IEEE 802.15.4

- **Small packet** size (the maximum transmission unit or MTU on IEEE 802.15.4 links is **127 bytes**), which provides even **less room** for data when including other header
- Support for both 16-bit short or IEEE 64-bit extended media access control (MAC) addresses.
- Low data rates; the IEEE 802.15.4 specification allows various data rates from 20Kbits/s (868 MHz) to 250Kbits/s (2.45 GHz).
- Support of star and mesh topologies.

THE 6LoWPAN ADAPTATION LAYER

- Since **IPv6 mandates** supporting links with an MTU (Maximum Transmission Unit) of **1280 bytes**, it was necessary for IEEE 802.15.4 links that have an MTU of 127 bytes to specify an adaptation layer below IP responsible for handling packet fragmentation and reassembly.
- The MTU size of IEEE 802.15.4 links was **purposely small** to cope with limited **buffering capabilities** and to limit the packet error rate since the **bit error rate (BER)** is relatively high.
- an adaptation layer is needed to comply with the IPv6 requirement to support a minimum MTU size of 1280 bytes as well as to support **compression techniques** to reduce protocol overhead.

The 6LoWPAN adaptation layer provides three main services:

- Packet fragmentation and reassembly
- Header compression
- Link layer (layer 2) forwarding when multi-hop is used by the link layer

- The 6LoWPAN adaptation currently supports three headers:
  - a mesh addressing header,
  - the fragment header, and
  - the IPv6 header compression header

  (they must appear in that order when present).

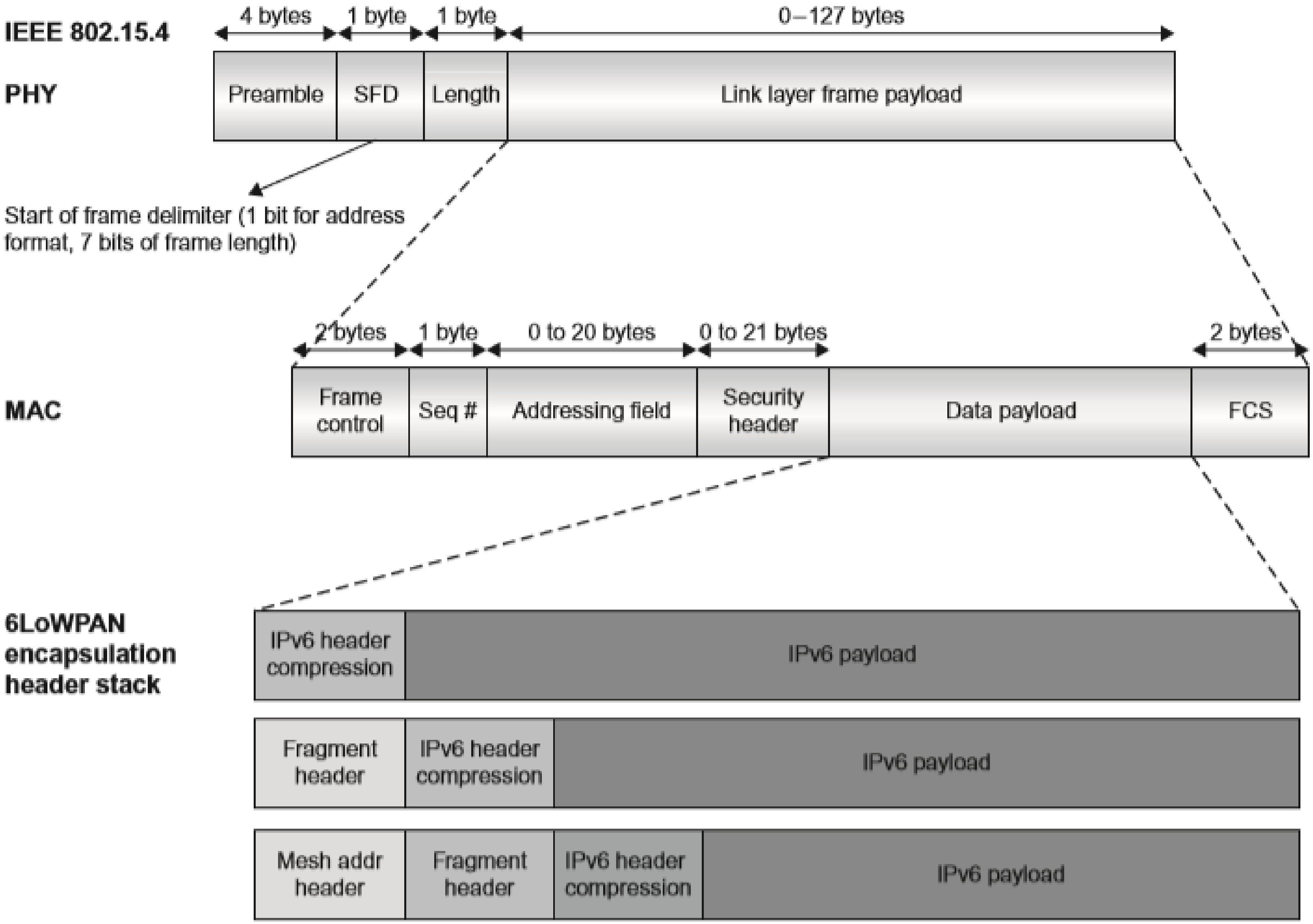
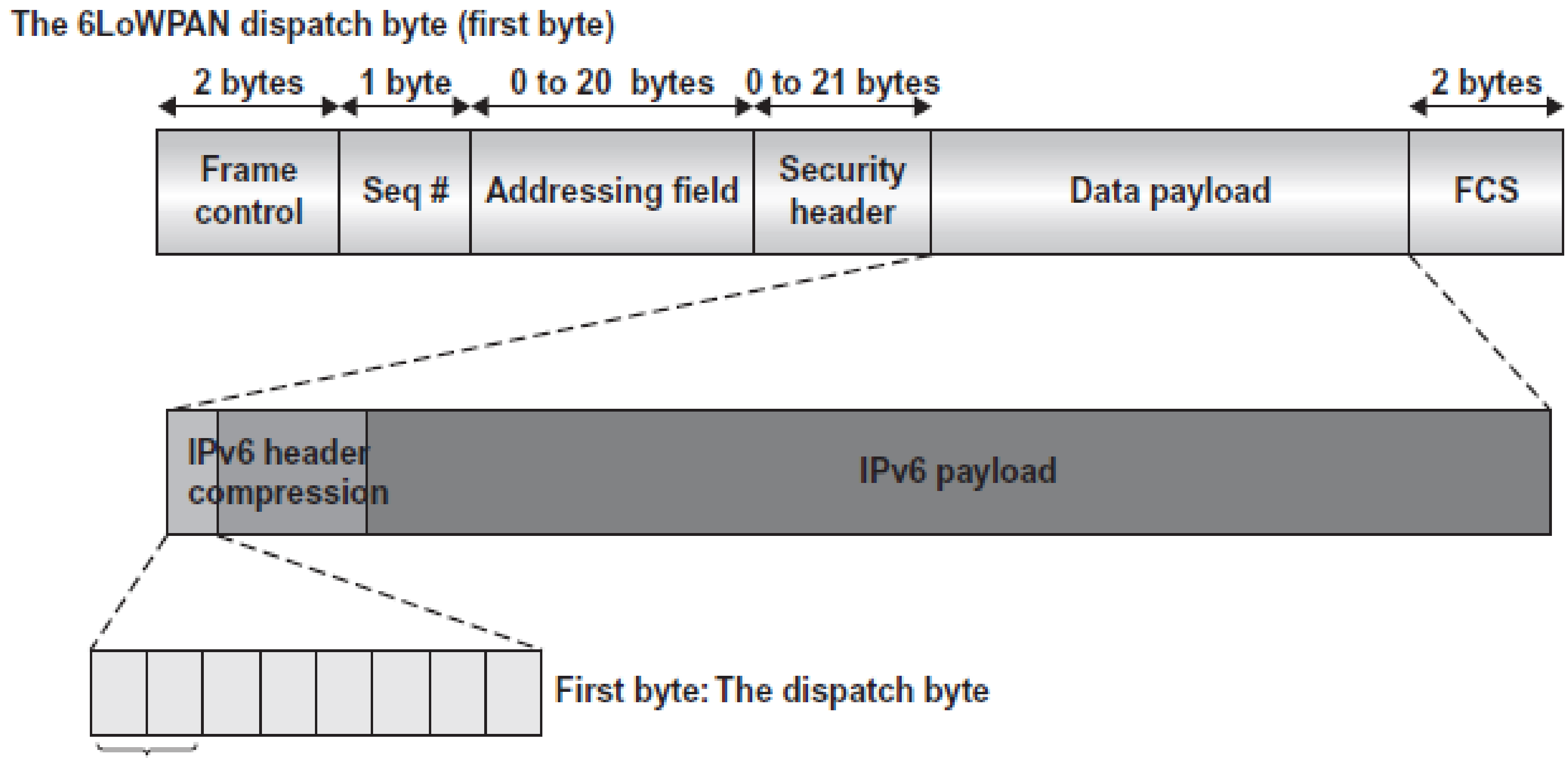


FIGURE 16.1

6LoWPAN encapsulation header stack.

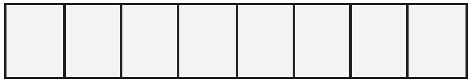


00	Not a 6LoWPAN frame
01	IPv6 addressing header
10	Mesh header
11	Fragmentation header (6 lower bits are 100xxx)

FIGURE 16.2

Dispatch byte of the IPv6 header compression header.

The 6LoWPAN dispatch byte (first byte)



First byte: The dispatch byte

Pattern	Header type
00 xxxxxx	NALP - not a LoWPAN frame
01 000001	IPv6 - uncompressed IPv6 addresses
01 000010	LOWPAN_HC1-LOWPAN_HC1 compressed IPv6
01 000011	reserved - reserved for future use
...	reserved - reserved for future use
01 001111	reserved - reserved for future use
01 010000	LOWPAN_BCO - LOWPAN_BCO broadcast
01 010001	reserved - reserved for future use
...	reserved - reserved for future use
01 111110	reserved - reserved for future use
01 111111	ESC - additional dispatch byte follows
10 xxxxxx	MESH - Mesh header
11 000xxx	FRAG1 - fragmentation header (first)
11 001000	reserved - reserved for future use
...	reserved - reserved for future use
11 011111	reserved - reserved for future use
11 100xxx	FRAGN - fragmentation header (subsequent)
11 101000	reserved - reserved for future use
...	reserved - reserved for future use
11 111111	reserved - reserved for future use

FIGURE 16.3

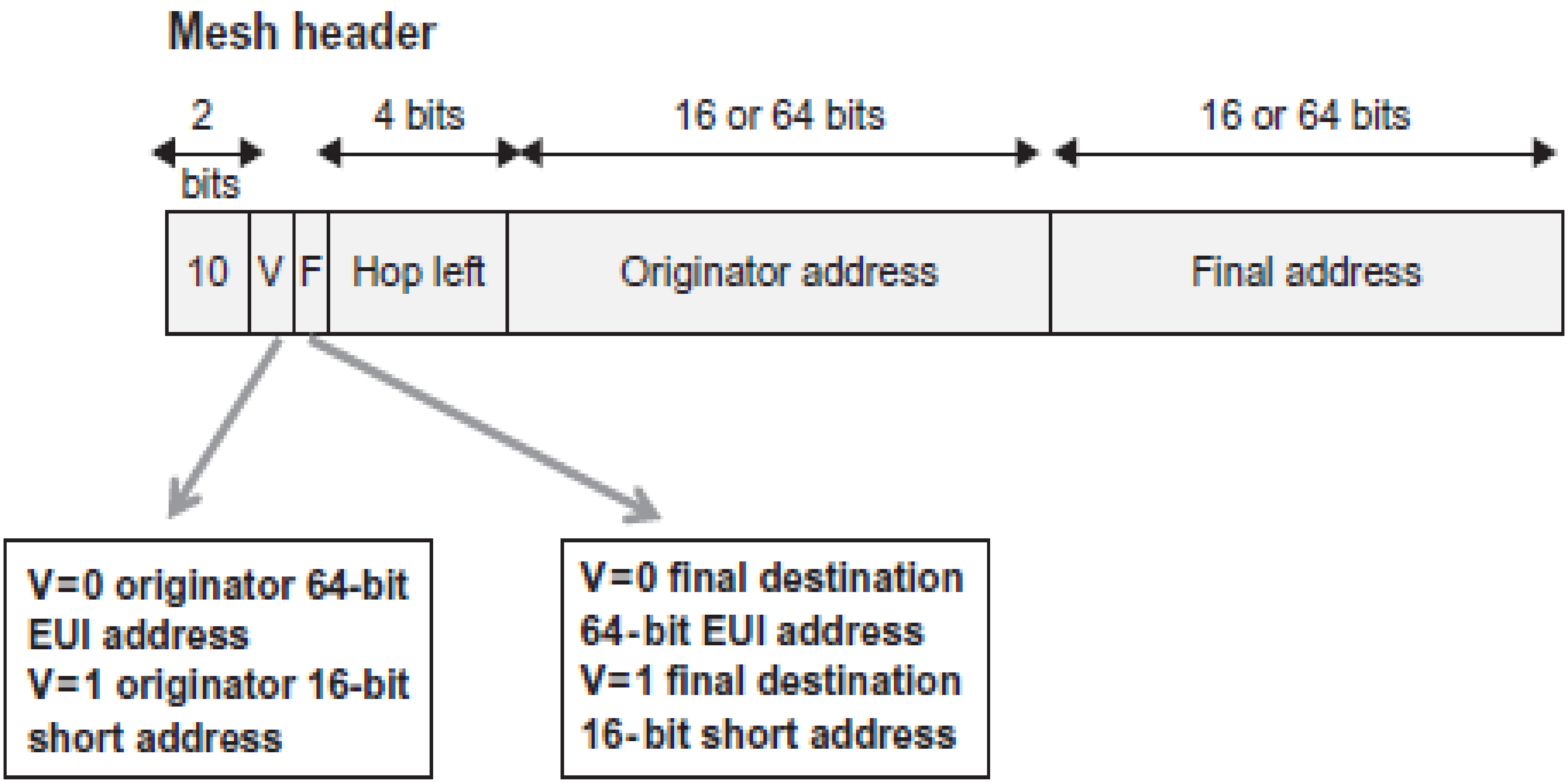
Value of the 6LoWPAN dispatch byte.

- The first byte of the encapsulation header identifies the next header.
- For example, if the first 2 bits are equal to 11, the next header is a **fragmentation** header.
- If the first 8 bits are equal to 01000001, what follows is an IPv6 *uncompressed packet. In contrast,* a value of 01000010 indicates that what follows is a header related to a compressed header using HC1 compression

The Mesh Addressing Header

- The mesh addressing header is used in conjunction with a mesh-under “routing ” approach where nodes that are **not in direct communication** make use of **multi-hop** “ routing ” at the link layer using link layer addresses.
- According to IEEE 802.15.4, only **full function devices (FFDs)** perform mesh-under operation. **Reduced function devices (RFDs)** systematically send all of their traffic to FFDs.

- **The source and destination nodes** are then referred to as the originator and final destination, respectively.
- the first 2 bits of the dispatch byte identify the presence of a mesh header and are equal to 10.
- **Bit 2 (V, Very first bit):**
- 0: The originator address is an IEEE extended 64-bit address (EUI-64).
- 1: The originator address is a short 16-bit address.
- **Bit 3 (F, Final destination):**
- 0: The final address is an IEEE extended 64-bit address (EUI-64).
- 1: The final address is a short 16-bit address.



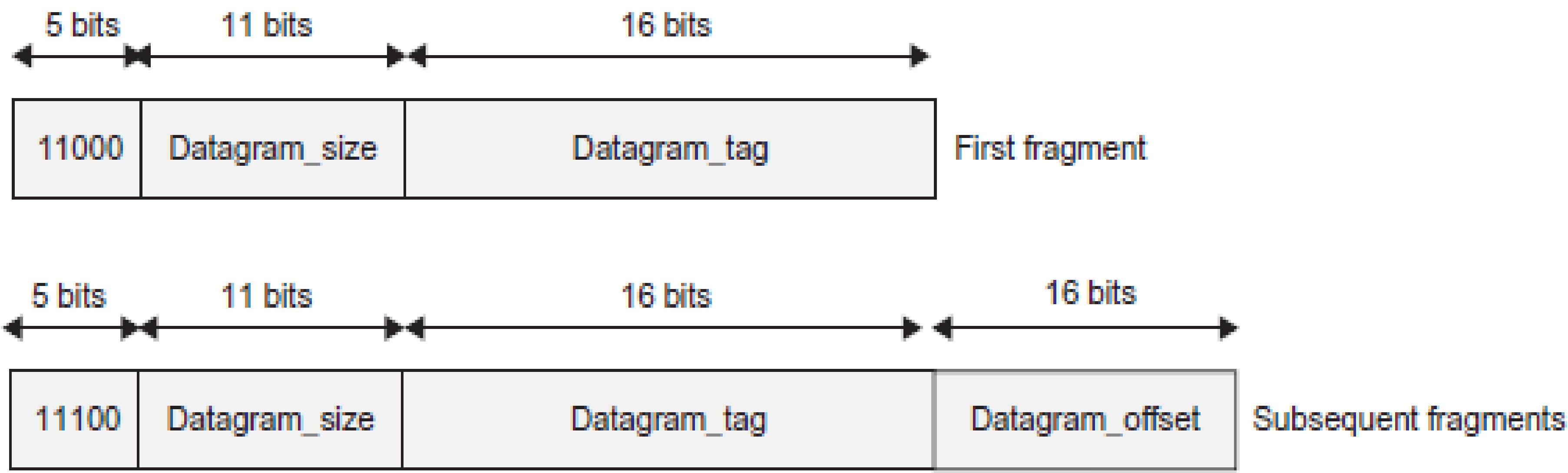
Mesh header
2 bits
4 bits
16 or 64 bits
16 or 64 bits
10
V
F
Hop left
Originator address
Final address
V=0 originator 64-bit EUI address
V=1 originator 16-bit short address
V=0 final destination 64-bit EUI address
V=1 final destination 16-bit short address

- **Bits 4 through 7 (HopLeft):**
- The HopLeft field value is decremented by each node before sending the packet to its next hop.
- When the HopLeft field reaches the value of 0, the packet is simply discarded.
- When equal to 15, an additional byte (called the deep hops left) immediately follows when forwarding along a path with more than 14 hops is needed.
- The originator and final link layer address fields then follow (16 or 64 bits).

- Thus the set of link layer addresses is as follows. When a node A sends a frame to a final destination C via the node B:
- The **originator address** of the mesh header is set to the link layer address of A.
- The **final destination address** of the mesh header is set to the link layer address of C.
- The **source address of the IEEE 802.15.4** frame is the address of the node sending the frame (A).
- **The destination address of the IEEE 802.15.4** frame is the link layer address of the next-hop node as determined by the mesh-under routing protocol (B in this example).

- Upon receiving the frame, B performs the following process:
- The hop left field is decremented.
- If the hop left field is not equal to 0 (if equal to 0, the frame is discarded), then B determines that the next hop is C.
- The originator and final destination address of the mesh header are unchanged.
- The source address of the IEEE 802.15.4 frame is set to the link layer address of B.
- The destination address of the IEEE 802.15.4 frame is set to the link layer address of C.

Fragment header



6LoWPAN Header Compression

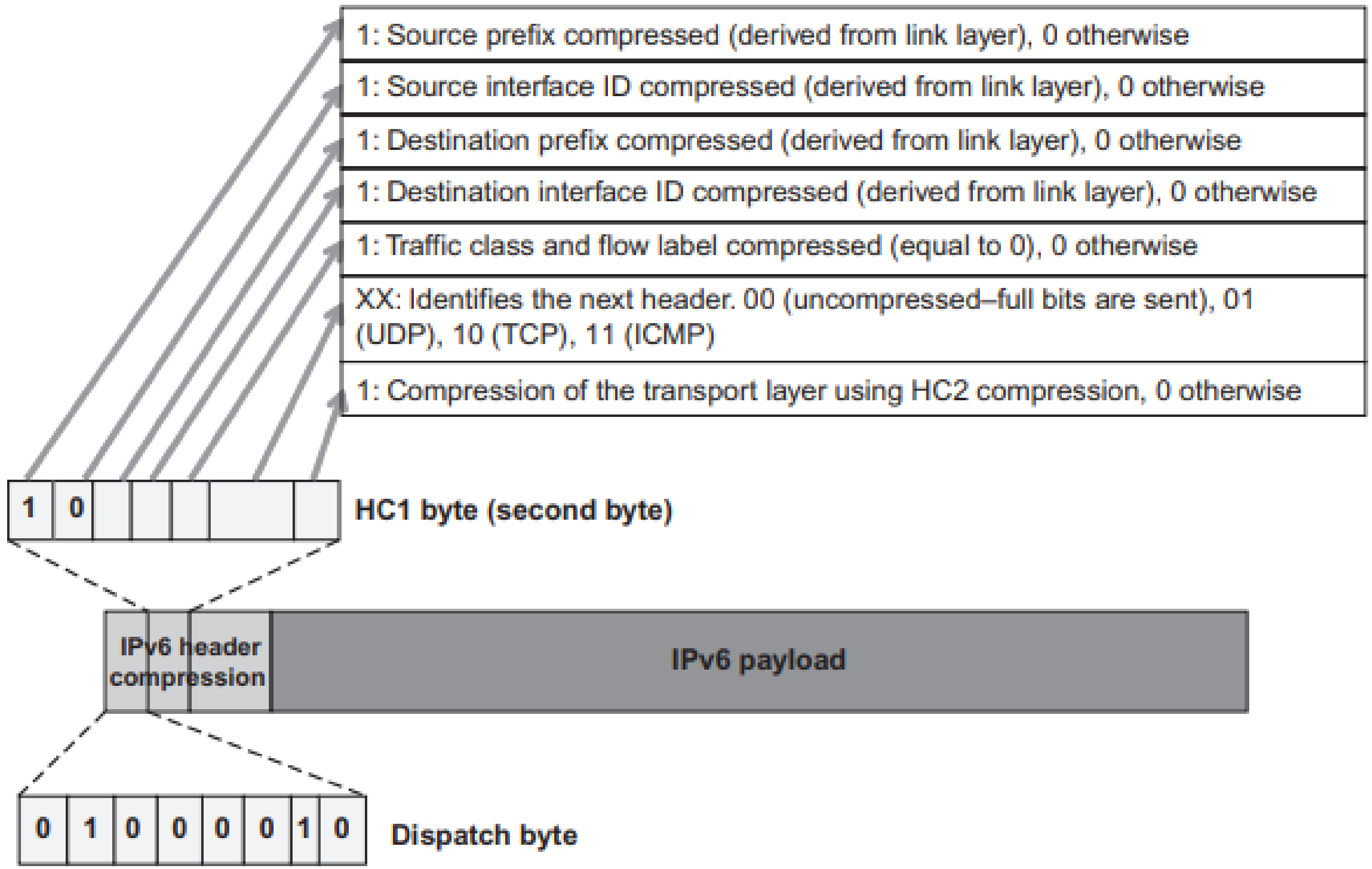
- Header Compression Using LOWPAN_HC1

focused on highly optimizing the compression unicast link-local addresses

- Encoding technique (IPHC) –multicast addresses
- LOWPAN_HC2-The HC_UDP Compression Technique

The HC1 Compression Technique The HC1 compression technique relies on the following observations:

- IP version is always 6.
- Since HC1 is optimized for link-local addresses, the IPv6 interface ID (bottom 64 bits of the IPv6 address) can be inferred from the link layer MAC address.
- The packet length can be inferred from the frame length fi eld of the IEEE 802.15.4 frame (or from the datagram size fi eld of the fragment header when present).
- Common value for the TC and flow label is 0
- Next header is UDP, TCP, or ICM


1: Source prefix compressed (derived from link layer), 0 otherwise
1: Source interface ID compressed (derived from link layer), 0 otherwise
1: Destination prefix compressed (derived from link layer), 0 otherwise
1: Destination interface ID compressed (derived from link layer), 0 otherwise
1: Traffic class and flow label compressed (equal to 0), 0 otherwise
XX: Identifies the next header. 00 (uncompressed–full bits are sent), 01 (UDP), 10 (TCP), 11 (ICMP)
1: Compression of the transport layer using HC2 compression, 0 otherwise
1
0
HC1 byte (second byte)
IPv6 header compression
IPv6 payload
0
1
0
0
0
0
1
0
Dispatch byte