

Deossify

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Acknowledgements

My thanks to lots of people (including some in this room) for discussions and pointers to clue over many years.

None of what I will say is novel.

This is just a reminder that

**we can be disruptive, in a good way,
with our research in networking protocols!**

Treat this all as “something to disagree with” ... 😊

ossify

ossify *verb*

If habits or ideas ossify, or if something ossifies them, they become **fixed and unable to change**

<https://dictionary.cambridge.org/dictionary/english/ossify>

Ossification in networking research

Intellectual ossification—The pressure for compatibility with the current Internet risks **stifling innovative intellectual thinking**.

Infrastructure ossification—The **ability of researchers to affect what is deployed** in the core infrastructure (which is operated mainly by businesses) **is extremely limited**.

System ossification—**Limitations in the current architecture** have led to shoe-horn solutions that increase the fragility of the system.

Looking Over the Fence at Networks: A Neighbor's View of Networking Research.

National Academies of Sciences, Engineering, and Medicine. **2001**. Washington, DC: The National Academies Press. <https://doi.org/10.17226/3688>

Just accept it – that's life 😞

*Please, please, please **do not break anything!***

*... **Ossification is still a major issue in today's networking environment**, and while it's not something we see in the architecture of the transmission platform, **we see it in the Internet Protocol (IP) itself, in transport protocols, in routing protocols, and in various applications.** ...*

*... However, the scale and complexity of large deployments, with multiple vendors, service operators, diverse users, and **varied use cases, demand a far more restrictive operational framework.***

*... **I would observe that this situation appears to be the price of success.***

Ossification and the Internet.

Geoff Huston, 25 June 2025

<https://blog.apnic.net/2025/06/25/ossification-and-the-internet/>

Work around it: testbeds 😊, overlays 😊 | 😐, datacentres 😊 | 😐

*Finding ourselves in a more research-friendly environment (as I believe we now are) does not mean the concern about ossification was unwarranted or our approaches to overcoming it were wasted. **Research initiatives like PlanetLab and SDN helped pave the way for the opportunities we have today.***

Internet Research: What Happened to Ossification?

Larry Peterson, 10 March 2025

<https://systemsapproach.org/2025/03/10/internet-research-what-happened-to-ossification/>

Middleboxes & Firewalls ☹️ | 😐

The goal of the workshop was to produce architectural and engineering guidance on future work to break the logjam, focusing on incrementally deployable approaches with clear incentives to deployment both on the endpoints (in new transport layers and applications) as well as on middleboxes (run by network operators).

Middleboxes are commonplace in the Internet and constrain the ability to deploy new protocols and protocol extensions. Engineering around this problem requires a "bestiary" of middleboxes ...

Report from the IAB Workshop on Stack Evolution in a Middlebox Internet (SEMI), RFC7663(I), IAB. B. Trammell, Ed.; M. Kuehlewind, Ed. October 2015 (workshop date 26-27 January 2015)

<https://www.rfc-editor.org/rfc/rfc7663.html>

<https://datatracker.ietf.org/group/semiws/materials/>

Just build it! 😊

We argue that end systems should try to use the protocols they want, to be able to benefit from paths that do support them, and efficiently fall back to a compromise behavior only in case a path does not support the desired protocol(s).

Ossification: a result of not even trying?

Michael Welzl, Gorrry Fairhurst, David Ros. IAB Workshop on Stack Evolution in a Middlebox Internet, 26-27 January 2015. (PDF document, 30 October 2014)

<https://datatracker.ietf.org/doc/slides-semiws-ossification-a-result-of-not-even-trying/>

See also RFC9621(PS), RFC9622(PS), RFC9623(I) from January 2025.

Multiplicity and Simplicity 😊

In practice, there are at least two reasons why **more than one network layer protocol might be in use on the public Internet.** Firstly, there can be a need for gradual transition from one version of IP to another. **Secondly, fundamentally new requirements might lead to a fundamentally new protocol.**

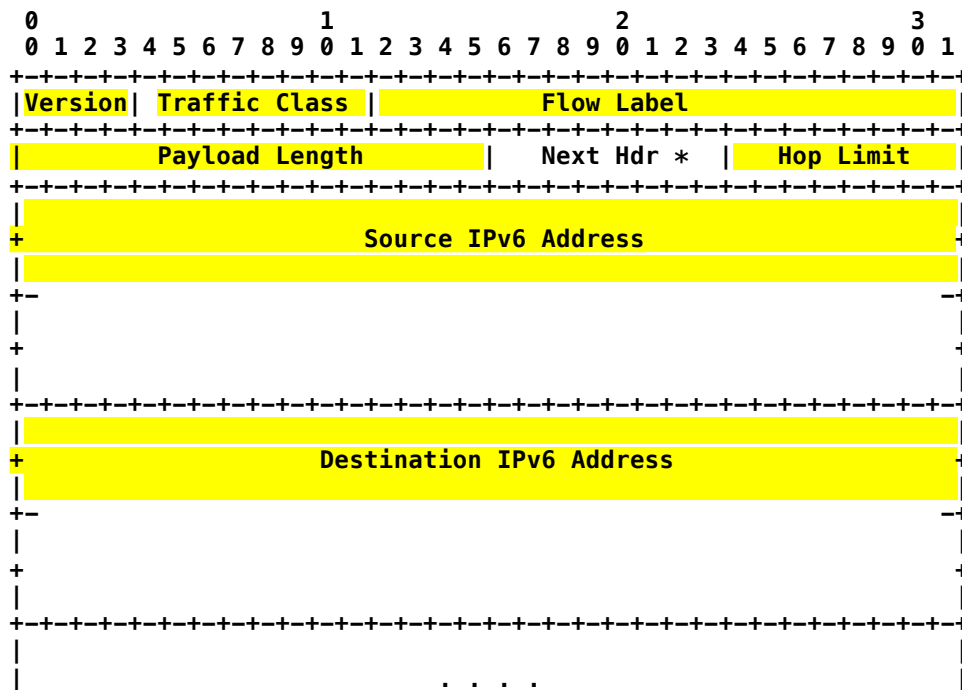
Architectural Principles of the Internet, RFC1958(I), IAB. B. Carpenter, Ed. June 1996.
<https://www.rfc-editor.org/rfc/rfc1958.html>

... complexity is the primary mechanism which impedes efficient scaling, and as a result is the primary driver of increases in both capital expenditures (CAPEX) and operational expenditures (OPEX). The implication for carrier IP networks then, is that **to be successful we must drive our architectures and designs toward the simplest possible solutions.**

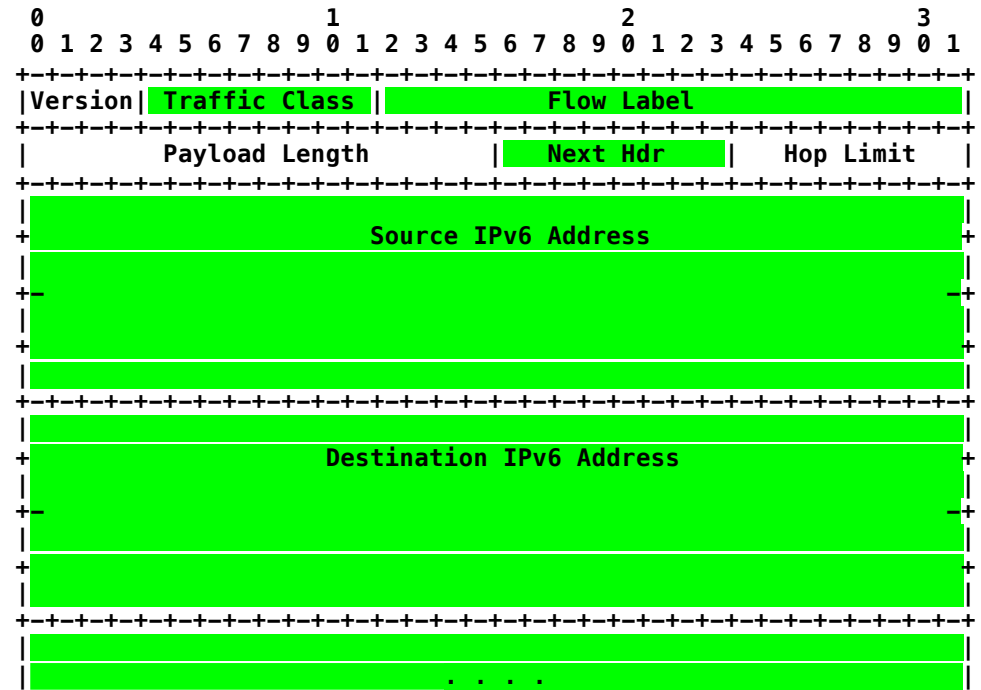
Some Internet Architectural Guidelines and Philosophy, RFC3439(I). R. Bush, D. Meyer. December 2002.
<https://www.rfc-editor.org/rfc/rfc3439>

IP still works end-to-end – it is your friend 😊

Used by **routers** – handle with care!



Can (re-)define or adapt for **end-to-end**.



* Packets with Hop-by-Hop Extension Headers mostly ignored / dropped by Internet routers, but see RFC7872(I), RFC9098(I), RFC9288(I), RFC9673(PS), and: Is it possible to extend IPv6? A. Custura, R. Secchi, E. Boswell, G. Fairhurst. Computer Communications, Vol. 214, 15 January 2024, pp 90-99. <https://doi.org/10.1016/j.comcom.2023.10.006>

Exploit the flexibility of end-to-end design.

Use IPv6: flexible, **end-to-end** control (e.g. Destination Option Extension Headers).

Ignore middleboxes: defer until deployment is required.

Set up your own testbed: so you can **break** / configure / control / measure / the network on an **end-to-end** basis (even if it is a small, desktop network).

Keep things simple.

Do build your own **end-to-end network and transport protocols. 😊**

End-to-end arguments in system design.

J. H. Saltzer, D. P. Reed, and D. D. Clark. 1984. ACM Transactions on Computer Systems 2, 4 (November 1984), 277–288.

<https://doi.org/10.1145/357401.357402>

Intellectual deossification

&

System deossification



Infrastructure deossification

Research

Deployment

**Build stuff.
Break things.
Deossify.**



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