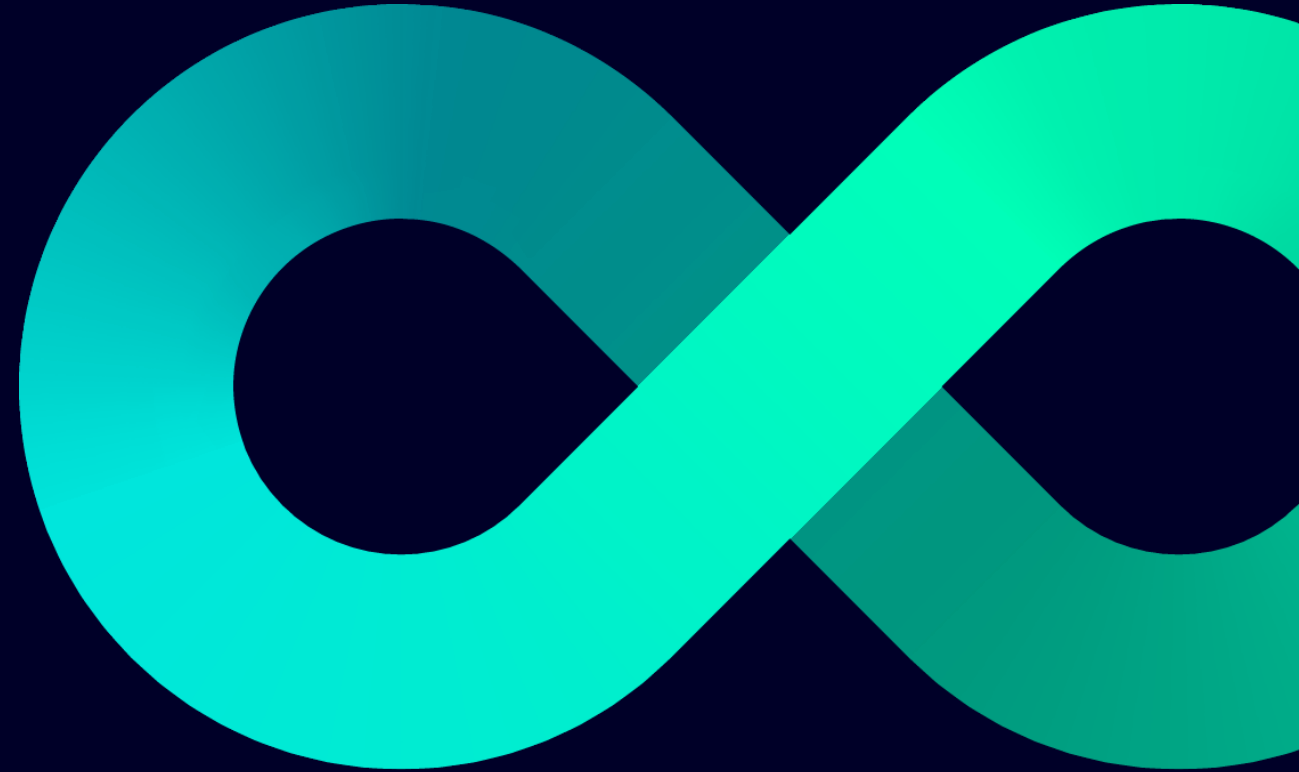


IP measurement options

Enabling passive network measurements with minimal additional data and efforts.



Enabling passive network measurements in interlocking systems

Measurement of Quality of Service without introducing additional measurement traffic as DS microflows

Quality of Service:

- SHALL be measurable without access to the network equipment
(use end-hosts only, no additional measurement equipment or data streams)
- SHALL be capable of measuring packet delay and loss
(needs data from both sending and receiving host)
- SHALL be independent of data-link layer choice
- SHALL deliver uniform measurement results for various transport layer protocols
(e.g., UDP, TCP, etc., → **measure IP packet properties**)
- SHALL not form a threat for hard real time protocols used in SIL-4 systems

Our conclusion / Solution direction:

Extend IP protocol with measurement data → Use an IP option

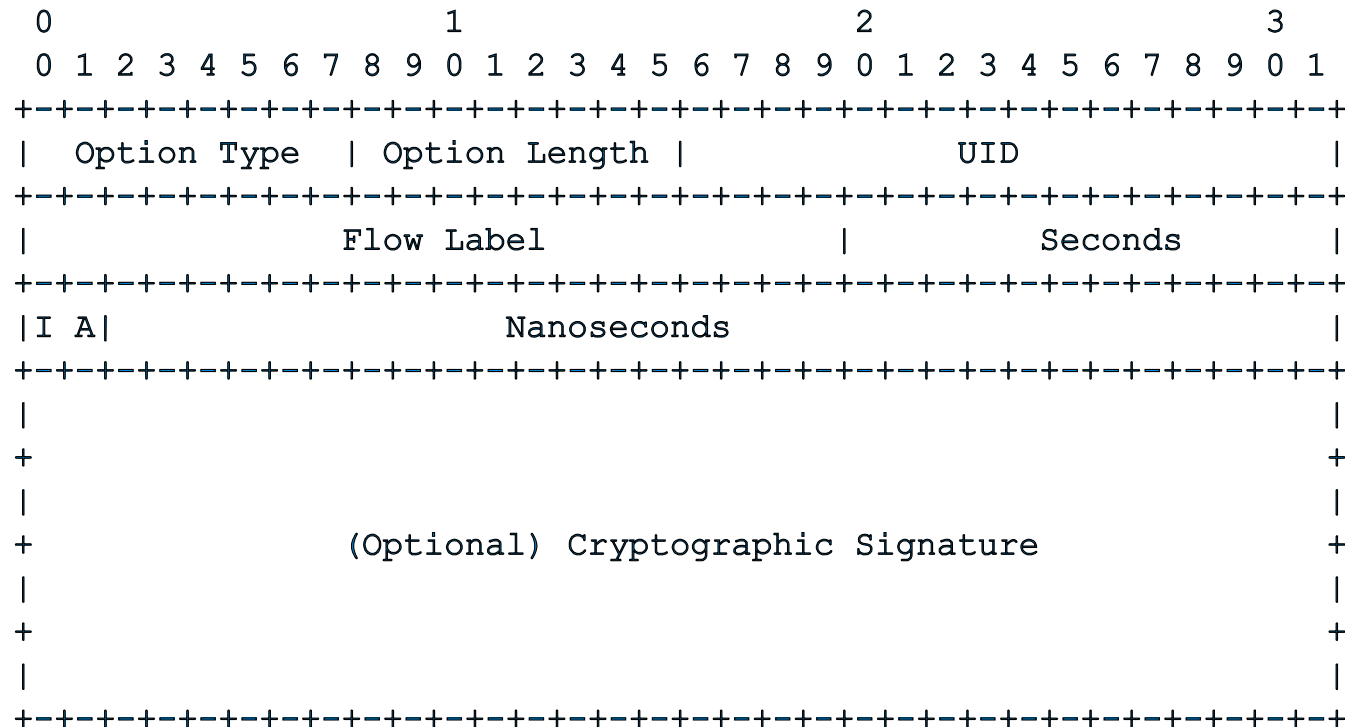
Define an IP measurement option suitable for delay and loss measurements

Information needed:

- Send and receive time of the IP packet, include send time in IP option (network delay = receive time – send time)
- Sequential packet number of sender, include packet count (UID) in IP option (loss = missed packet numbers after timeout)

Proposed IPv4 option:

- Flow label: helps identify flows (see IPv6, RFC 8200)
- I(nclude in measurement)
- A(lternate marker)
- Cryptographic Signature: helps to ensure validity of data.



Usage of the IP(v4) measurement option

Sender and Receiver are **active**:

- Sender MAY insert the IP measurement option (MO)
(SHALL if measurements are needed of course)
- Receiver MAY process the IP MO and perform measurements
(SHALL if measurements are needed of course)

Hosts en-route are **passive**:

- MAY read the IP MO, and SHALL NOT change the IP MO
- Behaviour is different than for most IPv4 options, where reading and processing MUST be performed (RFC 791).

RFC 1122 defines (Section 3.2.1.8) what to do with unknown IPv4 options:

“The IP and Transport layer MUST each interpret those IP options that they understand and silently ignore the others.”

- **Ignoring IP options by hosts en-route is allowed**
(dropping packets with IP options SHALL NOT be done according to the RFCs)
- Sending IP options from end-host to end-host without effort in routers is possible.

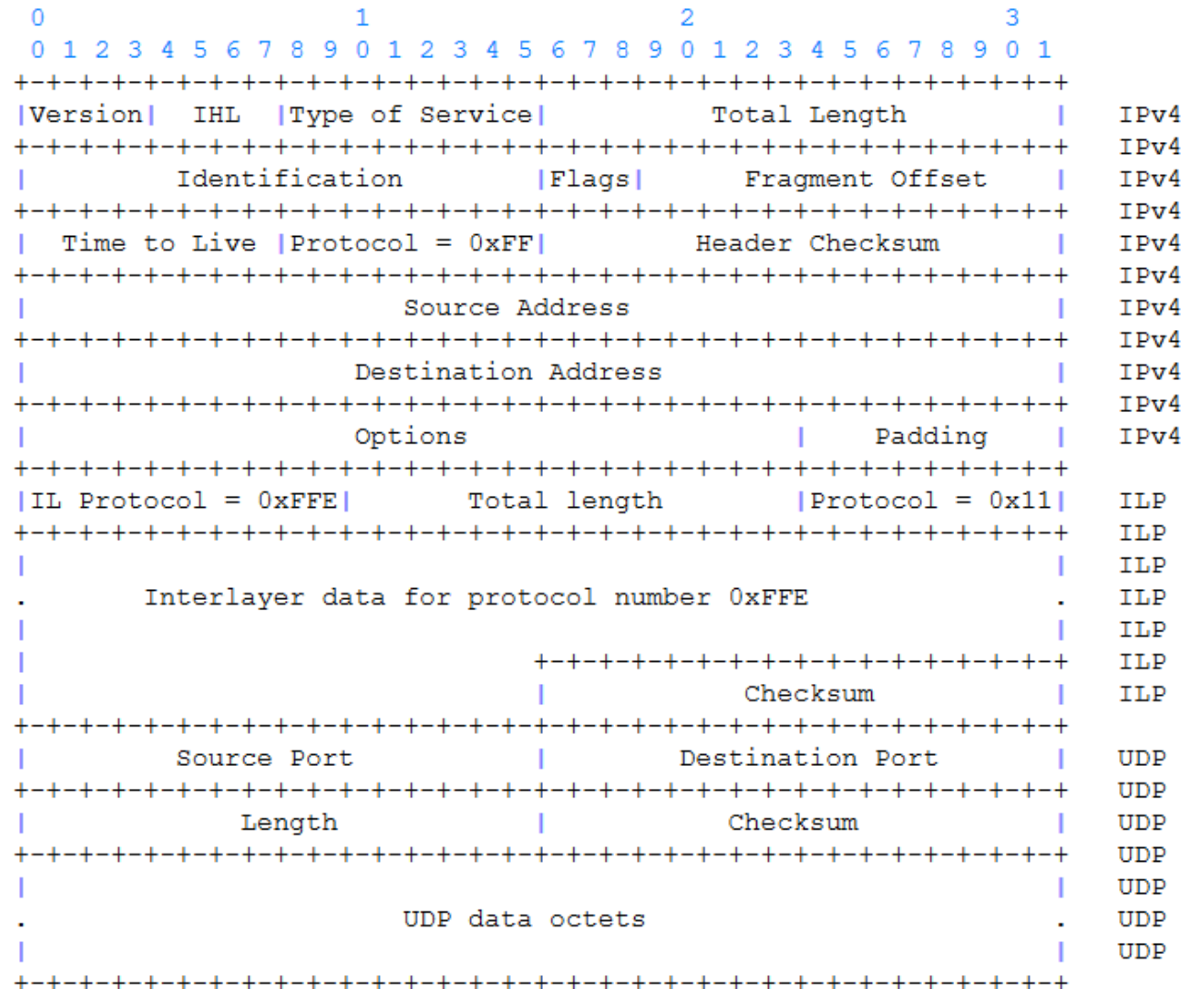
Inter-layer protocol creates more space for IPv4 options

It is dirty and does not observe rules regarding protocol layers

- hook in from IP Protocol field (protocol = inter-layer protocol)
- repeat IP Protocol as next protocol (protocol = inter-layer protocol)
- hook out when IP Protocol is something else (protocol ≠ inter-layer protocol)
- continue with normal protocol stack.

Advantage:

- It can take part of the user-data and use it for arbitrary things other than a transport layer protocol. E.g., to **have larger IP options**.
- Extends the number of types of information beyond the 255 IP option types.



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