

# Lightweight IKEv2: A Key Management Solution for both Compressed IPsec and IEEE 802.15.4 Security

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With the advent of 6LoWPAN [1], wireless sensor networks (WSN) can be connected to the traditional Internet using the well tested IP protocol. These protocols form the Internet of Things (IoT) or strictly speaking the IP-connected IoT. There is no doubt that the 6LoWPAN enabled sensors will be the underlying technology of the IoT [2]. In the IP-connected IoT, IP enabled WSN are connected to the untrusted, unreliable, and vulnerable Internet. Moreover, the wireless medium adds to untruthfulness and vulnerability. To enable secure communication with the traditional Internet one of the well tested secure Internet protocols such as IPsec should be extended to WSN.

Network or higher layer security and link layer security are not interchangeable. Upper layers are used to provide end-to-end security whereas link layer security controls provide hop-by-hop security. It is important to detect data modification attacks as early as possible in the wireless medium. With upper layer security protocols such as IPsec the authenticity of the data is, however, verified only at the end nodes as IPsec is end-to-end. For this reason link-layer security with authentication services is important also when IPsec is already used at the network layer.

On of the hardest problems in IoT security is the key management. IPsec uses the Internet Key Exchange (IKE) protocol [3] for automatic key exchange. Manual key exchange is also possible. It is based on symmetric pre-shared key for the initial authentication of two communicating parties. Automatic key exchange, on the other hand, uses asymmetric cryptography for the initial authentication. In IPsec, both manual and automatic key exchange protocol are possible. Most Internet hosts are capable of handling both mechanisms. Manual key exchange methods are lightweight but are not scalable. Moreover, they are less secure whereas automatic methods are a bit heavier but more flexible and scalable. They do not require that an Internet host has pre-

1	1	0	1	SPI	ET	ID	NH
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Figure 1. NHC encodings for the IKE Header

installed symmetric keys of the device with whom it wants to communicate securely.

There is no key management protocol defined in the IEEE 802.15.4 standard. Therefore, when we need to ensure stronger security at both the network and the link layer we require two key management protocols. IKE is a heavyweight protocol and full fledged IKE is not suitable for resource constrained nodes in the IP-connected Internet of Things (IoT). We propose a lightweight 6LoWPAN compressed IKEv2 that can be used with our previously implemented and evaluated 6LoWPAN compressed IPsec [4]. Further, we propose a solution that enables the use of IKEv2 for key management for IEEE 802.15.4 link layer security.

## 1 6LoWPAN Compression for IKEv2

To cope with the size limitations of IEEE 802.15.4 link layer frames we propose to compress the IKE header at the 6LoWPAN layer. The IKE header is part of the UDP payload. The header that precedes UDP should specify that the next header is UDP or IKE\_UDP. The 6LoWPAN compression defines NHC encodings for UDP. Unlike other specified NHCs, the NHC for UDP is not prepared to specify that the next header is compressed. In other words, the *NH* field is missing in the UDP encodings. Therefore, in the current specification it is not possible to link the compressed IKE header with the previous compressed headers (in this case compressed UDP header). To overcome this limitation we propose schemes that make it possible for 6LoWPAN enabled devices to recognize UDP-IKE (UDPIKE) as a compressed version of UDP that contains an IKE header as UDP payload. In this case the IKEv2 header is always in compressed form. The compressed IKEv2 header is recognized by the unique ID bits 1101 (see Figure 1).

Figure 1 shows our proposed NHC encodings for the IKE header where SPI, exchange types, Message ID, and Next Header fields are compressed.

- The first 4 bits in the NHC.IKE represent the NHC ID we define for the UDPIKE header. These are set to 1101.
- If  $SPI = 0$ : The default SPI for the sensor network is

used and the SPI field is omitted. We set the default SPI value to 1. SPI 0 is reserved to indicate that a default security association exists. This does not mean that all nodes use the same security association (SA), but that every node has a single preferred SA, identified by SPI 1.

If  $SPI = 1$ : All 64 bits indicating the SPI are carried inline after the NHC\_IKE header.

- If  $ET = 0$ : A 2 bit exchange type is used that specifies the four standardized exchange types.

If  $ET = 1$ : All 8 bits of the exchange are carried inline after the NHC\_IKE header.

- If  $MessageID = 0$ : A 16 bit sequence number is used. The left most 16 bits are assumed to be zero.

If  $MessageID = 1$ : All 32 bits of the sequence number are carried inline after the NHC\_IKE header.

- If  $NH = 0$ : The next header field in IKE header will be used to specify the next header and it is carried inline.

If  $NH = 1$ : The next header field in IKE is skipped. The next header will be encoded using NHC. This enables us to provide 6LoWPAN NHC encodings for the IKEv2 payloads.

The Length field in the IKE header is emitted as it can be inferred from the low layers. The other fields are carried inline as they contain values that MUST be included in all messages. The same 6LoWPAN NHC mechanisms can be used to compress other IKEv2 payloads.

Recently a generic compression scheme was proposed for the protocol header or header-like structure [5]. We also plan to make use of this scheme for the IKEv2 payloads compression, as an alternate approach.

## 2 IKEv2 for IEEE 802.15.4 Security

IKEv2 [3] uses the security association payload to negotiate attributes of a Security Association (SA). Each SA payload has one or more proposals to be used for the particular SA. Each proposal includes one protocol identified by a protocol ID. Each protocol in the SA proposal contains one or more transforms. Each proposal transform specifies a cryptographic algorithm. The protocol ID in the proposal is used to specify that this SA is being established for a particular security protocol. The protocol ID is 8 bits long where three values: IKE (1), AH (2), ESP (3) are already defined. We propose to use, say 4, as the protocol ID for IEEE 802.15.4 link layer security. This will allow us to establish an SA for the link layer security between the two neighboring sensor nodes.

A sensor node in the wireless network can access the security association database (SAD) to retrieve the key and other necessary information to provide security at the link layer. We will provide implementation details in the upcoming release of our source code and in subsequent publications.

## 3 ECC for IKEv2

IPsec uses the Diffie Hellman protocol for key exchange. The current IKE implementations for Internet hosts mostly

use RSA for automatic key exchange. However, RSA is very heavyweight for resource constrained sensor nodes. To overcome this we plan to use Elliptic Curve Cryptography (ECC) as an asymmetric cryptographic system in Diffie Hellman. Our implementation is the first ECC implementation for the uIP stack and the Contiki operating system [6]. We use standardized ECC algorithms [7] and NIST recommended elliptic curve and prime numbers in our ECC implementation.

## 4 Acknowledgments

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