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HIP support for RFIDs
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Abstract

This document describes an architecture based on the Host Identity Protocol (HIP), for active RFIDs, i.e. Radio Frequency Identifiers inluding tamper resistant computing resources, as specified for example in the ISO 14443 or 15693 standards. HIP-RFIDs never expose their identity in clear text, but hide this value (typically an EPC-Code) by a particular equation (f) that can be only solved by a dedicated entity, referred as the portal. HIP exchanges occurred between HIP-RFIDs and portals; they are shuttled by IP packets, through the Internet cloud.

Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

Status of this Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on September 2011.

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1 Overview

1.1 Motivation

RFIDs are electronic devices, associated to things or computers, who transmit their identity (usually a serial number) via radio links.

The first motivation for designing HIP support for RFIDs is to enforce a strong privacy for the Internet of Things, e.g. identity is protected by cryptographic procedures compatible with RFID computing resources. As an illustration EPC codes or IP addresses are today transmitted in clear form.

The second motivation is to define an identity layer for RFIDs logically independent from the transport facilities, which may optionally support IP stacks.

In other words we believe that the Internet of Things will be Identity oriented; RFIDs will act as electronic ID for objects to which they are linked. In this context privacy is a major challenge.

1.2 Passive and active RFIDs

An RFID is a slice of silicon whose area is about 1 mm2 for components used as cheap electronic RFIDs, and around 25 mm2 for chips like contact-less smart cards inserted in passports and mobile phones.

RFIDs are divided into two classes, the first includes devices that embed CPU and memories (RAM, ROM, E2PROM) such as contact-less smart cards, the second comprises electronic chips based on cabled logic circuits.

There are multiple standards relative to RFIDs.

The ISO 14443 standard introduces components dealing with the 13,56Mhz frequency that embed a CPU and consume about 10mW; data throughput is about 100 Kbits/s and the maximum working distance (from the reader) is around 10cm.

The ISO 15693 standard also uses the same 13,56 MHz frequency, but enables working distances as high as one meter, with a data throughput of a few Kbits/s.

The ISO 18000 standard defines parameters for air interface communications associated with frequency such as 135 KHz, 13.56 MHz, 2.45 GHz, 5.8 GHz, 860 to 960 MHz and 433 MHz. The ISO 18000-6 standard uses the 860-960 MHz range and is the basis for the Class-1 Generation-2 UHF RFID, introduced by the EPCglobal [EPCGLOBAL] consortium.

1.3 About the Internet of Things (IoT)

The term "Internet of Thing (IoT)" was invented by the MIT Auto-ID Center, in 2001, and refers to an architecture that comprises four levels,

- Passive RFIDs, such as Class-1 Generation-2 UHF RFIDs, introduced by the EPC Global consortium and operating in the 860-960 MHz range.

- Readers plugged to a local (computing) system, which read the Electronic Product Code [EPC].

- A local system, offering IP connectivity, which collects information pointed by the EPC thanks to a protocol called Object Naming Service (ONS)

- EPCIS (EPC Information Services) servers, which process incoming ONS requests and returns PML (Physical Markup Language) files [PML], e.g. XML documents that carry meaningful information linked to RFIDs.

1.4 HIP-RFIDs

This document suggests embedding a modified version of HIP stack in active RFIDs, named HIP-RFIDs. It assumes that such devices would not support an IP stack, but should be rather identity oriented, i.e. will use readers IP resources in order to unveil their EPC-Code only to trusted entities (called portals in the architecture shown by Figure 1). Privacy, e.g. identity protection seems a key prerequisite [SEC] before the effective massive deployment of these devices.

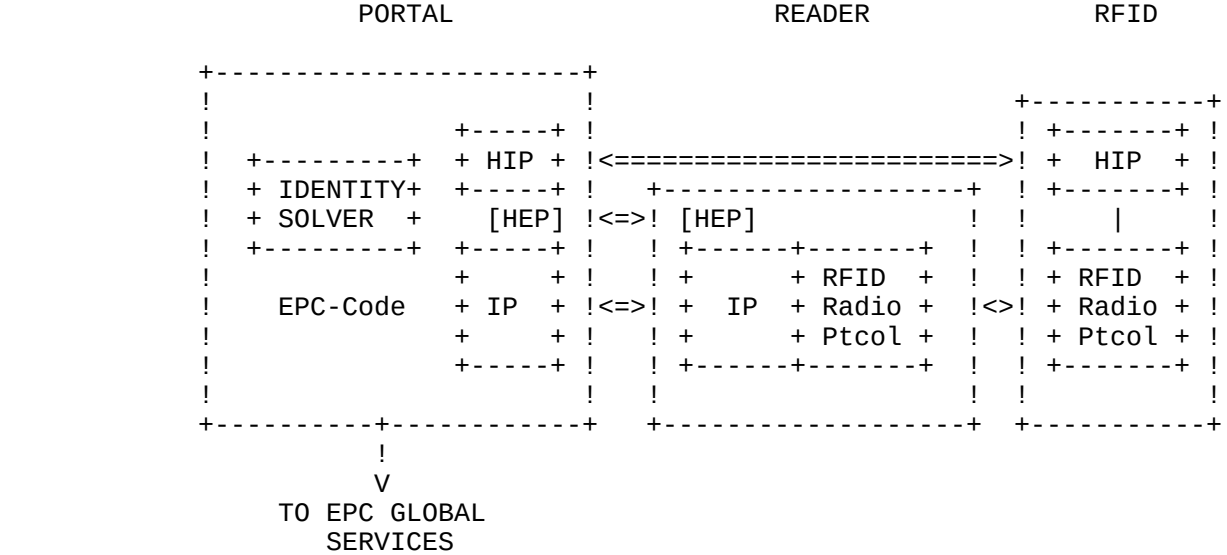


Figure 1. HIP-RFID Architecture

The functional HIP-RFID architecture includes three logical entities,

- HIP RFIDs. HIP is transported by IP packets. HIP-RFIDs support a modified version of this protocol but don’t require end-to-end IP transport.

- RFID readers. They provide IP connectivity and communicate with RFIDs through radio link either defined by EPC Global or ISO standards. The IP layer transports HIP messages between RFIDs and other HIP entities. According to HIP, an SPI (Security Parameter Index) associated to an IPSEC tunnel MAY be used by the IP host (e.g. a reader) in order to route HIP packets to/from the right software identity.

- HEP, HIP Encapsulation Protocol. HIP messages MAY be encapsulated by protocols such as UDP or TCP in order to facilitate HIP transport in existing software and networking architectures. The HEP does not modify the content of an HIP packet. This class of protocol is not specified by this document.

- PORTAL entity. This device manages a set of readers; it is an HIP entity that includes a full IP stack. Communications between portal and RFIDs logically work as peer to peer HIP exchanges. RFID identity (HIT) is hidden and appears as a pseudo random value; within the portal a software block called the IDENTITY SOLVER resolves an equation f, whose solution is an EPC Code. The portal accesses to EPCIS services; when required privacy may be enforced by legacy protocol such as SSL or IPSEC.

- The portal maintains a table linking HIT and EPC-Code. It acts as a router for that purpose it MUST provide an identity resolution mechanism, i.e. a relation between HIT and EPC-Code.

1.5 Main differences between HIP-RFID and HIP

In HIP [HIP], the HIT (Host Identifier Tag) is a fix value obtained from the hash of an RSA public key. This parameter is therefore linked to a unique identity, and can be used for traceability purposes; in other words HIP does not natively include privacy features.

In [BLIND], it is proposed to hide the HIT with by random number thanks to a hash function, i.e.

B-HIT = sha1(HIT || N), with N a random value and || the concatenation operation.

The case in which only one HIT (either initiator or responder) is blinded looks similar to the HIP-RFID protocol described in this draft working with a particular transform (HMAC Transform, 0x0001)

2. Basic Exchange

The HIP-RFID basic exchange (T-BEX) is derived from the "classical" BEX exchange, introduced in [HIP]. It is a four ways handshake illustrated by Figure 2.

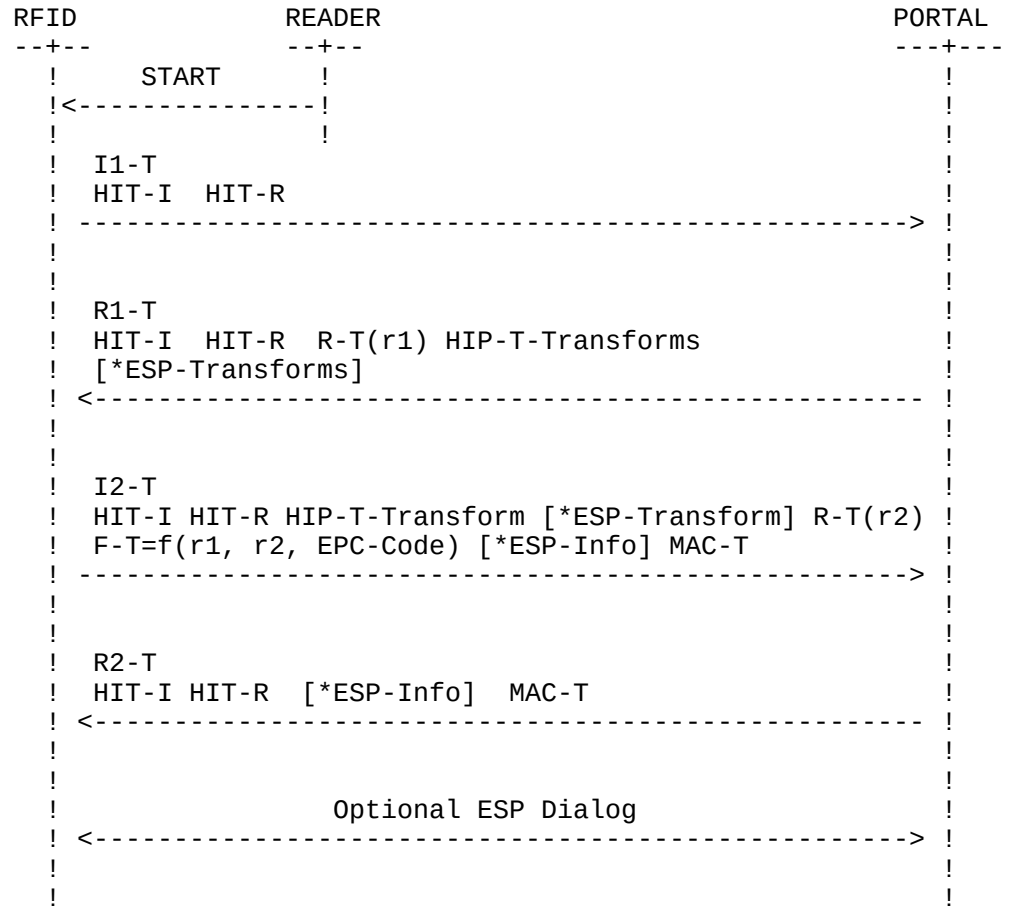


Figure 2. HIP-RFIDs Basic Exchange (T-BEX), *means optional attributes

A HEP layer MAY be used to transport HIP messages in non IP context, but this optional facility is out of scope from this document.

2.1 I1-T

When a reader detects an RFID, it realizes all low level operations in order to set up a radio communication link. Finally the reader delivers a START message that trigs the RFID.

The HIP-RFID sends the I1-T packet (I suffix meaning initiator), in which HIT-I is a true random value internally generated by the HIP-RFID.

If the RFID doesn’t known the portal HIT it sets the HIT-R value to zero; in that case the reader MAY modify this field in order to identify the appropriate entity.

The I1-T message is not MACed.

2.2 R1-T

The portal produces the R1-T (R suffix meaning responder) packet, which includes a nonce r1 and optional parameters. These fields indicate a list of supported authentication schemes (HIP-T-TRANSFORMs) and a list of ESP-TRANSFORMs, i.e. secure channels that could be opened between portal and RFIDs.

This message includes the following fields:
- HIT-I, a random number which identifies a RFID
- HIT-R, the portal HIP either a null or fix value.
- HIT-T-TRANSFORMs, a list of authentication schemes
- ESP-T-TRANSFORMs, an optional list of ESP secure channels

The R1-T message is not MACed.

2.3 I2-T

The HIP-RFID builds the I2-T message, which contains

- The selected HIP-T-TRANSFORM (the current authentication scheme).
- An optional ESP-TRANSFORM (a class of secure channel between RFID and portal).
- A nonce r2, included in the R-T attribute.
- An equation f(r1, r2, EPC-Code), whose solution, according to the selected HIP-T-TRANSFORM, unveils the EPC-Code value.
- An optional ESP-Info attribute that gives information about the secure (ESP) channel, and which includes the SPI-I value.
- A keyed MAC (MAC-T), which works with a KI-Auth-key deduced from r1, r2 and the hidden EPC-CODE value.

KI-Auth-key = g(r1, r2, EPC-Code)

The keyed MAC is computed over the complete I2-T message, the content of MAC-T resulting from this calculation is initially set to a nul value

The portal and the RFID shares secret keys. The meaning of these keys are dependent upon the f equation.

In some cases the EPC-Code is the only shared key. The portal knows a list of EPC-Code and tries all solutions for solving f, according to brute force techniques. As an illustration a hash function may be used for f:

f= sha1(r1 || r2 || EPC-Code), where || is the concatenation operation.

In other cases a set of keys is shared between portal and RFIDs. For example a binary tree of HMAC procedure MAY be used, each HMAC beeing associated to a particular key. A binary tree of depth n may identify 2**n RFIDs, each of them stores n keys (ki:j). The f function is a list of n values such as

HMAC(r1 || r2, ki:j)

Where ki:j is a secret key, and j the bit value (either 0 or 1) at the rank i (ranging between 0 and n-1)for the EPC-Code (or RFID index).

2.4 R2-T

The fourth and last R2-T packet is optional. It includes

- A keyed MAC (MAC-T) computed with the KI-Auth-key deduced from r1, r2 and the hidden EPC-CODE value.

KI-Auth-key = g(r1, r2, EPC-Code)

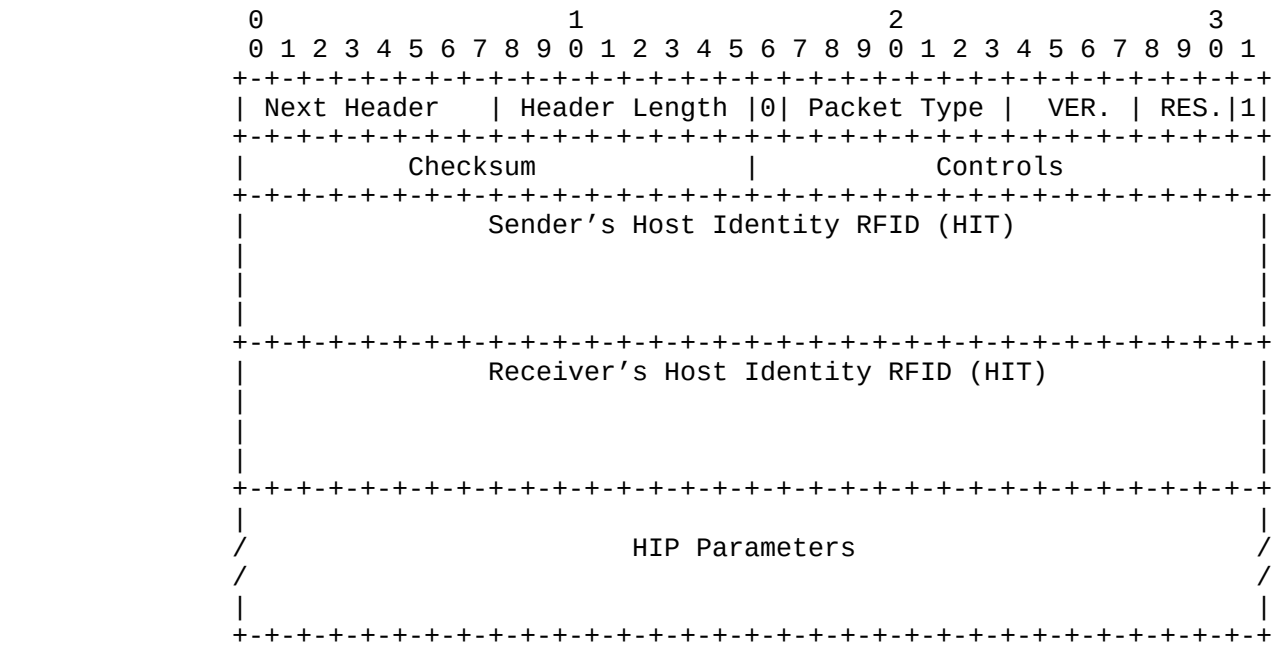
- An optional ESP-Info attribute that gives information about the secure (ESP) channel, and which includes the SPI-R value.

The R2-T packet is mandatory when an ESP channel has been previously negotiated. ESP channel is required if the portal intends to perform read or write operations with the RFIDs.

3. Formats

3.1 Payload

The payload format is imported from the [HIP] specification.



Next Header : normal value is decimal 59, IPPROTO_NONE.

Header Length: the length of the HIP Header and HIP parameters in 8 bytes units, excluding the first 8 bytes

Packet Type: Detailed in section 4.2

VER: 0001

RES: 000

Checksum: This checksum covers the source and destination addresses in the IP header.

HIP-RFIDs always deliver HIP packets with the null value for the checksum field. The reader MUST compute the checksum.

HIP-RFIDs do not check the checksum of received packets.

Controls: this field is reserved for future use (RFU)

Sender’s Host Identity RFID: 16 bytes HIT

Receiver’s Host Identity RFID: 16 bytes HIT

HIP Parameters: a list of attributes encoded in the TLV format

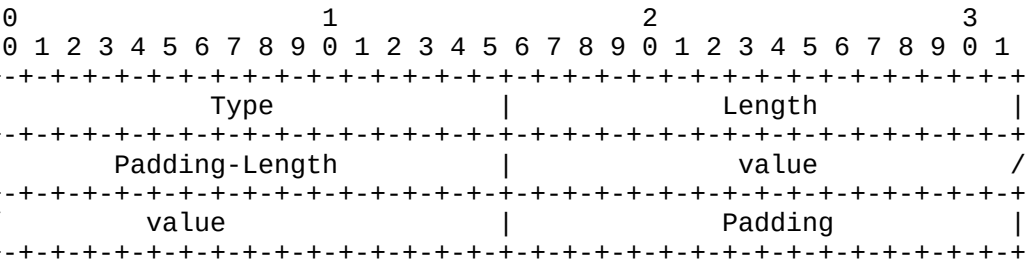
3.2 Packets types

Packet type	Packet name
0x40	I1-T - The HIP-RFID Initiator Packet
0x41	R1-T - The HIP-RFID Responder Packet
0x42	I2-T - The Second HIP-RFID Initiator Packet
0x43	R2-T - The Second HIP-RFID Responder Packet

3.3 Summary of HIP parameters

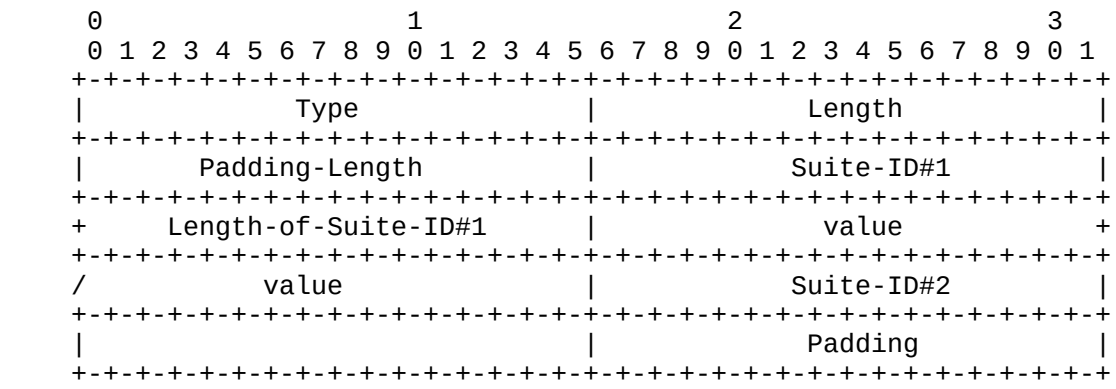
TLV	Type	Length	Data
R-T	0x400	variable	Random value r1 or r2
HIP-T-TRANSFORM	0x402	variable	HIP-RFID transform(s)
F-T	0x404	variable	f function value
MAC-T	0x406	variable	Keyed MAC
ESP-Transform	0x408	variable	ESP transform(s)
ESP-Info	0x40A	variable	ESP parameter(s)

3.4 R-T



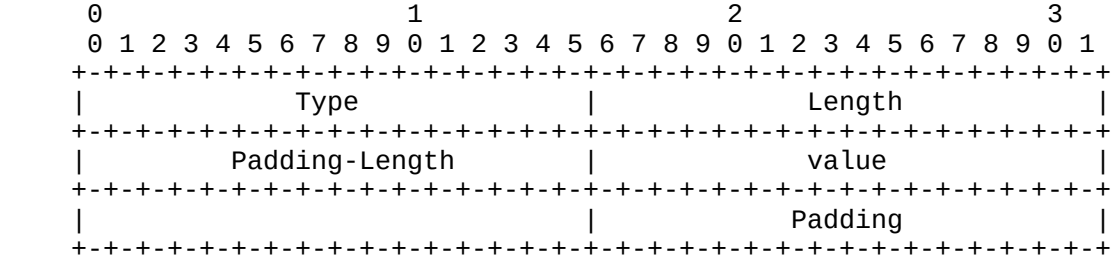
Type	0x400
Length	total length in bytes
Value	random value
Padding-Length	padding length in bytes
Padding	padding bytes

3.5 HIP-T-Transform



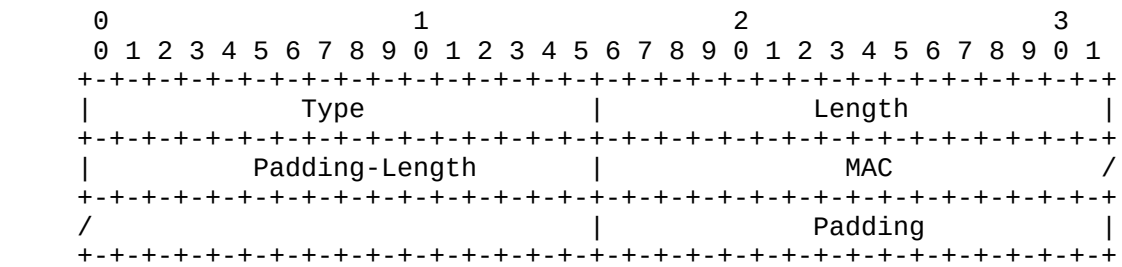
Type	0x402
Length	Total length
Padding-Length	Number of padding bytes
Suite-ID	Defines the HIP Cipher Suite to be used
Length-of-Suite-ID	Defines the length of optional data
Padding	Padding bytes

3.6 F-T



Type	0x404
Length	total length, in bytes
Padding-Length	padding length in bytes
Value	f value
Padding	padding bytes

3.7 MAC-T



Type	0x406
Length	total length, in bytes
Padding-Length	padding length, in bytes
Value	Keyed MAC value
Padding	padding bytes

A MAC procedure works with the K-Auth-Key and is computed over the whole HIP message according to the following rules

- The checksum field of the HIP header is set to a null value.

- The MAC field of the MAC-T attribute is set to a null value

3.8 ESP-Transform

Details of the attribute will be specified by another document.

3.9 ESP-Info

Details of the attribute will be specified by another document.

4. BEX Example

4.1 Generic example

4.1.1 I1-T

Next Header:	0x3B
Header Length:	0x4
Packet Type:	0x40
Version:	0x1
Reserved:	0x1
Control:	0x0
Checksum:	0x0000
Sender's HIT (RFID) :	0x0123456789ABCDEF 0123456789ABCDEF
Receiver's HIT (Portal) :	0x0000000000000000 0000000000000000

The checksum is computed by portal and reader according to rules specified in [HIP]; it covers the source and destination IP addresses.

4.1.2 R1-T

Next Header:	0x3B
Header Length:	0xB
Packet Type:	0x41
Version:	0x1
Reserved:	0x1
Control:	0x0
Checksum:	0xabcd
Sender's HIT (Portal)	0xA5A5A5A5A5A5A5A5 5A5A5A5A5A5A5A5A
Receiver's HIT (RFID)	0x0123456789ABCDEF 0123456789ABCDEF
R-T	0x040000280002rrrr rrrrrrrrrrrrrrrr rrrrrrrrrrrrrrrr rrrrrrrrrrrrrrrr rrrrrrrrrrrrpppp
HIP-T-Transforms	0x0402001000020001 000000020000pppp

r1 is a 128 bits value
Transforms 1, 2 are supported by the reader.

4.1.3 I2-T

Next Header:	0x3B
Header Length:	0x14
Packet Type:	0x42
Version:	0x1
Reserved:	0x1
Control:	0x0
Checksum:	0x0000
Sender's HIT (RFID) :	0x0123456789ABCDEF 0123456789ABCDEF
Sender's HIT (Portal) :	0xA5A5A5A5A5A5A5A5 5A5A5A5A5A5A5A5A
HIP-T-Transform	0x0402001000060001 0000pppppppppppp
R-T	0x040000280002rrrr rrrrrrrrrrrrrrrr rrrrrrrrrrrrrrrr rrrrrrrrrrrrrrrr rrrrrrrrrrrrpppp
F-T	0x040400280002ffff ffffffffffffffff ffffffffffffffff ffffffffffffffff fffffffffffpppp
MAC-T	0x040600040006ssss ssssssssssssssss ssssssssssssssss sssspppppppppppp

The RFID selects the HIP-Transform number one. It produces an r2 nonce and computes a f value. It appends a 20 bytes keyed MAC.

4.1.4 R2-T

Next Header:	0x3B
Header Length:	0x08
Packet Type:	0x40
Version:	0x1
Reserved:	0x1
Control:	0x0
Checksum:	0xabcd
Sender's HIT (RFID) :	0x0123456789ABCDEF 0123456789ABCDEF
Sender's HIT (Portal) :	0xA5A5A5A5A5A5A5A5 5A5A5A5A5A5A5A5A
MAC-T	0x040600040006ssss ssssssssssssssss ssssssssssssssss sssspppppppppppp

Reader ends the BEX-T.

4.2 HIP-T Transform 0x0001, HMAC

EPC = 0123456789abcdefcdab

4.2.1 I1-T

```
<< 3B 04 40 11 00 00 00 00 6A 68 2E 53 51 6B 51 6F
   2F 58 CE 60 25 42 1A E6 00 00 00 00 00 00 00 00
   00 00 00 00 00 00 00 00

HEAD 3b04401100000000
sHIT 6a682e53516b516f2f58ce6025421ae6
dHIT 00000000000000000000000000000000
```

4.2.2 R1-T

```
>> 3B 0A 41 11 00 00 00 00 00 00 00 00 00 00 00 00
   00 00 00 00 00 00 00 00 6A 68 2E 53 51 6B 51 6F
   2F 58 CE 60 25 42 1A E6 04 00 00 20 00 06 27 6D
   03 4D DD 2D 52 79 3B 17 2C B9 5B CD 02 97 E2 DF
   61 15 00 00 00 00 00 00 04 02 00 10 00 06 00 02
   00 00 00 00 00 00 00 00

HEAD 3b0a411100000000
sHIT 00000000000000000000000000000000
dHIT 6a682e53516b516f2f58ce6025421ae6

ATT 0400 20 bytes  276d034ddd2d52793b172cb95bcd0297e2df6115
ATT 0402 04 bytes  00020000
```

4.2.3 I2-T

```
<< 3B 13 40 11 00 00 00 00 6A 68 2E 53 51 6B 51 6F
   2F 58 CE 60 25 42 1A E6 00 00 00 00 00 00 00 00
   00 00 00 00 00 00 00 00 04 02 00 10 00 06 00 01
   00 00 00 00 00 00 00 00 04 00 00 20 00 06 C5 95
   8B 23 6B 9B 0E AA 7A BB 25 F2 7D 24 C5 04 6E 89
   19 9E 00 00 00 00 00 00 04 04 00 20 00 06 80 1D
   BC 55 C5 F3 97 89 F8 3C 6C BA 14 50 18 7D 83 83
   3C AF 00 00 00 00 00 00 04 06 00 20 00 06 2A 23
   68 93 2B F7 3A BE C4 6B DD B8 3F 1B 3F 7F 9D ED
   8B 83 00 00 00 00 00 00

HEAD 3b13401100000000
sHIT 6a682e53516b516f2f58ce6025421ae6
dHIT 00000000000000000000000000000000

ATT 0402 04 bytes  00010000
ATT 0400 20 bytes  c5958b236b9b0eaa7abb25f27d24c5046e89199e
ATT 0404 20 bytes  801dbc55c5f39789f83c6cba1450187d83833caf
ATT 0406 20 bytes  2a2368932bf73abec46bddb83f1b3f7f9ded8b83
```

5. HIP-T-Transforms Definition

5.1 Type 0x0001, HMAC

5.1.1 Suite-ID

```
Suite-ID:           0x0001
Length-of-Suite-ID: 0x0000
```

5.1.2 F-T computing (f function)

The F-T function produces a 20 bytes result, according to the relation:

K = HMAC-SHA1(r1 | r2, EPC-Code)

Y = f(r1, r2, EPC-Code) = HMAC-SHA1(K, CT1 | "Type 0001 key")

Where:

- SHA1 is the SHA1 digest function

- EPC-Code is the RFID identity

- HMAC-SHA1 is the keyed MAC algorithm based on the SHA1 digest procedure.

- CT1 is a 32 bits string, whose value is equal to 0x00000001

- r1 and r2 are the two random values exchanged by the BEX

5.1.3 K-Auth-Key computing (g function)

The K-Auth-Key is computing according to the relation:

K = HMAC-SHA1(r1 | r2, EPC-Code)

Y = HMAC-SHA1(K, CT2 | "Type 0001 key")

Where:

- SHA1 is the SHA1 digest function

- EPC-Code is the RFID identity

- HMAC-SHA1 is the keyed MAC algorithm based on the SHA1 digest procedure.

- CT2 is a 32 bits string, whose value is equal to 0x00000002

- r1 and r2 are the two random values exchanged by the BEX

5.1.4 MAC-T computing

The HMAC-SHA1 function is used with the K-Auth-Key secret value:

MAC-T(HIT-T packet) = HMAC-SHA1(K-Auth-Key, HIP-T packet)

5.2 Type 0x0002, Keys-Tree

5.2.1 Suite-ID

Suite-ID: 0x0002
Length-of-Suite-ID: 0x0006
Value1: an index identifying a HASH function (H), which produces t bytes.
Value2: n, the depth of the tree, a two bytes number.
Value3: p, the maximum number of child nodes, for each node, a two bytes number.

The maximum elements of a keys-tree is therefore p**n

5.2.2 F-T computing (f function)

The F-T function produces a list of Hi, 1<= i <= n, of nh bytes results, according to the relation:

Y = f(r1, r2, EPC-Code) = H1 | H2 | Hi | Hn

With
Hi = HMAC-SHA1(r1 | r2, Ki:j)

Where:

- H is digest function producing t bytes

- Ki:j is a set of pn secret keys.

Each EPC-Code is associated with an index, whose value is written as:

RFID-Index = an p**(n-1) + an-1 p**(n-2) + a1

Each ai digit(ai p**(i-1))whose value ranges between 0 and p-1, is associated with a key Ki:j (i.e. the tree is made with pn keys, but only n values are stored in a given RFID), with j=ai

- HMAC-H is the keyed MAC algorithm based on the H digest procedure.

- r1 and r2 are the two random values exchanged by the BEX.

5.2.3 K-Auth-Key computing (g function)

The K-Auth-Key is computing according to the relation:

K-Auth-Key = HMAC-H(r1 | r2, RFID-Index)

Where:

- H is a digest function producing t bytes

- HMAC-H is the keyed MAC algorithm based on the H digest procedure.

- RFID INDEX is the RFID index.

- r1 and r2 are the two random values exchanged by the BEX.

5.2.4 MAC-T computing

The HMAC-H function is used with the K-Auth-Key secret value:

MAC-T(HIT-T packet) = HMAC-H(K-Auth-Key, HIP-T packet)

6. Security Considerations

To be done.

7. IANA Considerations

To be done.

8 References

8.1 Normative references

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9 Annex I

This annex provides a sample code, for NFC RFIDs working at 13.56 Mhz and implementing a Java Virtual Machine.

9.1 Binary Interface with HIP RFIDs

According to the ISO 7816 standards, embedded RFID applications are identified by an AID attribute (Application IDentifier) whose size ranges between 5 and 16 bytes.

Commands exchanged between RFIDs and readers are named APDUs and are associated with a short prefix, whose size is usually 5 bytes referred as CLA, INS, P1, P2, P3.

In our sample we choose an arbitrary value for the AID (11223344556601, in hexadecimal representation) and a unique command CLA=00, INS=C2, P1=00, P2=00. The P3 byte is set to null in order to trig the RFID (which resets its state machine and returns the I1 packet, or a non null value when it pushes the R1 packet.

9.3 Exchanged data

The reader selects the embedded HIP-RFID application.

```
>> 00 A4 04 00 07 11 22 33 44 55 66 01
<< 90 00
```

The reader trigs the first packet I1-T.

```
>> 00 C2 00 00 00
```

The RFID delivers the I1-T packet.

```
<< 3B 04 40 11 00 00 00 00 A3 12 9D 5E 28 16 67 4F FC 4F A8 08 4E 30
55 E8 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 90 00
```

The reader forwards the R1-T packet to the HIP RFID.

```
>> 00 C2 00 00 58 3B 0A 41 11 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 A3 12 9D 5E 28 16 67 4F FC 4F A8 08 4E 30 55 E8
04 00 00 20 00 06 68 46 95 15 02 10 32 C2 B7 8D 13 E7 53 F6 25 0F 09
AD 7A BD 00 00 00 00 00 00 04 02 00 10 00 06 00 01 00 00 00 00 00 00
00 00
```

The RFID produces the I2-T packet.

```
<< 3B 13 40 11 00 00 00 00 A3 12 9D 5E 28 16 67 4F FC 4F A8 08 4E 30
55 E8 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 04 02 00 10 00
06 00 01 00 00 00 00 00 00 00 00 04 00 00 20 00 06 71 3A DD 19 C4 CB
59 D4 AF D0 2B FD F9 7C 2F 8A D1 23 32 E0 00 00 00 00 00 00 04 04 00
20 00 06 70 DA C1 F7 0B CA 63 15 57 CB D7 AA 66 A9 FD 36 B4 1F DB E3
00 00 00 00 00 00 04 06 00 20 00 06 A6 A7 00 67 5D FD A9 2F 3E 5C 00
D6 B0 8A 55 A2 99 D8 86 79 00 00 00 00 00 00 90 00
```

9.3 Javacard code sample

```
package hiprfid;

// Author Pascal Urien

import  javacard.framework.*;
import  javacard.security.* ;


public class rfid extends Applet
{
 final static byte  SELECT          = (byte)0xA4 ;
 final static byte  INS-HIP         = (byte)0xC2 ;

 final static short R-T             = (short)0x400 ;
 final static short HIP-T-TRANSFORM = (short)0x402 ;
 final static short F-T             = (short)0x404 ;
 final static short Signature-T     = (short)0x406 ;
 final static short ESP-Transform   = (short)0x408 ;
 final static short ESP-Info        = (short)0x40A ;

 final static int ALIGN = 8;
 final static short len-r2 =(short)20;
 final byte[] algo1 = {(byte)0x00,(byte)0x01,(byte)0x00,(byte)0x00 };

 final byte[] ct1 =  {
 (byte)0x00,(byte)0x00,(byte)0x00,(byte)0x01,
 (byte)'T',(byte)'y', (byte)'p',(byte)'e',
 (byte)' ',(byte)'0',(byte)'0',(byte)'0',(byte)'1',
 (byte)' ',(byte)'k',(byte)'e',(byte)'y' };

 final byte[] ct2 =  {
 (byte)0x00,(byte)0x00,(byte)0x00,(byte)0x02,
 (byte)'T',(byte)'y',(byte)'p',(byte)'e',
 (byte)' ',(byte)'0',(byte)'0',(byte)'0',(byte)'1',
 (byte)' ',(byte)'k',(byte)'e',(byte)'y' };

 MessageDigest sha1=null ;
 RandomData rnd=null;
 byte[] DB =null;
 final static short DBSIZE=(short)200;
 final static short off-myHIT = (short)0   ;
 final static short off-rHIT =  (short)16  ;
 final static short off-R1   =  (short)32  ;
 final static short off-R2   =  (short)64  ;
 final static short off-kaut =  (short)96  ;
 final static short off-k    =  (short)128 ;
 final static short off-FT   =  (short)160 ;
```

```
final byte[] HEADER= {
 (byte)0x3b,(byte)0x04,(byte)0x40,(byte)0x11,
 (byte)0x00,(byte)0x00,(byte)0x00,(byte)0x00 };


 final byte[] MyEPCCODE = {
 (byte)0x01,(byte)0x23,(byte)0x45,(byte)0x67,(byte)0x89,
 (byte)0xab,(byte)0xcd,(byte)0xef,(byte)0xcd,(byte)0xab };

 public void init(){
 try { sha1=MessageDigest.getInstance(MessageDigest.ALG-SHA,false);}
 catch (CryptoException e){sha1=null;}

 try { rnd = RandomData.getInstance(RandomData.ALG-SECURE-RANDOM);}
 catch (CryptoException e){}

 DB = JCSystem.makeTransientByteArray(DBSIZE,
                                      JCSystem.CLEAR-ON-DESELECT);

}

public short GetAttOffset(byte[] pkt, short off, short len,short att)
{ boolean more=true;
  short type=(short)0;
  short tl=(short)0;

  if (len <= (short)40) return (short)-1 ;

  while (more)
  { type = Util.getShort(pkt,off)           ;
    tl   = Util.getShort(pkt,(short)(off+2));
    if (type == att) return off    ;
    off =(short)(off+tl) ;
    if (off >= (short)(off+len))more=false;
  }

 return -1;
}


public static short GetPadLength(short size)
{
 if ( (short)(size % ALIGN) == (short)0) return (short)0;
 return (short)(ALIGN - size % ALIGN );
 }


public static short Set_Att(short att, byte[] ref-att, short off-att,
                            short len-att, byte[] pkt, short off)
{
  short tl = (short) (len-att + 6) ;
```

```
  short tp = GetPadLength(tl)      ;

  tl= (short) (tp+tl);

  Util.setShort(pkt,off,att)  ;
  Util.setShort(pkt,(short)(off+2),tl);
  Util.setShort(pkt,(short)(off+4),tp);

  if (ref_att != null)
  Util.arrayCopy(ref-att,off-att,pkt,(short)(off+6),len-att);
  else
  Util.arrayFillNonAtomic(pkt,(short)(off+6),len-att,(byte)0);

  if (tp != (short)0)
  Util.arrayFillNonAtomic(pkt,(short)(off+6+len-att),tp,(byte)0);

  return tl ;
 }


public void process(APDU apdu) throws ISOException
{
 short len=(short)0, readCount=(short)0;
 short off=(short)0,pad=(short)0,len-r1=(short)0;
 short size=(short)0;

 byte[] buffer = apdu.getBuffer() ; // CLA INS P1 P2 P3

 byte cla = buffer[ISO7816.OFFSET_CLA];
 byte ins = buffer[ISO7816.OFFSET_INS];
 byte P1  = buffer[ISO7816.OFFSET_P1] ;
 byte P2  = buffer[ISO7816.OFFSET_P2] ;
 byte P3  = buffer[ISO7816.OFFSET_LC] ;

 switch (ins)
 {
  case SELECT:
  size = apdu.setIncomingAndReceive();
  return;

 case INS_HIP:

  if (P3 == (byte)0)
  {
   rnd.generateData(DB,off_myHIT,(short)16);
   Util.arrayCopy(HEADER,(short)0,buffer,(short)0,(short)8);
   Util.arrayCopy(DB,off-myHIT,buffer,(short)8,(short)16)  ;
   Util.arrayFillNonAtomic(DB,(short)24,(short)16,(byte)0) ;
   apdu.setOutgoingAndSend((short)0,(short)40)             ;
   break;
  }
```

```
  else
  {
  size = apdu.setIncomingAndReceive();
  len  = Util.makeShort((byte)0,buffer[6]);
  len  = (short)(len << 3);
  len  = (short)(len+(short)8)   ;

  if (len != size) ISOException.throwIt(ISO7816.SW-DATA-INVALID) ;
  size = (short)(len-(short)40);

  // HEADER 00...08
  // HIT-S  08...24
  // HIT-D  24...40

  Util.arrayCopy(buffer,(short)13,DB,off_rHIT,(short)16);
  off= GetAttOffset(buffer,(short)45,size,R-T);
  if (off==(short)-1) ISOException.throwIt(ISO7816.SW-DATA-INVALID) ;
  len = Util.getShort(buffer,(short)(off+2));
  pad = Util.getShort(buffer,(short)(off+4));
  len = (short)(len-pad-6);

  len-r1=len;
  Util.arrayCopy(buffer,(short)(off+6),DB,off-R1,len);
  off= GetAttOffset(buffer,(short)45,size,HIP-T-TRANSFORM)      ;

  if (off==(short)-1) ISOException.throwIt(ISO7816.SW-DATA-INVALID) ;
  len = Util.getShort(buffer,(short)(off+2));
  pad = Util.getShort(buffer,(short)(off+4));
  len = (short)(len-pad-6);

  // algo=Util.getShort(buffer,(short)(off+6)
  rnd.generateData(DB,(short)(off-R1+len-r1),len-r2); // r1 || r2

  Util.arrayCopy(MyEPCCODE,(short)0,buffer,
                           (short)0,(short)MyEPCCODE.length);

  hmac(DB,off_R1,(short)(len-r1 + len-r2),
       buffer,(short)0,(short)MyEPCCODE.length,
       sha1,
       DB,off-k);

  Util.arrayCopy(ct1,(short)0,buffer,(short)0,(short)ct1.length);

  hmac(DB,off_k,(short)20,
       buffer,(short)0,(short)ct1.length,
       sha1,
       DB, off-FT);

  Util.arrayCopy(ct2,(short)0,buffer,(short)0,(short)ct2.length);
```

```
  hmac(DB,off-k,(short)20,
       buffer,(short)0,(short)ct2.length,
       sha1,
       DB, off-kaut);

  Util.arrayCopy(HEADER,(short)0,buffer,
                 (short)0,(short)HEADER.length);

  Util.arrayCopy(DB,off-myHIT, buffer, (short)8,(short)16);
  Util.arrayCopy(DB, off-rHIT, buffer,(short)24,(short)16);

  off=(short)40;
  len = Set-Att(HIP-T-TRANSFORM,algo1,
                 (short)0,(short)algo1.length,buffer,off);
  off = (short)(off+len);
  len = Set-Att(R-T,DB,(short)(off-R1+len-r1),len-r2,buffer,off);
  off = (short)(off+len);
  len = Set-Att(F-T,DB,off-FT,(short)20,buffer,off);
  off = (short)(off+len);
  len = Set-Att(Signature-T,null,(short)0,(short)20,buffer,off);
  size= (short)(off+len);
  buffer[1] = (byte) (size >>3);

 hmac(DB,off-kaut,(short)20,
      buffer,(short)0,size,
      sha1,
      buffer,(short)(off+6));

apdu.setOutgoingAndSend((short)0,size);
  break;
}

 default:
 ISOException.throwIt(ISO7816.SW-INS-NOT-SUPPORTED);
  }

}

protected rfid(byte[] bArray,short bOffset,byte bLength)
{init();
 register();
}

public static void install( byte[] bArray, short bOffset, byte
bLength )
{
new rfid(bArray,bOffset,bLength);
}
```

```
public boolean select()
{
return true;
}

public void deselect()
{
}
```

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