Supporting Future Internet Services with Extensible In-band Processing (EIP)

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Extensible In-band Processing (EIP) - What is?

A generic and extensible mechanisms to carry information in IPv6 packets headers.

IPv6 end systems and network nodes can read and write this "extensible" EIP information. Nodes can take packet processing decisions depending on the EIP information.

EIP can support many use cases that need custom data plane processing features.

https://datatracker.ietf.org/doc/draft-eip-arch/
EIP can support several use cases

- Advanced Monitoring
- Semantic routing
- Deterministic Networking
- Slicing

IPv6 Header | Payload

This list of use cases is not exhaustive…
Carrying EIP information in IPv6… Where?

See: https://eip-home.github.io/eip-headers/draft-eip-headers-definitions.html
Extensible In-band Processing (EIP) - Why?

IPv6 header is already "extensible" by definition, with "Extension Headers" and "Options" inside the Extension Headers.

Anyway, there are practical barriers in this extension process:
- (1) standardization hurdles
- (2) implementation/experimentation

(1) EIP reduces the “pressure” on the standardization
(2) Open Source prototypes of EIP support the experimentation
Standardization pressure on HbH Options

Some Hop-by-Hop Option code points have been already allocated.

There are several further ongoing proposals and discussions to allocate Hop-by-hop Options for different use cases.

- In-situ Operations, Administration, and Maintenance (already allocated)
- Minimum Path MTU
- Alternate marking
- Path Tracing
- Application-aware networking
- Path signals for transport protocols
- Virtual Transport Network (VTN) Identifier
- Topology Identifier
- Generic Identifier

Details are provided in [https://datatracker.ietf.org/doc/draft-eip-arch/](https://datatracker.ietf.org/doc/draft-eip-arch/)
Benefits of a common EIP header

The EIP header carries different **EIP Information Elements** to support the different use cases.

It is useful to define a common EIP header for multiple use cases!

- the number of available Option Types in HBH header is limited (the same for TLVs in the SRH)
- common EIP Information Elements can be re-used across use cases
The specific content of the EIP “Information Elements” will be defined considering the requirements of the different use cases.

Some requirements are common to different use cases e.g. time stamping, authentication (HMAC) => a "library" of common protocol components can be defined

The EIP IEs can be coded with up to 24 bits => \(2^{24} = 16.7 \text{ M}\) (compare with 8 bits for HbH Options)
EIP does not need to work end-to-end across Internet

EIP targets "limited domains" (a.k.a. "controlled domains")
Definition of the EIP header and IEs

The EIP header can be carried as an “Option” in the IPv6 Hop-by-Hop Extension Header, or as a TLV in SRH.

The EIP header carries a set of EIP Information Elements a.k.a. EIP “LTV”s (Length-Type-Value)

https://eip-home.github.io/eip-headers/draft-eip-headers-definitions.html
We focused on a specific scenario of Semantic Routing, i.e. we considered the use of the geographical positions ("Geotagging").

We have defined a **Geotagging** Information Element for EIP, that can carry the geographical coordinates of the destination node or of the source node.

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<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
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<td>0</td>
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<td>2</td>
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<tr>
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<td>5</td>
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<td>7</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
<td>0</td>
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</tr>
</tbody>
</table>

https://eip-home.github.io/eip-headers/draft-eip-headers-definitions.html
We support 2 encodings of the coordinates (Quantized and Geohash) with 2 precisions each (64 / 32 bits), corresponding to 4 formats:

<table>
<thead>
<tr>
<th>Format</th>
<th>Encoding</th>
<th>Precision (error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Quantized Long: Lat. 32 bits, Lon. 32 bits</td>
<td>Lat. ± 2.3 mm, Lon. ± 4.6 mm (max)</td>
</tr>
<tr>
<td>1</td>
<td>Quantized Short: Lat. 16 bits, Lon. 16 bits</td>
<td>Lat. ± 153 m, Lon. ± 305 m (max)</td>
</tr>
<tr>
<td>2</td>
<td>Geohash Long 60 bits (padded to 64 bits)</td>
<td>Lat. ± 18 mm, Lon. ± 9 mm (max)</td>
</tr>
<tr>
<td>3</td>
<td>Geohash Short 30 bits (padded to 32 bits)</td>
<td>Lat. ± 600 m, Lon. ± 300 m (max)</td>
</tr>
</tbody>
</table>
We have an open source prototype for EIP in Linux.

Two main components:

1) Scapy based packet generator / dissector
2) EIP aware router

The EIP aware router is based on eBPF/XDP, hence it is very efficient.

We are considering the use cases:
- Semantic Routing (Geotagging)
- Advanced Monitoring (in-band end-to-end delay monitoring, path tracing)
The basic EIP prototype is a docker container which includes:

- the development environment for EIP
- a testbed with 4 “namespaces” that implement EIP Packet generator/dissector and EIP aware router
EIP - Interest Group

We've set up an informal Interest Group on Extensible In-band Processing

[Image of EIP diagram]

https://eip-home.github.io/eip/

Mailing list
eip@cnit.it

Join the mailing list
https://tiny.one/join-eip
Take home messages

We think that the evolution of Internet Routing and Addressing requires protocol extensions in the networking layer.

EIP is a generic framework that supports the evolution of IPv6 in a "scalable" and "ordered" way.

An open source prototype of EIP is available - “running code”!

Join us at https://eip-home.github.io/eip/
Thank you for your attention!

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S. Salsano, H. ElBakoury, D. Lopez,
“Extensible In-band Processing (EIP) Architecture and Framework”,
https://datatracker.ietf.org/doc/draft-eip-arch/

S. Salsano, G. Sidoretti, C. Scarpitta, H. ElBakoury,
“Extensible In-band Processing (EIP) Headers Definitions”
https://eip-home.github.io/eip-headers/draft-eip-headers-definitions.html

S. Salsano, H. ElBakoury, D. Lopez,
“Extensible In-band Processing (EIP) Use Cases”,
https://eip-home.github.io/use-cases/draft-eip-use-cases.txt
As for security... we added (optional) authentication in the EIP header (i.e. HMAC as done for SRH in SRv6)

In general, our security concerns are aligned with those of SRv6 Network Programming model.