New IKEv2 Payload Format?

Valery Smyslov

svan@elvis.ru

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Existing Format Limitation

- Payload Length field occupies 2 bytes, so payload size is limited to 64 Kbytes
  - might not be enough for some PQ algorithms
  - no problem with Message size, which is limited to 4 Gbytes

Existing Format Redundancy

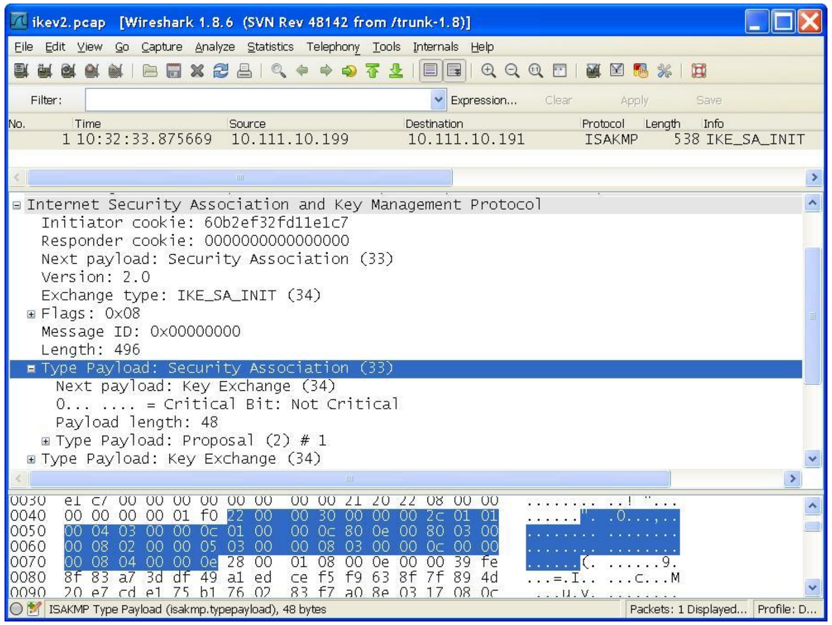
Many payloads contain substantial redundancy

– Payload Length field occupies 2 bytes, while most payloads are shorter
– most parameters occupy 2 bytes, while less than 256 values are defined
– zero-filled RESERVED fields

Example: SA Payload on the right contains one Proposal with four Transforms:

- `ENCR_AES_CBC` (128 bits)
- `PRF_HMAC_SHA2_256`
- `AUTH_HMAC_SHA2_256_128`
- `2048-bit MODP Group`

Payload size is **48** bytes, among which **24** bytes are zeroes.


ikev2.pcap [Wireshark 1.8.6 (SVN Rev 48142 from /trunk-1.8)]
File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help
Filter:
Expression...
Clear
Apply
Save

```
No.  Time               Source         Destination    Protocol  Length Info
   1 10:32:33.875669    10.111.10.199  10.111.10.191  ISAKMP       538 IKE_SA_INIT
```

```
⊟ Internet Security Association and Key Management Protocol
    Initiator cookie: 60b2ef32fd11e1c7
    Responder cookie: 0000000000000000
    Next payload: Security Association (33)
    Version: 2.0
    Exchange type: IKE_SA_INIT (34)
  ⊞ Flags: 0x08
    Message ID: 0x00000000
    Length: 496
  ⊟ Type Payload: Security Association (33)
      Next payload: Key Exchange (34)
      0... .... = Critical Bit: Not Critical
      Payload length: 48
    ⊞ Type Payload: Proposal (2) # 1
  ⊞ Type Payload: Key Exchange (34)
```

```
0030  e1 c7 00 00 00 00 00 00  00 00 21 20 22 08 00 00   ........ ..! "...
0040  00 00 00 00 01 f0 22 00  00 30 00 00 00 2c 01 01   ......". .0...,..
0050  00 04 03 00 00 0c 01 00  00 0c 80 0e 00 80 03 00   ........ ........
0060  00 08 02 00 00 05 03 00  00 08 03 00 00 0c 00 00   ........ ........
0070  00 08 04 00 00 0e 28 00  01 08 00 0e 00 00 39 fe   ......(. ......9.
0080  8f 83 a7 3d df 49 a1 ed  ce f5 f9 63 8f 7f 89 4d   ...=.I.. ...c...M
0090  20 e7 cd e1 75 b1 76 02  83 f7 a0 8e 03 17 08 0c    ...u.v. ........
```

ISAKMP Type Payload (isakmp.typepayload), 48 bytes | Packets: 1 Displayed... | Profile: D...

Lifting 64 Kbytes Size Limit

- Would allow using PQ algorithms with long public keys and signatures
  - Classic McEliece is NIST round 4 candidate, it is also recommended by some national state organizations (e.g. BSI in Germany)
- Would allow transferring large chunks of data (e.g. in CP payload)

Making Payloads Smaller

- Would decrease power and network bandwidth consumption (important for IoT devices)
- Would decrease chances of IP fragmentation in `IKE_SA_INIT` and chances of IKE fragmentation in the following exchanges
  - these chances grow as the number of transforms proposed by initiator increases making SA payload larger, e.g. when draft-ietf-ipsecme-ikev2-multiple-ke is used with full range of PQ algorithms with different parameters

Existing Proposals

- A Larger Internet Key Exchange version 2 (IKEv2) Payload
  `draft-nir-ipsecme-big-payload`
- Beyond 64KB Limit of IKEv2 Payloads
  `draft-tjhai-ikev2-beyond-64k-limit`
- Compact Format of IKEv2 Payloads
  `draft-smyslov-ipsecme-ikev2-compact`
  (expired)

"A Larger Internet Key Exchange version 2 (IKEv2) Payload”

- addresses only 64Kbytes limitation
- generic solution suitable for any payload
  - payloads in new and old formats can be mixed in a message
- explicitly negotiated via exchange of notifies in `IKE_SA_INIT`
  - cannot be used in initial exchange (`IKE_SA_INIT`)
- relatively easy to implement (depending on base IKEv2 code)
  - no implementations exists (?)

“Beyond 64KB Limit of IKEv2 Payloads”

- addresses only 64Kbytes limitation
- suitable only for some payloads (`KE, AUTH, CERT`)
  - existing payload format is preserved
  - Encrypted Payload is mangled (zero payload length)
- no explicit negotiation, implicitly negotiated in `IKE_SA_INIT` by selecting transforms with large public keys
  - cannot be used in initial exchange (`IKE_SA_INIT`)
- relies on mandatory use of IKE fragmentation
- relatively easy to implement
  - implementations exist

“Compact Format of IKEv2 Payloads”

- addresses redundancy of IKE payloads
- suitable for any payload
  - compact and standard payloads can be mixed in a message
- some payloads have special, extremely compact format
- no negotiation, new initial exchange is used (`ALT_IKE_SA_INIT` instead of `IKE_SA_INIT`)
  - can be used in new initial exchange (`ALT_IKE_SA_INIT`)
  - initiator can revert to `IKE_SA_INIT` if this extension is not supported by responder (based on receiving of fatal error or on timeout)
- moderately difficult to implement
  - can be implemented as post-/pre- message processing
  - no implementations exist

Questions

- Do we want to revise IKE payload format?
- If yes, then what problems should be addressed:
  - remove 64K limitation?
  - decrease IKEv2 messages redundancy?
  - both?
- Any interest in this work?

Thanks!

Backup Slides

Possible new payload format that would support large payloads and also would make IKE messages smaller by eliminating some redundancy

New Format Overview

- Three formats for new Generic Payload Header
  - for small payloads (up to 64 bytes)
  - for medium size payloads (up to 8 Kbytes)
  - for large payloads (up to 512 Mbytes)
- No RESERVED fields
- Revise existing payloads headers to reduce their size
  - remove unnecessary fields
- Special Format for some payloads (SA, some status notifies)

New Generic Payload Header

1. Small payloads (2 bytes, 6 bits for Payload Length)

Next Payload	C	0	Payload Length

2. Medium size payloads (3 bytes, 13 bits for Payload Length)

Next Payload	C	1	0	Payload Length

3. Large payloads (5 bytes, 29 bits for Payload Length)

Next Payload	C	1	1	Payload Length
Payload Length (cont)				

Revised Existing Payload Headers

The following payload headers can be revised:

- Key Exchange, Identification, Authentication, Configuration
  - remove `RESERVED` field
- Notify
  - remove `SPI Size` field (can be deducted from Protocol ID)
- Delete
  - remove `SPI Size` field (can be deducted from Protocol ID)
  - remove `Num of SPIs` field (can be deducted from Payload Length)
- Traffic Selector
  - remove `RESERVED` field
  - remove `Number of TSs` field (can be deducted from Payload Length)

Special Format

Special format (*) for:

- SA Payload
  - SA Payload grows quickly as more and more new transforms are defined and offered by initiators
- Notify Payload with some Status Type Notification containing no data
  - Exchange of such payloads is a common way to negotiate support for various protocol extensions, so initial IKEv2 messages grow up as more and more extensions are defined

Both payloads contain a lot of redundancy and can be effectively compacted.

(*) Inspired by draft-smyslov-ipsecme-ikev2-compact

SA Payload

Outline:

- Remove all `RESERVED` fields
- Remove `Length` fields in substructures (where they are unnecessary)
- Encode all currently defined transforms w/o attributes using one octet (both `Transform Type` and `Transform ID`)
- Encode currently defined `Encryption` transforms having `Key Length` attribute using two octets
- Leave possibility to encode arbitrary (even not yet defined) `Transform Type` and `Transform ID`, as with regular format

Example: SA Payload with one Proposal and four Transforms:

- `ENCR_AES_CBC` (128 bits)
- `PRF_HMAC_SHA2_256`
- `AUTH_HMAC_SHA2_256_128`
- `2048-bit MODP Group`

Header | Proposal

Original: **48** bytes

```
22 00 00 30 00 00 00 2c 01 01 00 04 03 00 00 0c
01 00 00 0c 80 0e 00 80 03 00 00 08 02 00 00 05
03 00 00 08 03 00 00 0c 00 00 00 08 04 00 00 0e
```

Four transforms (with one attribute)

Compact SA Payload Header | Compact Proposal | Four compact transforms

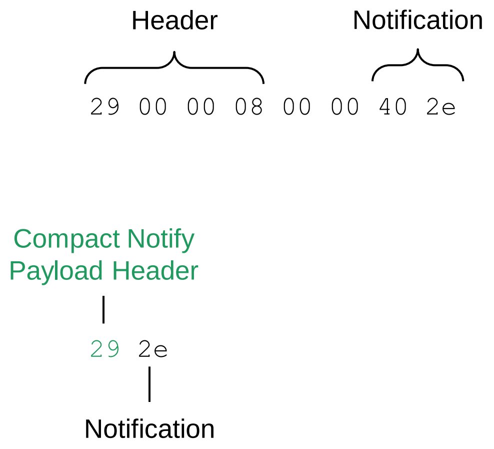
```
22 01 01 01 00 04 4c 20 e5 cc 8e
```

Compact: **11** bytes

Notify Payload

Outline: encode notification in one octet (limited to first 256 status notifications) and omit all other fields from Notify Payload

Example: Notify Payload with `IKEV2_FRAGMENTATION_SUPPORTED` notification.



```
29 00 00 08 00 00 40 2e
```

Original: **8** bytes

```
29 2e
```

Compact: **2** bytes

Negotiation

If new format is used from the very beginning then the following options exist:

- New major IKE version (v3)
  - old responders would return `INVALID_MAJOR_VERSION`
- New type of initial exchange (e.g. `ALT_IKE_SA_INIT`)
  - old responders would return `INVALID_SYNTAX`
- New critical payload in the `IKE_SA_INIT`, followed by payloads in new format
  - old responders would return `UNSUPPORTED_CRITICAL_PAYLOAD`

Discussion

- We don’t need to assign new payload types except for special format payloads (SA and empty status Notify), do we? What about revised payloads?
- Transport issues for transferring large payloads are out of scope
  - IKE over TCP combined with IKE fragmentation (to solve limitation on 64 Kbytes on a single IKE message over TCP)
  - mixed mode (draft-tjhai-ikev2-beyond-64k-limit: IKE over TCP combined with plain ESP or ESP over UDP) can be used to avoid ESP performance degradation of TCP encapsulation
- Certificates consume a lot of space, can be compressed
  - RFC 8879 is an example of certificate compression

Thanks again!