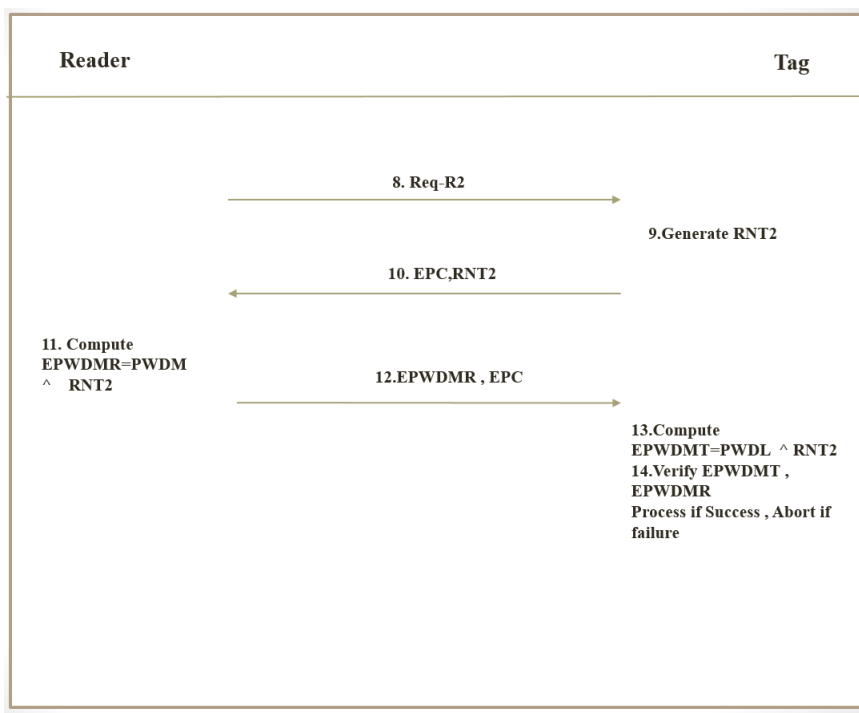


Figure 3.2: Authentication Approach Proposed by EPC Global

Step 3: The tag responds by generating R1 and EPC.

Step 4: EPC and R1 information is send for the server by the reader.

Step 5: The server compute the value of R2 by P, Q and PWDL.

Step 6: Checking of R1=R2 is completed. Whether it is true the process continues

else communication is finished.

Step 7: The server calculate the value of R3 by P, Q and PWDM.

Step 8: The server responds by R3 and EPC to reader.

Step 9: The reader responds by R3 and EPC to tag.

Step 10: The tag compute the value of R4 by P, Q and PWDM.

Step 11: Checking of R4=R3 is done. If it is true the process continues else communication is finished.

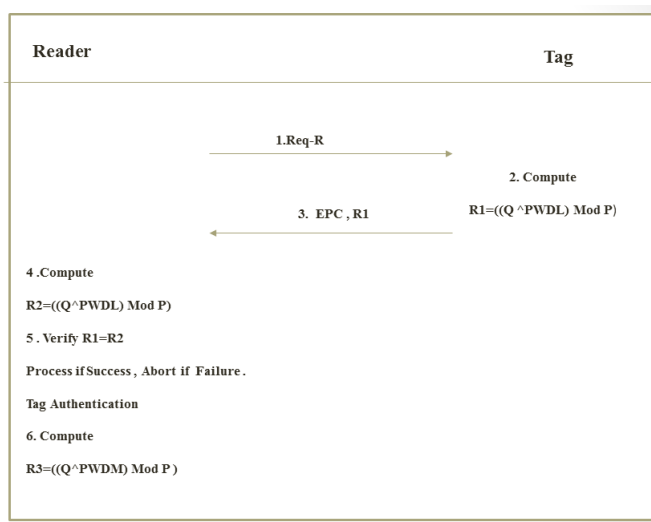


Figure 3.3: Authentication using Diffie Hellman Algorithm

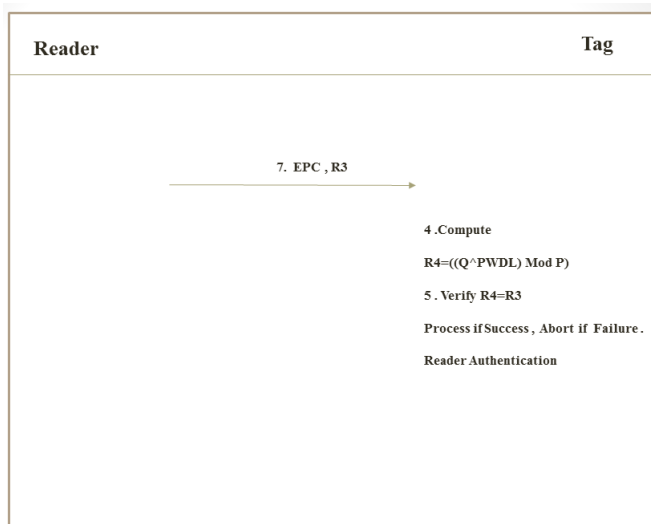


Figure 3.4: Authentication using Diffie Hellman Algorithm

3.3 Proposed Authentication Scheme

3.3.1 Proposed Scheme

There are three main component of proposed scheme. First is tag and Second is reader and third one is database or server. In the proposed scheme, each tag have an unique Electronic Product Code(EPC), Password(PWD) and Linear Feedback Shift Register(LFSR) given by manufacturer to encrypted Password(PWD). The database hold the information about Electronic Product Code(EPC) and Password(PWD) for all tags. It also keep a same protocol architecture. It is given in all tags (5) (12).

Fig.3.5 and Fig.3.6 shown the proposed scheme communication step between a reader and a tag and the detailed classification of the proposed scheme is as follow.

Step 1: Firstly, Reader transmits a request message for Tag.

Step 2: Tag transmits the response to reader with EPC and Seed value.

Step 3: Reader generate Random Number Reader One(RNR1) using Seed Value(SV).

Step 4: Reader compute Encrypted Password Lower Reader(EPWDLR) using Random Number Reader One(RNR1) and Password Lower(PWDL).

Step 5: Reader transmits Encrypted Password Lower Reader(EPWDLR) and Electronic product Code(EPC) to Tag.

Step 6: Tag generate Random number using Seed value.

Step 7: Tag compute Encrypted Password Lower Tag(EPWDLT) using Random Number Tag One(RNT1) and Password Lower (PWDL).

Step 8: Checking of Encrypted Password Lower Tag(EPWDLT)=Encrypted Password Lower Reader(EPWDLR) is completed. Whether it is true the process continues else communication is finished.

Step 9: Tag generate Random Number Tag Two(RNT2) using Random Number Tag One(RNT1).

Step 10: Tag compute Encrypted Password Most Tag (EPWDMT) using Random Number Tag Two(RNT2) and Password Most(PWDM).

Step 11: Tag send Encrypted Password Most Tag(EPWDMT) and Electronic Product Code(EPC) to Reader.

Step 12: Reader generate Random Number Reader Two(RNR2) using Random Num-

ber Reader One(RNR1).

Step 13: Reader compute Encrypted Password Most Reader(EPWDMR) using Random Number Reader(RNR2) and Password Most(PWDM).

Step 14:Checking of Encrypted Password Most Reader(EPWDMR)=Encrypted Password Most Tag(EPWDMT)is completed. whether it is true the process continues else communication is finished.

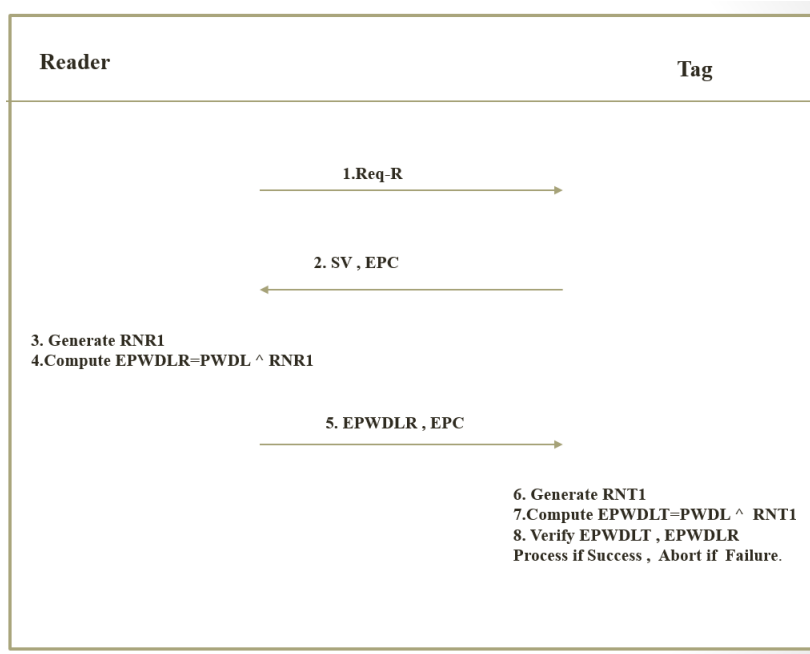


Figure 3.5: Proposed RFID Authentication Scheme

3.3.2 Reader Operation

Reader is read the information from the tags after store in database. Reader operation is shown in Fig. 3.6.

Initialize: RRT[16], EPWDLR[16], EPWDLR[16], EPC, PWDL[16], PWDM[16]
RNR1[16], C, RNR2[16], I;

1. Begin For I = 1 to 16
 - RRT[I]=rand()÷2
- End For
2. ReaderSendRequest(RRT)
3. TagSendSeedValue(EPC,SV)
 - Begin For I =1 to 16

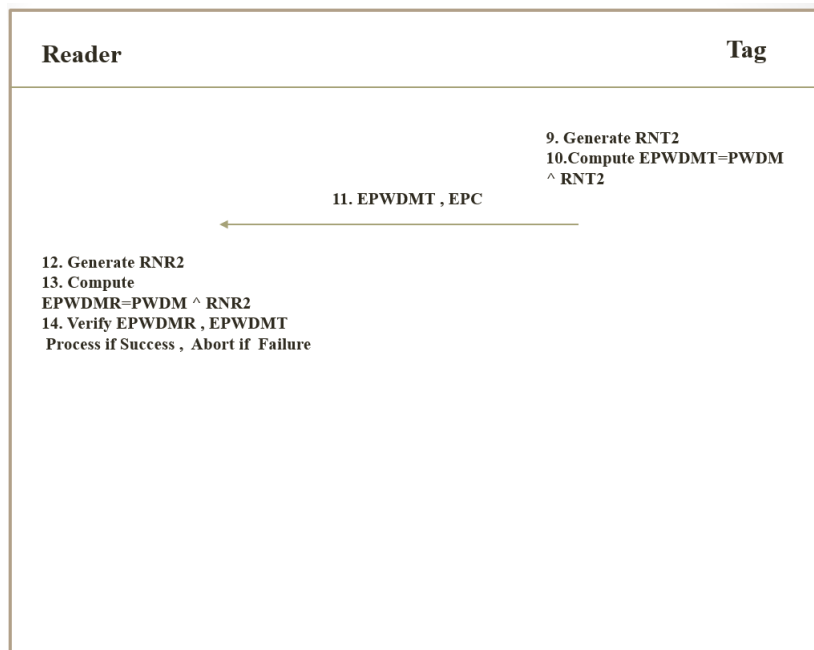


Figure 3.6: Proposed RFID Authentication Scheme

$$C = SV[16] \oplus SV[14] \oplus SV[13] \oplus SV[11]$$

Begin For I=1 to 15

$$SV[I+1] = SV[I]$$

End For

$$SV[1] = C$$

$$RNR1[I] = SV[16]$$

End For

Begin For I=1 to 16

$$EPWDLR[I] = RNR1[I] \oplus PWDL[I]$$

End For

4. ReaderSendEncrypted(EPWDLR, EPC)

5. TagSendEncrypted(EPWDMT, EPC)

Begin :For I=1 to 16

$$C = RNR1[16] \oplus RNR1[14] \oplus RNR1[13] \oplus RNR1[11]$$

Begin : For I=1 to 15

$$RNR1[I+1] = RNR1[I]$$

End For

$$RNR1[1] = C$$


```

        RNR2[I]=RNR1[16]

    End For

    Begin : For I=1 to 16

        EPWDMR[I]=RNR2[I]  $\oplus$  PWDM[I]

    End For

    Begin : For I=1 to 16

        Begin :

            If (EPWDMR[I] == EPWDMT[I])

                Else

                    Abort

                    Break

            End If

        End For

    End For

Tag Authentication

Process Continue
    
```

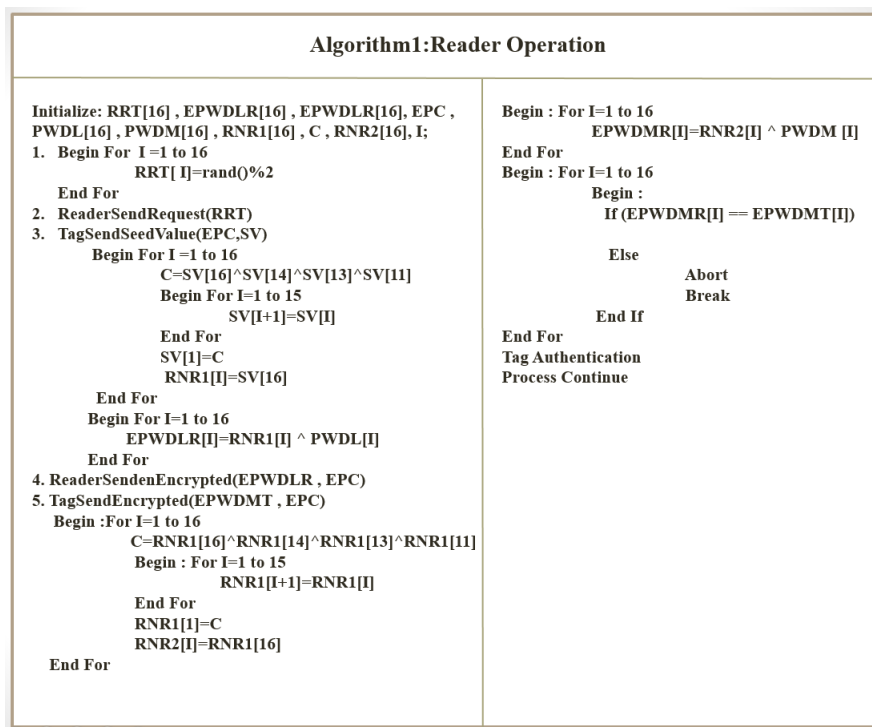


Figure 3.7: Reader Operation

3.3.3 Tag Operation

Tag hold information about that things. That information is store in barcode. Tag hold a unique Electronic product code. Tag operation is shown in Fig.3.7.

Initialize: EPWDLT[16] , EPWDMT[16] ,SV[16] , RNT1[16] , RNT2[16] , I , EPC , C

1. ReaderSendRequest(RRT)

Begin : For I=1 to 16

SV=rand() \div 2

End For

2.TagSendSeedValue(EPC , SV)

3. ReaderSendEncrypted(EPWDLR , EPC)

Begin : For I=1 to 16

$C=SV[16] \oplus SV[14] \oplus SV[13] \oplus SV[11]$

Begin : For I=1 to 15

SV[I+1]=SV[I]

End For

SV[1]=C

RNT1[I]=SV[16]

End For

Begin : For I=1 to 16

$EPWDLT[I]=RNT1[I] \oplus PWDL[I]$

End For

Begin :For I=1 to 16

Begin :

If(EPEDLT[I] = = EPWDLR[I])

Else

Process Abort

Break

End If

End For

Reader Authentication

Begin : For I=1 to 16

$$C = RNT1[16] \oplus RNT1[14] \oplus RNT1[13] \oplus RNT1[11]$$

Begin : For I=1 to 15

$$RNT1[I+1] = RNT1[I]$$

End For

$$RNT1[1] = C$$

$$RNT2[I] = RNT1[16]$$

End For

Begin : For I=1 to 16

$$EPWDMT[I] = RNT2[I] \oplus PWDM[I]$$

o cm End For

4. TagSendEncrypted(EPWDMT , EPC)

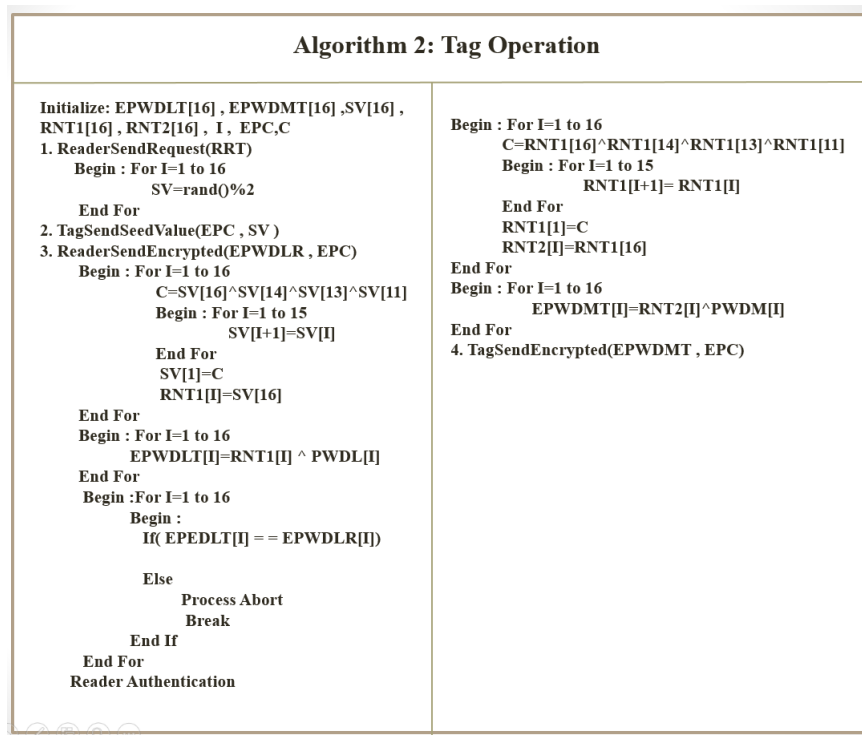


Figure 3.8: Tag Operation

3.3.4 Linear Feedback Shift Register

Linear Feedback Shift Register(LFSR) is a shift register its input bit is a linear function of its previous state. The most commonly used linear function of single bits is exclusive-

or. An Linear Feedback Shift Register(LFSR)is most often a shift register its input bit is driven by the exclusive or (EXOR) of the whole shift register value. The initial value of the Linear Feedback Shift Register(LFSR) is called Seed Value. So the register has a definite number of possible states. Though, an Linear Feedback Shift Register(LFSR)with a select feedback function can be produced a order of bits that appeared random number (20) (15).

16-bit Linear Feedback Shift Register(LFSR) as maximum length feedback polynomial $X^{16} + X^{14} + X^{13} + X^{11} + 1$ creates $2^{16} - 1 = 65535$ random outputs (11) (13).

The diagram for 16-bit linear feedback shift register(LFSR) with maximum length polynomial is shown in Fig.3.8.

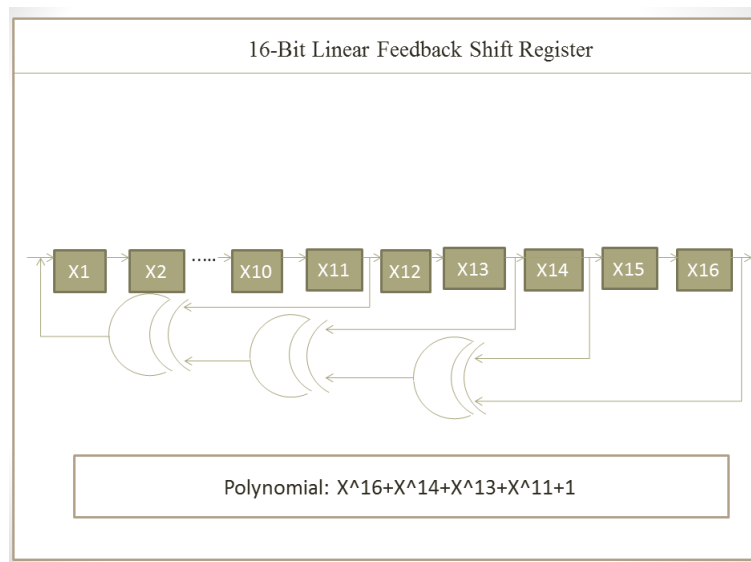


Figure 3.9: 16-bit Linear Feedback Shift Register with Maximum Length Feedback Polynomial $X^{16} + X^{14} + X^{13} + X^{11} + 1$

Chapter 4

Simulation & Results

Simulation and Implementation

Security Analysis

Chapter 4

Simulation & Results

This chapter gives overview about simulation and security analysis. Section 4.1 explain about simulation and implementation. Section 4.2 explain about security analysis.

4.1 Simulation and Implementation

Linear feedback shift register is used to described the proposed RFID authentication scheme. This approach is simulated in C language.

Fig 4.1 shows simulation output of the propose scheme.

Where SV=001110111100101.

RR=1011011011110111.

PWDL=1001011010110011.

PEDM=1100110011001100.

RNT1=1101001110111110.

RNT2=1011110111100101.

RNR1=1101001111011110.

RNR2=1011110111100101.

EPWDLT=0100010101101101.

EPWDLR=0100010101101101.

EPWDMT=0111000100101001.

EPWDMR=0111000100101001.

Whenever the EPWDLR and EPWDMR mathces with the value of EPWDLT and EPWDMT respectively mutual authentication becomes high.

R:Generate RR

16 Times RR=rand()%2

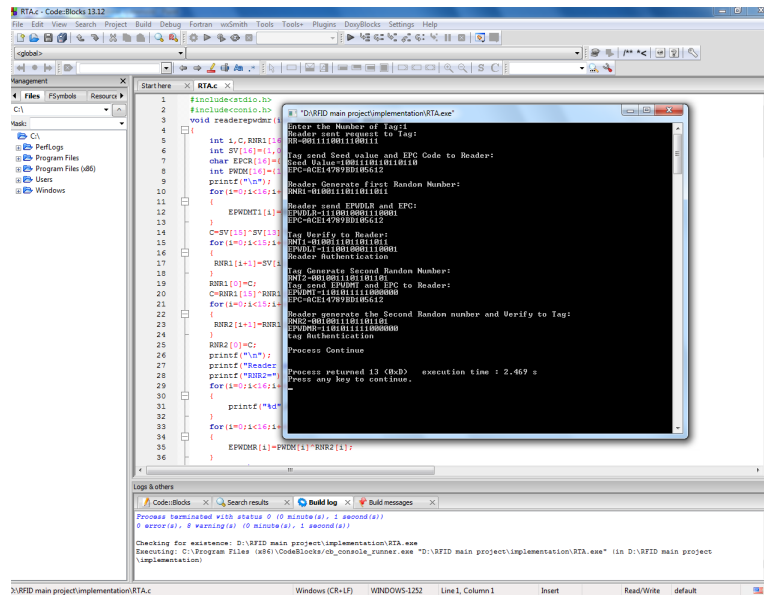


Figure 4.1: Simulation Results of Proposed Scheme

RR=1011011011110111

R send request to T: RR=101101110111

T:Generate SV

16 Times SV=rand()%2

SV=001110111100101

T send SV and EPC to R: SV=001110111100101 EPC=ACE14789BD105612

R: Generate RNR1

16 Times C=SV[16] XOR SV[14] XOR SV[13] XOR SV[11]

SV[I+1]=SV[I]

SV[I]=C

RNR1[I]=SV[16]

RNR1=1101001111011110

PWDL=1001011010110011

R : Compute EPWDLR

16 Times EPWDLR[I]=RNR1[I] XOR PWDL[I]

EPWDLR=0100010101101101

Reader send EPC and EPWDLR to Tag: EPC=ACE14789BD105612 EPWDLR=01000101011011

T : Generate RNT1

	RNR1[I]=SV[16]	SV[I+1]=SV[I]	SV[I]=C	C=SV[16] XOR SV[14] XOR SV[13] XOR SV[11]
SV		001111011110010	1	
1	0	011110111100101	1	1
2	1	111101111001011	0	0
3	1	111011110010110	0	0
4	1	110111100101100	1	1
5	1	101111001011001	1	1
6	0	011110010110011	0	0
7	1	111100101100110	0	0
8	1	111001011001100	1	1
9	1	110010110011001	1	1
10	1	100101100110011	1	1
11	0	001011001100111	1	1
12	0	010110011001111	0	0
13	1	101100110011110	1	1
14	0	011001100111101	1	1
15	1	110011001111011	0	0
16	1	100110011110110	0	0

Table 4.1: RNR1 generate by Reader

	RNR1[I]	PWDL[I]	EPWDLR[I] = RNR1[I] XOR PWDL[I]
1	0	1	1
2	1	1	0
3	1	0	1
4	1	0	1
5	1	1	0
6	0	1	1
7	1	0	1
8	1	1	0
9	1	0	1
10	1	1	0
11	0	1	1
12	0	0	0
13	1	1	0
14	0	0	0
15	1	0	1
16	1	1	0

Table 4.2: EPWDLR compute by Reader

16 times $C=SV[16] \text{ XOR } SV[14] \text{ XOR } SV[13] \text{ XOR } SV[11]$

$SV [I+1] = SV[I]$

$SV[I]=C$

$$RNT1[I]=SV[16]$$

	RNRT1[I]=SV[16]	SV[I+1]=SV[I]	SV[I]=C	C=SV[16] XOR SV[14] XOR SV[13] XOR SV[11]
SV		001111011110010	1	
1	0	011110111100101	1	1
2	1	111101111001011	0	0
3	1	111011110010110	0	0
4	1	110111100101100	1	1
5	1	101111001011001	1	1
6	0	011110010110011	0	0
7	1	111100101100110	0	0
8	1	111001011001100	1	1
9	1	110010110011001	1	1
10	1	100101100110011	1	1
11	0	001011001100111	1	1
12	0	010110011001111	0	0
13	1	101100110011110	1	1
14	0	011001100111101	1	1
15	1	110011001111011	0	0
16	1	100110011110110	0	0

Table 4.3: RNT1 generate by Tag

$$RNT1=110100111011110$$

$$PWDL=1001011010110011$$

T : Compute EPWDLT

$$16 \text{ Times } EPWDLT[I]=RNT1[I] \text{ XOR } PWDL[I]$$

T : Verify EPWDLT , EPWDLR

$$EPWDLT= 0100010101101101$$

$$EPWDLR=0100010101101101$$

Process If Success, Abort if failure

Reader Authentication

T : Generate RNT2

$$RNT1=1101001111011110$$

$$16 \text{ times } C=RNT1[16] \text{ XOR } RNT1[14] \text{ XOR } RNT1[13] \text{ XOR } RNT1[11]$$

$$RNT1 [I+1] = RNT1[I]$$

$$RNT1[I]=C$$

	RNT1[I]	PWDL[I]	EPWDLT[I] = RNT1[I] XOR PWDL[I]
1	0	1	1
2	1	1	0
3	1	0	1
4	1	0	1
5	1	1	0
6	0	1	1
7	1	0	1
8	1	1	0
9	1	0	1
10	1	1	0
11	0	1	1
12	0	0	0
13	1	1	0
14	0	0	0
15	1	0	1
16	1	1	0

Table 4.4: EPWDLR compute by Tag

	EPWDLT[I]	EPWDLR[I]	EPWDLT[I] = EPWDLR[I]
1	1	1	T
2	0	0	T
3	1	1	T
4	1	1	T
5	0	0	T
6	1	1	T
7	1	1	T
8	0	0	T
9	1	1	T
10	0	0	T
11	1	1	T
12	0	0	T
13	0	0	T
14	0	0	T
15	1	1	T
16	0	0	T

Table 4.5: Reader Authentication

$$RNT2[I]=RNT1[16]$$

$$RNT2=1011110111100101$$

$$PWDM=1100110011001100$$

T : Compute EPWDMT

$$16 \text{ times } EPWDMT[I]=RNT2[I] \text{ XOR } PWDM[I]$$

	RNT2[I]=RNT1[16]	RNT1[I+1]=RNT1[I]	RNT1[I]=C	C=RNT1[16] RNT1[14] RNT1[13] RNT1[11]	XOR XOR XOR
RNT1		110100111101111	0		
1	1	101001111011110	0	0	
2	0	010011110111100	1	1	
3	1	100111101111001	1	1	
4	0	001111011110011	1	1	
5	0	011110111100111	1	1	
6	1	111101111001111	0	0	
7	1	111011110011110	0	0	
8	1	110111100111100	1	1	
9	1	101111001111001	1	1	
10	0	011110011110011	1	0	
11	1	111100111100110	1	1	
12	1	111001111001101	0	1	
13	1	110011110011011	1	0	
14	1	100111100110110	1	1	
15	0	001111001101101	0	1	
16	1	011110011011011	0	0	

Table 4.6: RNT2 generate by Tag

	RNT2[I]	PWDM[I]	EPWDMT[I] = RNT2[I] XOR PWDM[I]
1	1	0	1
2	0	0	0
3	1	1	0
4	0	1	1
5	0	0	0
6	1	0	1
7	1	1	0
8	1	1	0
9	1	0	1
10	0	0	0
11	1	1	0
12	1	1	0
13	1	0	1
14	1	0	1
15	0	1	1
16	1	1	1

Table 4.7: EPWDMT compute by Tag

EPWDMT=0111000100101001

Tag send EPWDMT and EPC to Reader: EPWDMT = 0111000100101001. EPC

= ACE14789BD105612

R : Generate RNR2

RNR1=1101001111011110

16 times C=RNR1[16] XOR RNR1[14] XOR RNR1[13] XOR RNR1[11]

RNR1 [I+1] = RNR1[I]

RNR1[I]=C

RNR2[I]=RNR1[16]

	RNR2[I]=RNR1[16]	RNR1[I+1]=RNR1[I]	RNR1[I]=C	C=RNR1[16] XOR RNR1[14] XOR RNR1[13] XOR RNR1[11]
RNR1		110100111101111	0	
1	1	101001111011110	0	0
2	0	010011110111100	1	1
3	1	100111101111001	1	1
4	0	001111011110011	1	1
5	0	011110111100111	1	1
6	1	111101111001111	0	0
7	1	111011110011110	0	0
8	1	110111100111100	1	1
9	1	101111001111001	1	1
10	0	011110011110011	1	0
11	1	111100111100110	1	1
12	1	111001111001101	0	1
13	1	110011110011011	1	0
14	1	100111100110110	1	1
15	0	001111001101101	0	1
16	1	011110011011011	0	0

Table 4.8: RNR2 generate by Reader

R:Compute EPWDMR

RNR2=1011110111100101

PWDM=1100110011001100

16 times EPWDMR[I]=RNR2[I] XOR PWDM[I]

EPWDMR=0111000100101001

R : Verify EPWDMR , EPWDMT

EPWDMR = 0111000100101001

EPWDMT=0111000100101001

	RNR2[I]	PWDM[I]	EPWDLT[I] = RNR2[I] XOR PWDM[I]
1	1	0	1
2	0	0	0
3	1	1	0
4	0	1	1
5	0	0	0
6	1	0	1
7	1	1	0
8	1	1	0
9	1	0	1
10	0	0	0
11	1	1	0
12	1	1	0
13	1	0	1
14	1	0	1
15	0	1	1
16	1	1	1

Table 4.9: EPWDLR compute by Tag

	EPWDMT[I]	EPWDMR[I]	EPWDMT[I] = EPWDMR[I]
1	1	1	T
2	0	0	T
3	0	0	T
4	1	1	T
5	0	0	T
6	1	1	T
7	0	0	T
8	0	0	T
9	1	1	T
10	0	0	T
11	0	0	T
12	0	0	T
13	1	1	T
14	1	1	T
15	1	1	T
16	0	0	T

Table 4.10: Tag Authentication

Process If Success, Abort if failure

Tag Authentication

Parameters	EPC Global Authentication	Proposed Scheme based on 8-Bit LFSR	Proposed Scheme based on 16-Bit LFSR	Proposed Scheme based on Diffie Hellman Algorithm
Man in middle attack	low	moderate	High	High
Mutual Authentication	low	moderate	High	High
Cost	less expensive	less expensive	Medium expensive	More expensive
Operation used	XOR Operation, Random() function	XOR Operation 8-bits LFSR, Seed value, rand() function, EXOR Operation, Random() function	EXOR Operation 16-bits LFSR, Seed value, rand() function	Mod operation, Power Operation, Public value P and Q

Table 4.11: Comparison between Existing Scheme and Proposed Scheme

4.2 Security Analysis

Man-in-the-middle attack prevention: In this approach a man-in-the-middle attack is prevented. So, this is depend on a mutual authentication. Proposed scheme share only Seed value(SV), not random number (18).

Mutual authentication :Authentication for Reader and tag is checking through EPWDLR=EPWDLT and Authentication for Tag to reader is checking from EPWDMR=EPWDMT. Authentication is fail. And it finishes the connection else connection has been established between tag and reader. So, mutual authentication is hold in this given scheme (3) (9).

Chapter 5

Conclusion and Future Work

Conclusion

Future Work

Chapter 5

Conclusion and Future Work

In this thesis, an efficient Radio Frequency Identification mutual authentication scheme is proposed using 16-bits Linear feedback shift register. 16-bit random number is found using 16-bit linear feedback shift register. This proposed scheme is improving the drawback of EPC global class-1 generation-2 standard (C1G2) communication authentication scheme. Using this scheme mutual authentication and man-in-middle attack are prevented.

The debate around technology and privacy has been going on for many years. Such that technologies have become increasingly sophisticated for intercepting messages, the ability of other people to see what we are doing has endangered an individual's privacy in our society. Inevitably, users place high priority on privacy and security in every RFID application.

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Dissemination of Work

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