Native Minimal Protocol with Flexibility at Edge Networks

draft-jiang-intarea-nmp-edge-00

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Introduction - Extending IP Wider

- **Many edge networks deploy Non-IP technologies**
  - ☐ ZigBee, BLE, CAN-bus, and Modbus
  - ☐ Application-layer gateways are mandatory
  - ☐ IP is heavy for energy-sensitive devices
  - ☐ Cannot communication between different non-IP technologies

- **Three main drawbacks:**
  1. Not to support end-to-end security, IPSec or TLS
  2. Non-IP terminals are invisible to the TCP/IP network
     - Hard to conduct QoS or OAM operations
  3. Dynamic join and leave to IP network is complicated

- **Why not IPv6: drawbacks caused by long address and header length (40 bytes in total)**
  1. Consume more energy and time - both on terminals and network transmission
  2. 6lo/6lowpan compress the header, including addresses, to save energy for network transmission; but terminals' burden gets even heavier

Resource-constrained end devices are the key of problem! They are short of both energy and memory!

```
                          Data
       +- - - - - - - - - - - - - - - - - - -+
       |                                     |
       V                                     V
     +--+    ZigBee      +--+    TCP/IP     +--+
     |  |<-------------->|  |<------------->|  |
     +--+                +--+               +--+
    Non-IP              Gateway            TCP/IP
    Terminal                              Terminal
```
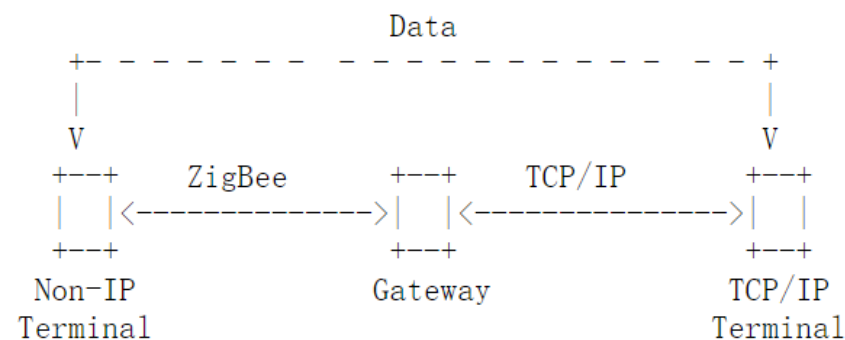
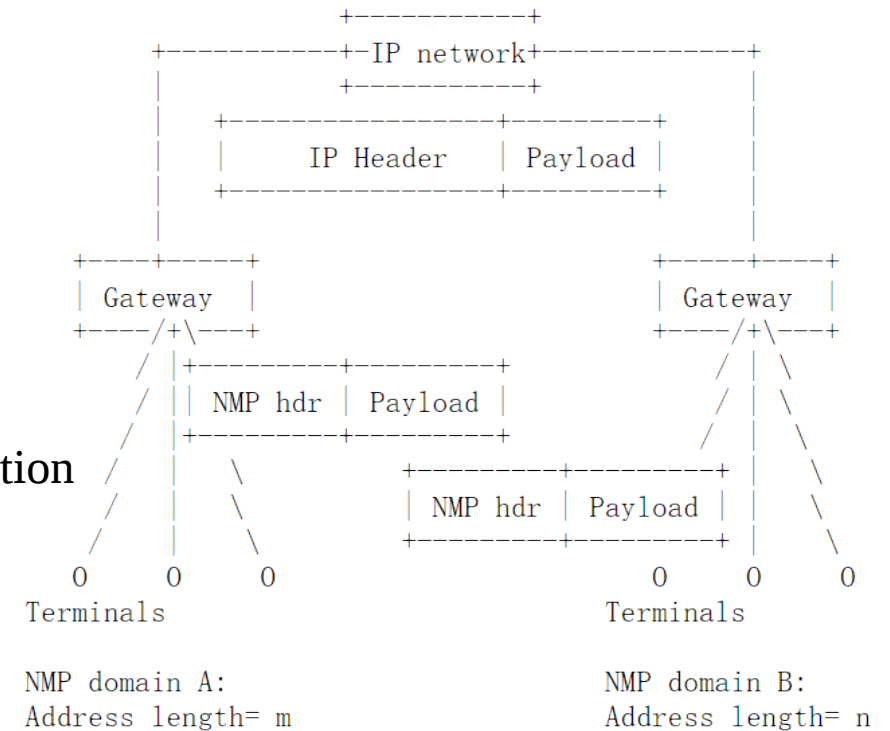Figure 1: Communication Architecture with Application Gateway

Overview

- **What's NMP?**

  NMP (Native Minimal Protocol) is a simplest protocol with native short addresses that particularly designs for edge networks with resource-constrained devices.

  - Address length are mainly 8 bits or 16 bits, extendable

  - Minimized header with short addresses

  - Simplified signaling

  - NMP supports communication between terminal & gateway, also between terminals within the same edge network

  - Functionalities include header design for both data packet & control message address, allocation & management, DNS Delegation

- **NMP-Native IP translation on the gateway**

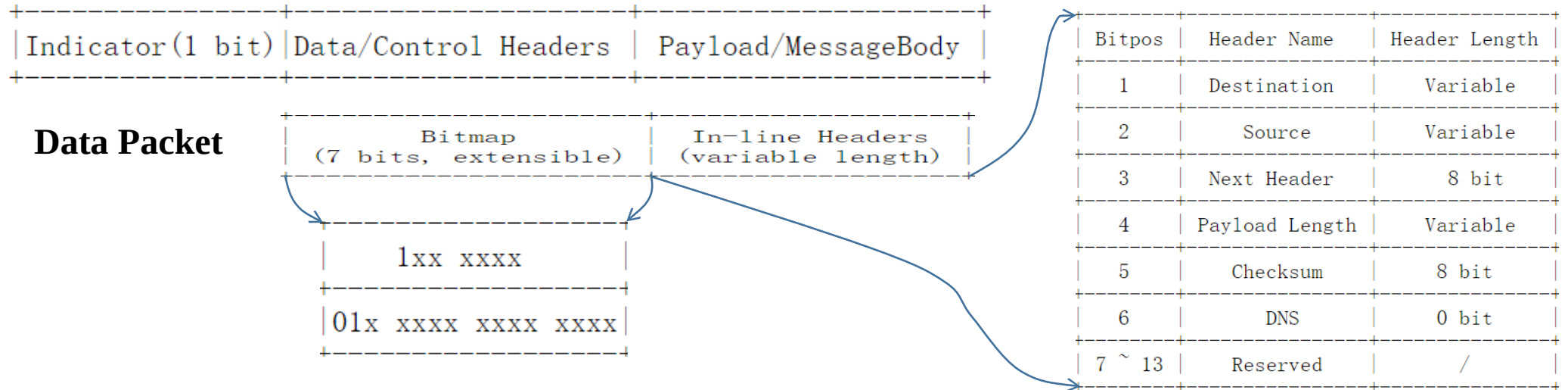 - Gateways translate packets into native IPv4/IPv6 packets

```
                              +-----------+
                      +-------+-IP network+-----------+
                      |       +-----------+           |
                      |    +----------------+-------+  |
                      |    | IP Header   | Payload | |
                      |    +----------------+-------+  |
                      |                               |
            +----+----+                    +-----+----+
            | Gateway |                    | Gateway |
            +----/+\---+                    +----/+\---+
             / |+----------+---------+        / | \
            /  || NMP hdr | Payload |        /  |  \
           /   |+----------+---------+      /   |   \
          /    |    \      +----------+--------+ |    \
         /     |     \     | NMP hdr | Payload | |     \
        /      |      \    +----------+--------+ |      \
       /       |       \                       |       \
      0        0        0                    0    0     0
   Terminals                              Terminals

   NMP domain A:                           NMP domain B:
   Address length= m                       Address length= n

   Only Support Extreme Simplified Control Messages within NMP Domain

         Figure 2: Overview of Native Minimal Protocol
```

Data Packet Header Format

Data packet header is designed with the bitmap mechanism

- the most frequently used 6 fields encoded in an one-byte bitmap

- more fields can be supported by extended bitmap

```
+----------------+---------------------+------------------------+
|Indicator(1 bit)|Data/Control Headers |  Payload/MessageBody   |
+----------------+---------------------+------------------------+
```

Data Packet

```
              +------------------------+------------------------+
              |         Bitmap         |    In-line Headers     |
              |   (7 bits, extensible) |   (variable length)    |
              +------------------------+------------------------+

              +------------------------+
              |        1xx xxxx        |
              +------------------------+

              |01x xxxx xxxx xxxx|
              +------------------------+
```

Bitpos	Header Name	Header Length
1	Destination	Variable
2	Source	Variable
3	Next Header	8 bit
4	Payload Length	Variable
5	Checksum	8 bit
6	DNS	0 bit
7 ~ 13	Reserved	/

Data Packet Example （typical header is 5 bytes, can be shorten to 4 bytes without source address):

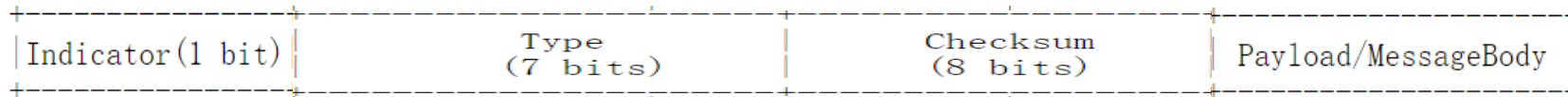| 0	1111100	D=0xF9	S=0x0A	NH=0x11	PL=0x08	8 bytes Payload including upper layer header

Address Management in NMP

- **All nodes in the same network use the same address length**
  - ✓ Configured on gateway
- **Address Allocation through AR & AA message**
  - ✓ AR ⬝ Address Request, sent by Terminal to ask for a short address from gateway and the address of gateway
  - ✓ AA ⬝ Address Assignment, replied by gateway that maintains short address pool for the domain

- **Address lifetime management through LRC & LRR message**
  - ✓ LRC: Lease Renewal Challenge, challenge whether a NMP address is still alive and continue to live. It is sent by gateway periodically.
  - ✓ LRR: Lease Renewal Response, Terminal use this to answer gateway's challenge about its NMP short address.
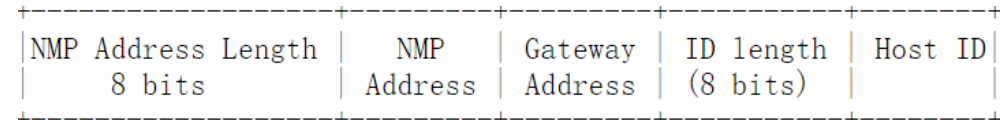 - ✓ Due to Terminal only need to answer with LRR, energy consumption will be low.

Terminal | Gateway

AR

AA

timer

LRC

LRR

timer
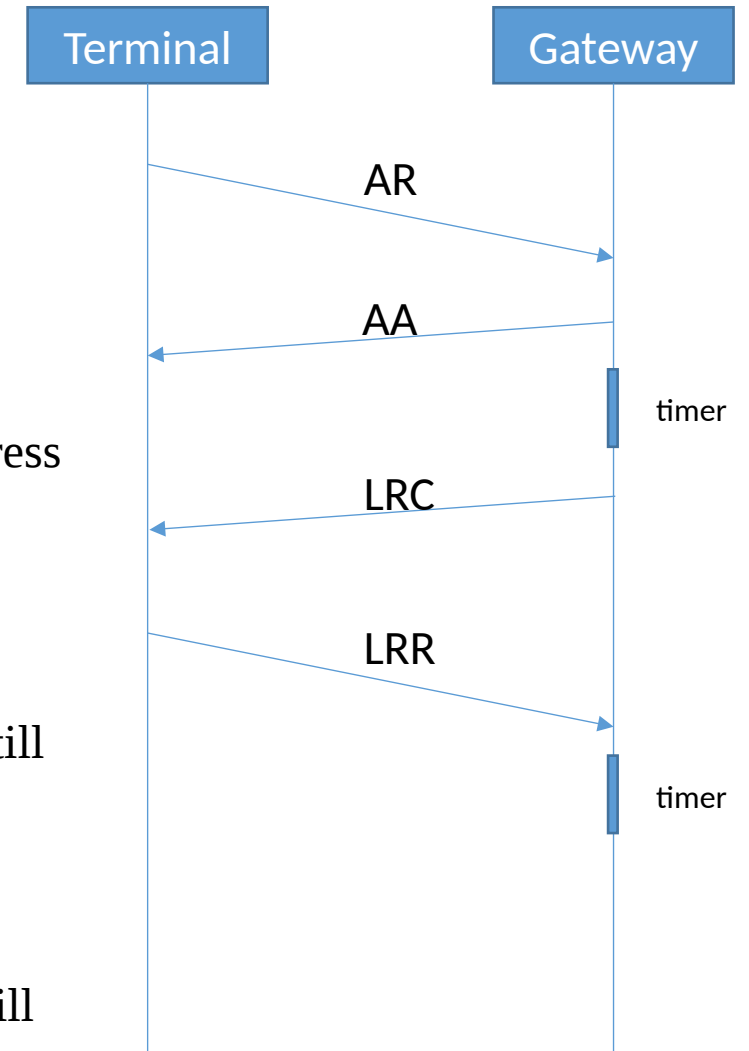
Control Message Body Format

Base Format （Types & checksum in the header）

```
+----------------+------------------+------------------+--------------------+
|Indicator(1 bit)|       Type       |     Checksum     | Payload/MessageBody |
|                |    (7 bits)      |    (8 bits)      |                    |
+----------------+------------------+------------------+--------------------+
```

- Address Request Message Body
    Message Type = 0b000 0001

```
+------------------+----------+
| ID length (8 bits) | Host ID |
+------------------+----------+
```

- Address Assignment Message Body
    Message Type = 0b000 0010

```
+------------------+--------+---------+---------+---------+
|NMP Address Length |  NMP   | Gateway | ID length | Host ID|
|     8 bits        | Address | Address | (8 bits) |        |
+------------------+--------+---------+---------+---------+
```
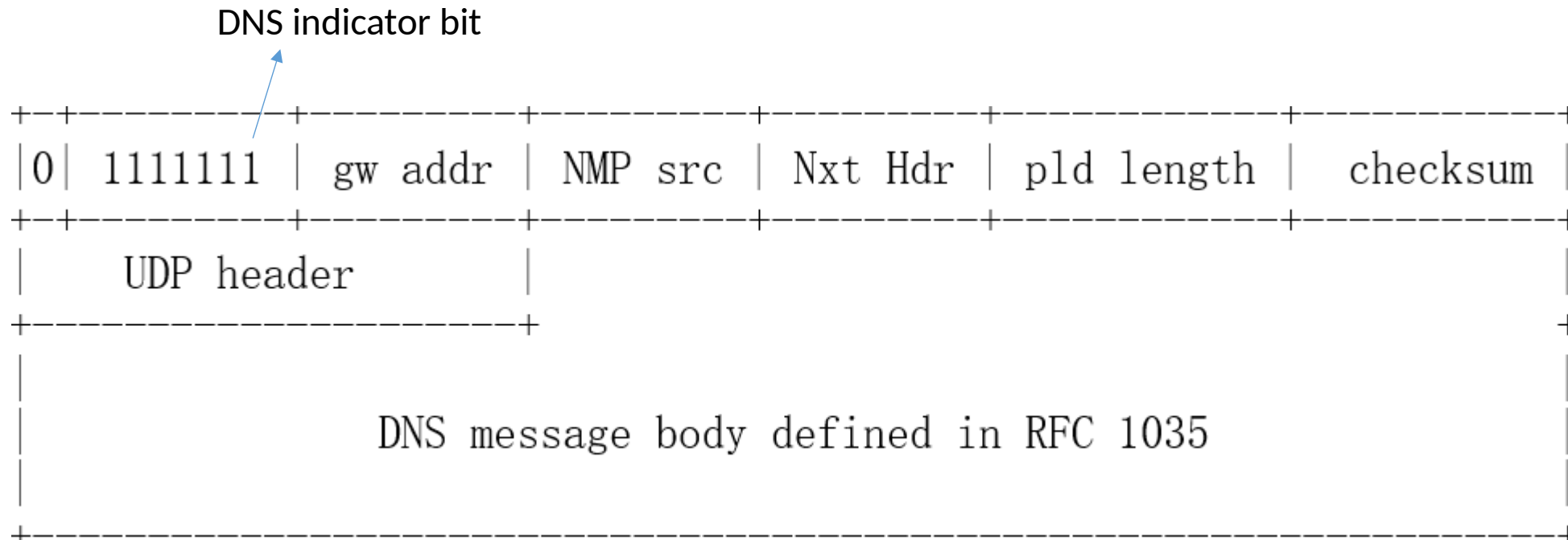
- Address Lease Renewal Challenge Message Body
    Message Type = 0b000 0011
  Address Lease Renewal Response Message Body
    Message Type = 0b000 0100

```
+------------------+--------+-----------+---------+
|NMP Address Length |  NMP   | ID length | Host ID|
|     8 bits        | Address | (8 bits) |        |
+------------------+--------+-----------+---------+
```
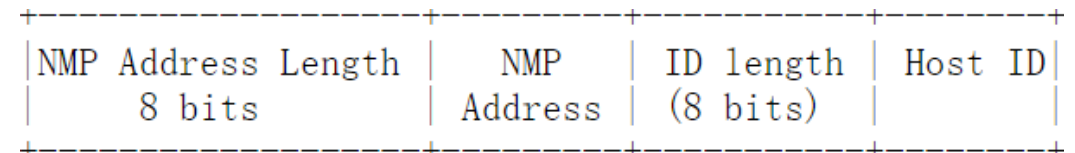
DNS Delegation

- The NMP terminal sends a DNS query packet to the gateway. The Indicator field of the packet is set to 0 (data message), and the DNS bit of the bitmap is set to 1. Destination of the packet is set to NMP address of gateway. When the gateway receives the packet, it directly translates the network layer information and sends a regular DNS packet to the DNS server configured on the gateway. The returned DNS message is encoded into the return data packet towards the source terminal.

```
              DNS indicator bit


+--+---------+---------+---------+---------+----------+--------+
|0| 1111111 | gw addr | NMP src | Nxt Hdr | pld length | checksum |
+--+---------+---------+---------+---------+----------+--------+
|     UDP header      |
+---------------------+
|                                                              |
|                                                              |
|          DNS message body defined in RFC 1035                |
|                                                              |
+--------------------------------------------------------------+
```

Some considerations

- For Security

    ✓ Checksum is shorter (from 16-bit to 8-bit). Cost less bits and computation, meanwhile increases possibility that checksum misses bit errors during transmission

- IANA

    ✓ New Ethtype is required

    ✓ New registries for NMP control message types & bitmap table

Thanks

Functionalities of Gateway

- Address Management

  - ✓ intra-domain host address allocation

  - ✓ intra-domain host address life cycle management

- Address Translation

  - ✓ Happen when communication occurs between NMP node and external IP node.

  - ✓ Detail method should be specified accordingly

- Forward data packets between end devices within the network