**Clark's Paradox**

In "Tussle in Cyberspace," David Clark advocates a redesigned Internet that would greatly expand consumer choice. "The Internet should support a mechanism for choice of source routing that would permit a customer to control the path of his packets at the level of providers."[[1]](#endnote--1)

Such a move would allow customers to make decisions throughout their digital supply chain much in the same way that consumers are beginning to demand similar visibility and control to the supply chains that provide them with physical goods and services. It would enable consumers to dictate network path based on economic criteria (e.g., providers with the least network congestion or highest data rate), political choices (e.g., routes or providers that circumvent free-speech restrictions), or even environmental bases (e.g., providers that use the energy-efficient 802.11az standard or green data center practices such as ambient-air cooling).

To facilitate such flexibility—without altering the current TCP/IP stack or violating the End-to-End principle—one can use source routing. Source routing uses the Options field in the IP header to list a pre-specified set of gateways comprising a desired network path. Strict source routing (SSR) lists the entire set of gateways, from end node to end node.[[2]](#endnote-0) This has some disadvantages: it undermines flexibility by overriding most other protocols, and it requires a detailed understanding of the network topology between those two endpoints. Loose source record routing (LSRR) undermines security. It does nothing to prevent source address spoofing, and it may allow packets to travel over private or protected networks if the source route specifies them. Such drawbacks drive network operators away from supporting source-routed packets.

Without a feasible source routing method, network operators would have to fall back on another means of providing customer choice: performing deep packet inspection on all traffic and routing according to parameters set and stored above the network layer. Deep packet inspection, the examination of IP payloads (and thus TCP segments and payloads) of packets in transit, offers capabilities that help solve problems in today’s Internet: intelligent routing, traffic shaping (deliberate control of traffic flows) and even payload alteration (modifying content for security reasons or other) based on TCP ports, higher-protocol headers, or application content.

Paradoxically, this would violate another of Clark's arguments, the end-to-end principle, defined in "End-To-End Arguments In System Design," which states that “low-level network functions are justified only as performance enhancements.”[[3]](#endnote-1) Furthermore, widespread use might embolden ISPs to use it regularly, and for less noble aims, such as quality-of-service manipulation based on customer or traffic type (e.g., Comcast's recent handling of BitTorrent traffic), privacy violations such as warrantless wiretapping, and more.

Did Clark anticipate such a paradox? Perhaps not, but as the goals of the Internet veered away from the original goals, he certainly acknowledged the potential necessity for design changes. In his retrospective on the design of the DARPA Internet protocols, he notes: “While the datagram has served very well in solving the most important goals of the Internet, it has not served so well when we attempt to address some of the goals which were further down the priority list [such as resource management and accounting]…This suggests that there may be a better building block than the datagram for the next generation of architecture. The general characteristic of this building block is that it would identify a sequence of packets traveling from the source to the destination, without assuming any particular type of service with that service. I have used the word ‘flow’ to characterize this building block.”[[4]](#endnote-2) Perhaps just as the stateless datagram might lose its primacy in the Internet Protocol, so too might the concept of a fully encapsulated architecture. Alternatively, however, it is entirely possible—especially in light of the market pressures against it—that consumer choice of source routing may never be realized fully.

1. Clark, D. D. (2002). Tussle in Cyberspace: Defining Tomorrow's Internet. *SIGCOMM’02.* Pittsburgh: ACM. [↑](#endnote-ref--1)
2. Information Sciences Institute, University of Southern California. (1981, September). *RFC 791.* Retrieved from http://www.ietf.org/rfc/rfc0791.txt [↑](#endnote-ref-0)
3. Saltzer, J. R. (1981). End-to-End Arguments in System Design. *2nd International Conference on Distributed Systems*, (pp. 509-512). Paris. [↑](#endnote-ref-1)
4. Clark, D. D. (1988). Design Philosophy of the DARPA Internet Protocols. *ACM*. [↑](#endnote-ref-2)