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Transmission of IPv6 Packets over Near Field Communication
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Abstract

Near field communication (NFC) is a set of standards for smartphones and portable devices to establish radio communication with each other by touching them together or bringing them into proximity, usually no more than 10 cm. NFC standards cover communications protocols and data exchange formats, and are based on existing radio-frequency identification (RFID) standards including ISO/IEC 14443 and FeliCa. The standards include ISO/IEC 18092 and those defined by the NFC Forum. The NFC technology has been widely implemented and available in mobile phones, laptop computers, and many other devices. This document describes how IPv6 is transmitted over NFC using 6LowPAN techiques.

Status of This Memo

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1. Introduction

NFC is a set of short-range wireless technologies, typically requiring a distance of 10 cm or less. NFC operates at 13.56 MHz on ISO/IEC 18000-3 air interface and at rates ranging from 106 kbit/s to

424 kbit/s. NFC always involves an initiator and a target; the initiator actively generates an RF field that can power a passive target. This enables NFC targets to take very simple form factors such as tags, stickers, key fobs, or cards that do not require batteries. NFC peer-to-peer communication is possible, provided both devices are powered. NFC builds upon RFID systems by allowing two-way communication between endpoints, where earlier systems such as contactless smart cards were one-way only. It has been used in devices such as mobile phones, running Android operating system, named with a feature called "Android Beam". In addition, it is expected for the other mobile phones, running the other operating systems (e.g., iOS, etc.) to be equipped with NFC technology in the near future.

Considering the potential for exponential growth in the number of heterogeneous air interface technologies, NFC would be widely used as one of the other air interface technologies, such as Bluetooth Low Energy (BT-LE), Wi-Fi, and so on. Each of the heterogeneous air interface technologies has its own characteristics, which cannot be covered by the other technologies, so various kinds of air interface technologies would be existing together. Therefore, it is required for them to communicate each other. NFC also has the strongest point (e.g., secure communication distance of 10 cm) to prevent the third party from attacking privacy.

When the number of devices and things having different air interface technologies communicate each other, IPv6 is an ideal internet protocols owing to its large address space. Also, NFC would be one of the endpoints using IPv6. Therefore, This document describes how IPv6 is transmitted over NFC using 6LoWPAN techiques with following scopes.

- o Overview of NFC technologies;
- o Specifications for IPv6 over NFC;
  - * Neighbor Discovery;
  - * Addressing and Configuration;
  - * Header Compression;
  - * Fragmentation & Reassembly for a IPv6 datagram;

RFC4944 [1] specifies the transmission of IPv6 over IEEE 802.15.4. The NFC link also has similar characteristics to that of IEEE 802.15.4. Many of the mechanisms defined in the RFC4944 [1] can be

applied to the transmission of IPv6 on NFC links. This document specifies the details of IPv6 transmission over NFC links.

2. Conventions and Terminology

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 [2].

3. Overview of Near Field Communication Technology

NFC technology enables simple and safe two-way interactions between electronic devices, allowing consumers to perform contactless transactions, access digital content, and connect electronic devices with a single touch. NFC complements many popular consumer level wireless technologies, by utilizing the key elements in existing standards for contactless card technology (ISO/IEC 14443 A&B and JIS-X 6319-4). NFC can be compatible with existing contactless card infrastructure and it enables a consumer to utilize one device across different systems.

Extending the capability of contactless card technology, NFC also enables devices to share information at a distance that is less than 10 cm with a maximum communication speed of 424 kbps. Users can share business cards, make transactions, access information from a smart poster or provide credentials for access control systems with a simple touch.

NFC's bidirectional communication ability is ideal for establishing connections with other technologies by the simplicity of touch. In addition to the easy connection and quick transactions, simple data sharing is also available.

3.1. Peer-to-peer Mode for IPv6 over NFC

NFC-enabled devices are unique in that they can support three modes of operation: card emulation, peer-to-peer, and reader/writer. Peer-to-peer mode enables two NFC-enabled devices to communicate with each other to exchange information and share files, so that users of NFC-enabled devices can quickly share contact information and other files with a touch. Therefore, a NFC-enabled device can securely send IPv6 packets to any corresponding node on the Internet when a NFC-enabled gateway is linked to the Internet.

3.2. Protocol Stacks in IPv6 over NFC

The IP protocol can use the services provided by Logical Link Control Protocol (LLCP) in the NFC stack to provide reliable, two-way transport of information between the peer devices. Figure 1 depicts the NFC P2P protocol stack with IPv6 bindings to the LLCP.

For data communication in IPv6 over NFC, an IPv6 packet SHALL be received at LLCP of NFC and transported to an Information Field in Protocol Data Unit (I PDU) of LLCP of the NFC-enabled peer device. Since LLCP does not support fragmentation and reassembly, Upper Layers SHOULD support fragmentation and reassembly. For IPv6 addressing or address configuration, LLCP SHALL provide related information, such as link layer addresses, to its upper layer. LLCP to IPv6 protocol Binding SHALL transfer the SSAP and DSAP value to the IPv6 over NFC protocol. SSAP stands for Source Service Access Point, which is 6-bit value meaning a kind of Logical Link Control (LLC) address, while DSAP means a LLC address of destination NFC-enabled device.

```
      |                                         |
      |                                         |  Application Layer
      |         Upper Layer Protocols           |   Transport Layer
      |                                         |    Network Layer
      |                                         |          |
      +-----------------------------------------+ <-------------------
      |            IPv6-LLCP Binding            |          |
      +-----------------------------------------+         NFC
      |                                         |    Logical Link
      |      Logical Link Control Protocol      |        Layer
      |                 (LLCP)                  |          |
      +-----------------------------------------+ <-------------------
      |                                         |          |
      |               Activities                |          |
      |            Digital Protocol             |         NFC
      |                                         |      Physical
      +-----------------------------------------+        Layer
      |                                         |          |
      |               RF Analog                 |          |
      |                                         |          |
      +-----------------------------------------+ <-------------------
```

Figure 1: Protocol Stack of NFC

3.3. NFC-enabled Device Addressing

NFC-enabled devices are identified by 6-bit LLC address. In other words, Any address SHALL be usable as both an SSAP and a DSAP address. According to NFCForum-TS-LLCP_1.1 [3], address values between 0 and 31 (00h - 1Fh) SHALL be reserved for well-known service access points for Service Discovery Protocol (SDP). Address values between 32 and 63 (20h - 3Fh) inclusively, SHALL be assigned by the local LLC as the result of an upper layer service request.

3.4. NFC Packet Size and MTU

As mentioned in Section 3.2, an IPv6 packet SHALL be received at LLCP of NFC and transported to an Information Field in Protocol Data Unit (I PDU) of LLCP of the NFC-enabled peer device. The format of the I PDU SHALL be as shown in Figure 2.

```
   0      0    1      1    2    2
   0      6    0      6    0    4
  +------+----+------+----+----+--------------------------------+
  |DDDDDD|1100|SSSSSS|N(S)|N(R)|       Service Data Unit        |
  +------+----+------+----+----+--------------------------------+
  | <------- 3 bytes --------> |                                |
  | <------------------- 128 bytes (default) ------------------> |
  |                                                             |
```

Figure 2: Format of the I PDU in NFC

The I PDU sequence field SHALL contain two sequence numbers: The send sequence number N(S) and the receive sequence number N(R). The send sequence number N(S) SHALL indicate the sequence number associated with this I PDU. The receive sequence number N(R) value SHALL indicate that I PDUs numbered up through N(R) - 1 have been received correctly by the sender of this I PDU and successfully passed to the senders SAP identified in the SSAP field. These I PDUs SHALL be considered as acknowledged.

The information field of an I PDU SHALL contain a single service data unit. The maximum number of octets in the information field SHALL be determined by the Maximum Information Unit (MIU) for the data link connection. The default value of the MIU for I PDUs SHALL be 128 octets. The local and remote LLCs each establish and maintain distinct MIU values for each data link connection endpoint. Also, An LLC MAY announce a larger MIU for a data link connection by transmitting an MIUX extension parameter within the information field.

4. Specification of IPv6 over NFC

NFC technology sets also has considerations and requirements owing to low power consumption and allowed protocol overhead. 6LoWPAN standards RFC4944 [1], RFC6775 [4], and RFC6282 [5] provide useful functionality for reducing overhead which can be applied to BT-LE. This functionality comprises of link-local IPv6 addresses and stateless IPv6 address auto-configuration (see Section 4.3), Neighbor Discovery (see Section 4.4) and header compression (see Section 4.5).

One of the differences between IEEE 802.15.4 and NFC is that the former supports both star and mesh topology (and requires a routing protocol), whereas NFC can support direct peer-to-peer connection and simple mesh-like topology depending on NFC application scenarios because of very short RF distance of 10 cm or less.

4.1. Protocol Stack

Figure 3 illustrates IPv6 over NFC. Upper layer protocols can be transport protocols (TCP and UDP), application layer, and the others capable running on the top of IPv6.

```
   |                                        |     Transport &
   |         Upper Layer Protocols          |  Application Layer
   +----------------------------------------+ <------------------
   |                                        |          |
   |                  IPv6                  |          |
   |                                        |       Network
   +----------------------------------------+        Layer
   |   Adaptation Layer for IPv6 over NFC   |          |
   +----------------------------------------+ <------------------
   |             IPv6-LLCP Binding                     |
   |      Logical Link Control Protocol     |   NFC Link Layer
   |                  (LLCP)                |          |
   +----------------------------------------+ <------------------
   |                                        |          |
   |                Activities              |         NFC
   |             Digital Protocol           |   Physical Layer
   |                RF Analog               |          |
   |                                        |          |
   +----------------------------------------+ <------------------
```

Figure 3: Protocol Stack for IPv6 over NFC

Adaptation layer for IPv6 over NFC SHALL support neighbor discovery, address auto-configuration, header compression, and fragmentation.

[TBD]

4.2. Link Model

In the case of BT-LE, Logical Link Control and Adaptation Protocol (L2CAP) supports fragmentation and reassembly (FAR) functionality; therefore, adaptation layer for IPv6 over BT-LE do not have to conduct the FAR procedure. However, NFC link layer is similar to IEEE 802.15.4. Adaptation layer for IPv6 over NFC SHOULD support FAR functionality. Therefore, fragmentation functionality as defined in RFC4944 [1] SHALL be used in NFC-enabled device networks.

The NFC link between two communicating devices is considered to be a point-to-point link only. Unlike in BT-LE, NFC link does not consider star topology and mesh network topology but peer-to-peer topology and simple multi-hop topology. Due to this characteristics, 6LoWPAN functionality, such as addressing and auto-configuration, and header compression, is specialized into NFC.

[TBD]

4.3. Stateless Address Autoconfiguration

A NFC-enabled device (i.e., 6LN) performs stateless address autoconfiguration as per RFC4862 [6]. A 64-bit Interface identifier (IID) for a NFC interface MAY be formed by utilizing the 6-bit NFC LLCP address (i.e., SSAP or DSAP) (see Section 3.3). In the case of NFC-enabled device address, the "Universal/Local" bit MUST be set to 0 RFC4291 [7]. Only if the NFC-enabled device address is known to be a public address the "Universal/Local" bit can be set to 1. As defined in RFC4291, the IPv6 link-local address for a NFC-enabled device is formed by appending the IID, to the prefix FE80::/64, as depicted in Figure 4.

```
     0          0                  0                     1    1
     0          1                  6                     2    2
     0          0                  4                     2    7
    +----------+------------------+---------------------+------+
    |1111111010|       zeros      |        zeros        | SSAP |
    +----------+------------------+---------------------+------+
    |                                                          |
    | <---------------------- 128 bits ---------------------> |
    |                                                          |
```

Figure 4: IPv6 link-local address in NFC

The tool for a 6LBR to obtain an IPv6 prefix for numbering the NFC network is can be accomplished via DHCPv6 Prefix Delegation (RFC3633 [8]).

[TBD]

4.4. Neighbor Discovery

Neighbor Discovery Optimization for 6LoWPANs (RFC6775 [4]) describes the neighbor discovery approach in several 6LoWPAN topologies, such as mesh topology. NFC does not consider complicated mesh topology but simple multi-hop network topology or directly connected peer-to-peer network. Therefore, the following aspects of RFC6775 are applicable to NFC:

1. In a case that a NFC-enabled device (6LN) is directly connected to 6LBR, A NFC 6LN MUST register its address with the 6LBR by sending a Neighbor Solicitation (NS) message with the Address Registration Option (ARO) and process the Neighbor Advertisement (NA) accordingly. In addition, DHCPv6 is used to assigned an address, Duplicate Address Detection (DAD) is not required.

2. For sending Router Solicitations and processing Router Advertisements the NFC 6LNs MUST follow Sections 5.3 and 5.4 of the RFC6775.

[TBD]

4.5. Header Compression

Header compression as defined in RFC6282 [5] , which specifies the compression format for IPv6 datagrams on top of IEEE 802.15.4, is REQUIRED in this document as the basis for IPv6 header compression on top of NFC. All headers MUST be compressed according to RFC6282 encoding formats.

[TBD]

4.6. Fragmentation and Reassembly

Fragmentation and reassembly (FAR) as defined in RFC4944, which specifies the fragmentation methods for IPv6 datagrams on top of IEEE 802.15.4, is REQUIRED in this document as the basis for IPv6 datagram FAR on top of NFC. All headers MUST be compressed according to RFC4944 encoding formats, but the default MTU of NFC is 128 bytes. This MUST be considered.

[TBD]

4.7. Unicast Address Mapping

The address resolution procedure for mapping IPv6 non-multicast addresses into NFC link-layer addresses follows the general description in Section 7.2 of RFC4861 [9], unless otherwise specified.

The Source/Target link-layer Address option has the following form when the addresses are 6-bit NFC link-layer (node) addresses.

```
 0                   1
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      Type     |   Length=1    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               |
+-     Padding (all zeros)     -+
|                               |
+-                   +-+-+-+-+-+-+
|                    | NFC Addr. |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5: Unicast address mapping

Option fields:

Type:

1: for Source Link-layer address.

2: for Target Link-layer address.

Length:

This is the length of this option (including the type and length fields) in units of 8 octets. The value of this field is 1 for 6-bit NFC node addresses.

NFC address:

The 6-bit address in canonical bit order. This is the unicast address the interface currently responds to.

[TBD]

4.8. Multicast Address Mapping

All IPv6 multicast packets MUST be sent to NFC Destination Address 255 (broadcast) and filtered at the IPv6 layer. When represented as a 16-bit address in a compressed header, it MUST be formed by padding on the left with a zero.

```
 0                   1
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Padding(all zeros)|    0x3F   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 6: Multicast address mapping

[TBD]

5. Internet Connectivity Scenarios

As two typical scenarios, the NFC network can be isolated and connected to the Internet.

[TBD]

5.1. NFC-enabled Device Connected to the Internet

One of the key applications by using adaptation technology of IPv6 over NFC is the most securely transmitting IPv6 packets because RF distance between 6LN and 6LBR SHOULD be within 10 cm. If any third party wants to hack into the RF between them, it MUST come to nearly touch them. Applications can choose which kinds of air interfaces (e.g., BT-LE, Wi-Fi, NFC, etc.) to send data depending characteristics of data. NFC SHALL be the best solution for secured and private information.

Figure 7 illustrates an example of NFC-enabled device network connected to the Internet. Distance between 6LN and 6LBR SHOULD be 10 cm or less. If there is any of close laptop computers to a user, it SHALL becomes the 6LBR. Additionally, When the user mounts a NFC-enabled air interface adapter (e.g., portable small NFC dongle) on the close laptop PC, the user's NFC-enabled device (6LN) can communicate the laptop PC (6LBR) within 10 cm distance.

```
                                          ************
       6LN ------------------- 6LBR -----* Internet *------- CN
        |  (dis. 10 cm or less)  |       ************         |
        |                        |                            |
        | <-------- NFC -------> | <----- IPv6 packet ------> |
        | (IPv6 over NFC packet) |                            |
```

Figure 7: NFC-enabled device network connected to the Internet

[TBD]

5.2. Isolated NFC-enabled Device Network

In some scenarios, the NFC-enabled device network may transiently be a simple isolated network as shown in the Figure 8.

```
       6LN ---------------------- 6LR ---------------------- 6LN
        |     (10 cm or less)      |     (10 cm or less)      |
        |                          |                          |
        | <--------- NFC --------> | <--------- NFC --------> |
        |   (IPv6 over NFC packet) |  (IPv6 over NFC packet)  |
```

Figure 8: Isolated NFC-enabled device network

In mobile phone markets, applications are designed and made by user developers. They may image interesting applications, where three or more mobile phones touch or attach each other to accomplish outstanding performance. For instance, three or more mobile phones can play multi-channel sound of music together. In addition, attached three or more mobile phones can make an extended banner to show longer sentences in a concert hall.

[TBD]

6. IANA Considerations

There are no IANA considerations related to this document.

7. Security Considerations

The method of deriving Interface Identifiers from 6-bit NFC Link layer addresses is intended to preserve global uniqueness when it is possible. Therefore, it is to required to protect from duplication through accident or forgery.

[TBD]

8. References

8.1. Normative References

[1] Montenegro, G., Kushalnagar, N., Hui, J., and D. Culler, "Transmission of IPv6 Packets over IEEE 802.15.4 Networks", RFC 4944, September 2007.

[2] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[3] "Logical Link Control Protocol version 1.1", NFC Forum Technical Specification , June 2011.

[4] Shelby, Z., Chakrabarti, S., Nordmark, E., and C. Bormann, "Neighbor Discovery Optimization for IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs)", RFC 6775, November 2012.

[5] Hui, J. and P. Thubert, "Compression Format for IPv6 Datagrams over IEEE 802.15.4-Based Networks", RFC 6282, September 2011.

[6] Thomson, S., Narten, T., and T. Jinmei, "IPv6 Stateless Address Autoconfiguration", RFC 4862, September 2007.

[7] Hinden, R. and S. Deering, "IP Version 6 Addressing Architecture", RFC 4291, February 2006.

[8] Troan, O. and R. Droms, "IPv6 Prefix Options for Dynamic Host Configuration Protocol (DHCP) version 6", RFC 3633, December 2003.

[9] Narten, T., Nordmark, E., Simpson, W., and H. Soliman, "Neighbor Discovery for IP version 6 (IPv6)", RFC 4861, September 2007.

8.2. Informative References

[10] "Near Field Communication - Interface and Protocol (NFCIP-1) 3rd Ed.", ECMA-340 , June 2013.

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