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Network Proxy Protocol
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Abstract

In the current Internet, it is implicitly assumed that a network node is always active so that it can receive the incoming packets at any time. Current networking services and applications are commonly designed to be fully available at all times with minimal response times. This assumption keeps network nodes from entering sleeping mode in order to reduce energy consumption. Further, during sleeping mode, network nodes may not immediately respond to the incoming packets or even lose them. If network nodes are allowed to go into a sleeping mode, they can effectively reduce energy consumption during idle period. Network proxy allows to delegate network node’s traffic processing to an external system within a network, so that the nodes maintain network presence during their sleep. This document describes communication mechanism between network nodes and proxy in order to accelerate the wider deployment of network proxy mechanism.

Status of this Memo

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1. Introduction

Information and Communications Technology (ICT) sector is facing rapid growth and consuming a lot of power in order to provide large bandwidth and complex application services.

According to an ITU-T report, wired and wireless networks consume large amount of power and the amount of green-house gas emissions caused by ICT sector is estimated 2% of total man-made emissions. It is also estimated that network sector including network equipment and equipment connected to networks contributes to 4% of world power consumption. Further, it is observed that the power consumption is higher at access networks and users, so how to reduce the power consumption in these areas is becoming an important issue [ITU].

According to recent surveys, network equipment show a constant power consumption profile irrespective of their utilization level, i.e., energy-agnostic power profile. Such equipment represent the worst case in terms of utilization and power consumption profile. On the contrary, ideally, energy-aware equipment represent power consumption pattern proportional to their utilization or offered load. Practical approaches for realizing the energy-aware equipment are implementing multi-stepped power profiles in order to adapt to the utilization level [EPC][GreenSurvey][EEE].

There is another researh direction for improving energy efficiency of network equipment using network proxy technology [I-D.winter-energy-efficient-internet][PROXZZZY][NCP]. Network proxy describes technologies that maintain network connectivity for other devices so that these can go into low power sleep modes. This mainly targets the reduction of unnecessary energy waste through edge devices.

There are typically two types of network proxies: internal and external, respectively.

- o Internal Proxy: proxy functionality is implemented within the ICT product, such as network interface card.

- o External Proxy: proxy functionality is placed within other network equipment such as switch and external server in networks.

This document describes a protocol that is need for communication between external proxies and network hosts.

ECMA International has published a proxying document [PROXZZZY]. This specification describes an overall architecture for network proxying and provides capabilities that a proxy may expose to a host.

Also, information that must be exchanged between a host and a proxy, and required and optional behavior of a proxy during its operation are described.

Within IETF, there are several documents related with the functionality of network proxy [RFC6762][RFC6763][I-D.cheshire-edns0-owner-option]. These documents defines DNS messages-based service discovery mechanisms, which can be used for facilitating various services. These mechanisms may be used for providing some of network proxy functionality, but generalized network proxy functionality is not fully supported.

Generalized network proxy is capable of providing full network presence for a broad range of network protocols and applications. The generalized network proxy include a list of packet types that may require routine reply, autogeneration, and wakeup, as well as the detailed steps and methods for state information transfer each requires [EEEC].

It is well known that many network hosts are in active state in order to maintain network presence and this behavior hinders hosts from entering energy saving state. Even when a node is idle with no running applications, background traffic is received that needs to be processed which inhibits the node from sleeping. Network proxy is one of the possible solutions for resolve this issue. The general framework of network proxy was developed, but the control and communication mechanisms between network hosts and proxies has not been developed. Thus, in order to promote the wider deployment of network proxy mechanism, the control and communication protocol should be specified.

This document defines a control protocol for external network proxy operation and relevant messages in order to increase energy efficiency of network hosts.

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 [RFC2119].

3. Overview of Network Proxy

Network proxy refers to a set of mechanisms dedicated to put network interfaces and network nodes into energy saving sleeping mode. Energy consumption in sleeping mode is less than active mode in general, so the longer the sleeping periods is, the higher the achievable energy saving can be. The network proxy enables network nodes to maintain network connectivity during sleep period. Figure 1 shows the typical operational scenario of network proxy [PROXZZZY]. When a host wants to enter sleeping mode, the host delivers its network status and state to a network proxy and goes into sleeping mode. Then, the network proxy responds to periodic messages on behalf of the host in sleeping mode. If the proxy receives a message that it cannot process, it sends a wake-up message to the host so that the host can process the message after wake-up.

```
                    Host                Proxy              Network
                     |                                        |
                     |                                        |
                     |         Full Network Connectivity      |
                     |<-------------------------------------->|
                     |                                        |
             Enter   |                    |                   |
             Sleeping|  Context Exchange  |                   |
             Mode    |<------------------>|                   |
                     |                    |                   |
             In      |                    |                   |
             Sleep   |                    |Selective Net.Conn.|
             Mode    |                    |<----------------->|
              .      |                    |                   |
              .      |                    |                   |
                     |                    |  Wake-up Event    |
                     |      Wake-up       |<------------------|
                     |<-------------------|                   |
                     |                    |                   |
                     |      Network Connectivity Resumed      |
             Wake-up |<-------------------------------------->|
                     |                                        |
```

Figure 1: Operational scenario of network proxy

According to the survey, even though a host is in idle mode, background network traffic is received and needs to be processed, which prevents the host from going into sleeping mode. Also, it is known that most of the incoming traffic received during the host’s idle period may be simply dropped or do not require more than a minimal computation and response. For instance, most broadcast packets or traffic related to port scanning may simply be ignored.

Usual exchanges, such as Address Resolution Protocol (ARP) processing, Internet Control Message Protocol (ICMP) echo answering or Dynamic Host Configuration Protocol (DHCP) rebinding, are simple tasks that could be easily performed directly by network proxy. The idea behind network proxy is delegating the processing of such traffic. Processing can imply plain filtering or may require simple responses (e.g., in the case of ARP, ICMP, DHCP), or even more complex task. Such tasks can be delegated from the CPUs of hosts to an external network proxy in networks [GreenSurvey].

The following list summarizes requirement status about what types of protocols network proxy should support [PROXZZZY]. Among them, this document describes ARP related operation first and other mandatory protocols will be defined later version of this document.

Mandatory 1: Media (802.3, 802.11)

Mandatory 2: IPv4 ARP

Mandatory 3: IPv6 Neighbor Discovery

Mandatory 4: Wake Packets

Option 1: DNS

Option 2: DHCP

Option 3: IGMP

Option 4: MLD

Option 5: Remote Access using SIP and IPv4

Option 6: Remote Access using Teredo for IPv6

Option 7: SNMP

Option 8: Service Discovery using mDNS

Option 9: Name Resolution with LLMNR

4. Network Proxy Operation

This section describes network proxy operation between proxy server and network nodes to support mandatory protocols. Figure 2 shows network proxy operations for IPv4 ARP. When a network host wants to enter sleeping mode in order to save energy, the host exchanges Proxy Solicitation and Advertisement messages with network proxy in network. Proxy may be implemented as a function within a switch or router, or it may be implemented as a separate server. Proxy Solicitation message queries to network, whether network proxy functionality can be supported within the host’s network. If there is a network proxy that can provide proxy functionality, it replies to the host by using Proxy Advertisement message. Network proxy supports required functional behavior defined in [PROXZZZY] in order to support IPv4 ARP.

After the network proxy discovery procedure, the host sends Sleep Request message to network proxy. The Request message contains the host’s MAC address(es) and IP address(es). After receiving the Sleep Confirm message from the network proxy, the host enters sleeping mode. Then the network proxy discards ARP Request messages sent from other hosts in the network. By doing so, the host can sleep without receiving or processing ARP broadcast message not destined to the node itself. If the network proxy receives an ARP request message for sleeping host, it sends a reply message on behalf of the sleeping hosts using the host’s MAC and IP address. When the network proxy receives a packet that it cannot process, the proxy sends a Wake-up packet to the sleeping host in order to wake it up. During its wake-up process, proxy may buffer additional packets destined to the sleeping hosts. After the sleeping node wakes up it can communicate with remote hosts. When Sleep Timer expires, the sleeping host wakes up and sends a Wake-up Report message to the network proxy. Then, the network proxy cleans up the state information for the sleeping host and replies with Wake-up confirm message.

Note that Figure 2 shows network proxy operation for processing ARP messages and operation for other mandatory protocols specified in [PROXZZZY] will be defined later version of this document.

```
                  Sleeping             Network             Remote
                    Host                Proxy               Host
                     |                    |                   |
                     | Proxy Solicitation |                   |
                     |------------------->|                   |
                     | Proxy Advertisement|                   |
                     |<-------------------|                   |
                     |         Full Network Connectivity      |
                     |<-------------------------------------->|
                     |   Sleep Request    |                   |
                     |------------------->|                   |
                     |   Sleep Confirm    |                   |
                     |<-------------------|                   |
                     |                    | ARP Request for   |
                     |                    |  Sleeping Host    |
                     |                    |<------------------|
                     |                    |  ARP Reply for    |
                     |                    |  Sleeping Host    |
                     |                    |------------------>|
                     |                    |                   |
                   ++|+++++++++++++++++++|+++++++++++++++++++|++
                   + |                    |Packet for Sleeping| +
                   + |                    | Host that Proxy   | +
             Case1 + |                    |  cannot process   | +
                   + |   Wake-up Packet   |<------------------| +
                   + |<-------------------|                   | +
                   ++|+++++++++++++++++++|+++++++++++++++++++|++
                   ++|+++++++++++++++++++|+++++++++++++++++++|++
                   + |   Wake-up Report   |                   | +
             Case2 + |------------------->|                   | +
                   + |   Wake-up Confirm  |                   | +
                   + |<-------------------|                   | +
                   ++|+++++++++++++++++++|+++++++++++++++++++|++
                     |   Exchange State   |                   |
                     |    Information     |                   |
                     |<------------------>|                   |
                     |        Full Network Connectivity       |
                     |<-------------------------------------->|
                     |                                        |
```

Figure 2: Network proxy operation for IPv4 ARP

5. Message Formats

Figure 3 depicts two types of new ICMP messages for Proxy Request/ Reply messages. The messages are defined as follows.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |     Code      |          Checksum             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Message Sub-Type       |         Transaction ID        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Options (variable size)                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 3: Proxy request message

Type	<TBD> (Proxy Request) <TBD> (Proxy Reply)
Code	0 Success 1 Fail
Checksum	The 16-bit one's complement of the one's complement sum of the ICMP message, starting with the ICMP Type.
Message Sub-Type	1 Proxy Solicitation Message 2 Proxy Advertisement Message 3 Sleep Request Message 4 Sleep Confirm Message 5 Wake-up Report Message 6 Wake-up Confirm Message
Transaction ID	Unique identifier created each time a host starts proxy operation
Options	Optional data for Sub-Type messages

Figure 4 shows the Option format for Sub-Type messages. The Option format is defined as a TLV format.

```
 0                   1                   2
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
|     Type      |    Length     |    Data ...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
```

Figure 4: Option format

Type — Indicates the particular sub-type option.
1 Proxy Solicitation Option
2 Proxy Advertisement Option
3 Sleep Request Option
4 Sleep Confirm Option
5 Wake-up Report Option
6 Wake-up Confirm Option

Length — Indicates the length (in bytes) of the data field within this option. The length does not include the Type and Length bytes.

Data — The particular data associated with this option. This field may be zero or more bytes in length. The format and length of the data field is determined by the type and length fields.

Figure 5 depicts Option format of Proxy Solicitation Sub-Type message. The sub-type message is broadcasted in order to discover proxy in networks. It contains 2 bytes Identifier and 2 bytes sequence number. Currently the detail of Identifier has not been developed, but its format and allocation method will be determined later.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |    Length     |          Identifier           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Sequence Number           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5: Proxy solicitation option

Figure 6 shows Option format for Proxy Advertisement Sub-Type message used for notifying the Proxy Server’s presence in network. It is periodically broadcasted to networks and unicasted to a network node that sent a Proxy Solicitation message. The Advertisement message contains the address of Proxy Server's IP address(es) and Preference(s).

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |    Length     | Num. of Addr |Addr Entry Size|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Lifetime            |        Proxy Address 1        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Proxy Address 1        |      Address Preference 1     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      Address Preference 1     |        Proxy Address 2        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Proxy Address 2        |      Address Preference 2     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      Address Preference 2     |            ...                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 6: Proxy advertisement option

Figure 7 shows Option format for Sleep Request Sub-Type message. The message is unicasted to Proxy Server and it informs the client's entering to sleep mode. Hardware Address Type indicates hardware address type of client. Protocol Type contains protocol address type. H/W length means the length of hardware address. Finally, number of addresses indicates the number of hardware and protocol pairs.

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |     Type      |    Length     |    Hardware Address Type      |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |          Protocol Type        |   H/W Length  | Protocol Len. |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |        Number of Address      |   Sender Hardware Address 1   |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   Sender Hardware Address 1   |   Sender Protocol Address 1   |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   Sender Protocol Address 1   |   Sender Hardware Address 2   |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   Sender Hardware Address 2   |   Sender Protocol Address 2   |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   Sender Protocol Address 2   |            ...                |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 7: Sleep request option

Figure 8 describes Option format for Sleep Confirm Sub-Type message that is sent from a Proxy Server to Client as a response of Sleep Request message. Code indicates the result of Sleep Request operation. 0 indicates success and 1 indicates failure. Client Identifier is a unique ID for identifying Client and will be allocated by Proxy Server.

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |     Type      |    Length     |     Client Identifier         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |         All zero              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 8: Sleep confirm option

Figure 9 depicts Option format for Wake-up report message. It is sent by a client to Proxy Server in order to notify the wake-up event of the client. It is unicasted to the Proxy Server. Client Identifier is the same Identifier assigned by Sleep Confirm message.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |    Length     |     Client Identifier         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         All zero              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 9: Wake-up report option

Figure 10 shows Option format for Wake-up Confirm message. It is unicasted to a Client as a reply of the Client's Wake-up Report message. Code 0 means success and 1 means failure. Client Identifier is the same Identifier assigned by Sleep Confirm message.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |    Length     |     Client Identifier         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         All zero              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 10: Wake-up confirm option

6. Security Considerations

[TBD]

7. IANA Considerations

[TBD]

8. References

8.1. Normative References

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