

Gateways: Historical Underpinnings of a Single Internet

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Abstract

Before the coherent internetworking protocol that enables the Internet today, machines called gateways 'translated' between dissimilar networks, at first in the early 1970s with great difficulty, and, by the early 1980s, comparatively seamlessly. This paper investigates some of the historical processes that drew multiple, formerly incompatible networks into a single logical network. Studying these processes can illustrate the Internet's historical contingency -- and the labor that was required to overcome the social and technical differences governing the multiple, independent networks that came to, and now comprise, the Internet.

Keywords: gateway, networks, internetworking, Internet, TCP/IP, protocol

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1 Introduction

In scholarly and popular writing it has become linguistically and conceptually useful to think of the Internet as a single network. We acknowledge that access to the Internet is uneven and access *quality* may vary, just as different cultural and discursive networks may *interface* with it in different ways. Certainly, literature discusses how access to, and impact by, the internet is mediated by a wide range of social forces (Sassen, 2006; Chun, 2008). When Manuel Castells writes of our contemporary network society as composed of multiple networks that vary widely in terms of power and control of the connection between them, he is referring to cultural and discursive formations (2009). However, we nonetheless conceptualize the Internet itself as a single entity. This conceptualization, while convenient, obscures the important historical processes that drew multiple, incompatible networks into a network of networks that function as a single logical network (in short, an internetwork, or, internet). The study of these processes can begin to illustrate the Internet's historical contingency -- and the work that was required to overcome the social and technical differences governing the multiple, independent networks that came to, and now comprise, the Internet.

This note describes a research area on the historical study of the technologies and techniques that were employed to create the internetwork that enables the Internet to function effectively -- and thus be conceptualized -- as a single entity. Specifically, we look to the broad history of gateways, machines that 'translated' between dissimilar networks, at first in the early 1970s with great difficulty, and, by the early 1980s, comparatively seamlessly as part of the protocol suite that governs our modern Internet. Gateways are important because they illuminate the difficulties and contingencies by which networks are interconnected. Yet as a liminal infrastructure, gateway technologies have received little recent attention in histories of networks beyond their role in the Transmission Control Protocol (TCP), the open protocol underpinning the Internet first introduced in 1974. Indeed, as we argue here, gateways began as an important predecessor technology to the more renowned TCP/IP protocol suite. Historically, narratives of gateways help us bring to light a neglected area of network and Internet historiography, while analytically they reveal the seamless and equal inter-connection of networks as a built capability, and not a natural state.

Drawing on historical accounts and technical papers, this research sets out to understand the politics and technologies of the network gateway, beginning with their earliest prototypes in the early 1970s and ending with their seamless integration into a global internet in the mid-1990s. Here, we begin our investigation with two early gateways: computer science projects at the University of Hawaii and University College London that connected local networks to the US Advanced Research Projects Agency Network (ARPANET).

2 ARPANET: A Point of Connection

Network gateways began as interfaces between early packet-switched networks. ARPANET was the first, largest, and most well-funded of these. ARPANET came about as a technology sponsored by the Advanced Research Projects Agency (ARPA), and one of the many envisioned during the Cold War as a

defence against US adversaries. ARPANET's planning started in 1967, as the first general purpose network to connect computers over long distances. According to its planners at ARPA, the primary benefit of participating in this experiment was resource sharing: researchers wouldn't need to duplicate software as they could connect to computers at other "centers of excellence" remotely around the United States, saving millions in costs.

At its most basic unit, the network involved a host that a user would interact with, and an Interface Message Processor, or IMP, a repurposed minicomputer that ensured that a host's message travels to a destination host through the best available path of IMPs that lie between them. Leased telephone lines linked the nodes. The entirety of IMPs and links that interconnected them was called the subnetwork, or subnet, comprising the core infrastructure responsible for transporting data between the hosts. One of its engineers' early tasks involved establishing a working subnetwork and routing algorithm, then maintaining and increasing reliability as the ARPANET grew in size and complexity (McQuillan & Walden, 1977).

UCLA became the first node of ARPANET in 1969, soon joined by other computing centers, including the Stanford Research Institute (SRI), University of California Santa Barbara, and the University of Utah, all devoted to devising and improving technologies to make the ARPANET more usable. The firm Bolt Beranek and Newman, contracted to design and build the IMP hardware and software, joined as the fifth node and dedicated much of its resources during the first years towards making the networks' basic functions operational. By March 1972 the network had grown to 25 nodes. As more sites adopted the network, and host-level technologies were developed, users began sending emails and transferring files. In an unforeseen shift, throughout the 1970s it became clear that person-to-person communication, not resource sharing, that became a central function of the network. In spite of these adaptations, the network's broader purpose also advanced a command and control technology swiftly adopted by the US military.

The stories of ARPANET's development both as an increasingly social space and of its relations with military are well-trod (Abbate, 1999; Hafner, 1996; Hauben & Hauben, 1997; Norberg & O'Neill, 2000; Randall, 1997; Ryan, 2013; Segaller, 1998; Waldrop, 2001). Historiography has dealt much less with the early role played by heterogenous networks developing in tandem with ARPANET and the international dialogues around hardware, software, standards and protocols they prompted. Important to these discussions were the changing role of the gateway, custom-built connections between networks using packet-switching computers. By late 1972 gateways assisted people on other much smaller networks in Hawaii via ALOHAnet, and London, through the Rutherford and Appleton Laboratory (RAL), who wanted to access ARPANET.

During that first decade, the gateways were technically and institutionally difficult to create - they were inelegant workarounds that nevertheless got the job done. Therefore as early as 1972 researchers began for more effective and general-purpose ways to inter-connect networks. This need culminated in ARPANET's 1 January 1983 transition from the original Network Control Program -- the protocol with which previous network connection experiments were made to contend -- to the TCP/IP protocol suite on the ARPANET. TCP/IP meant that ARPANET could evolve from a more isolated testbed status into a central civilian component network of the Internet. Networks that formerly spoke through customized gateways could finally all speak the same language, and inter-connection between networks became comparatively seamless. The Internet as such became easily conceptualized as a single, monolithic network. Today, gateways are a ubiquitous, invisible, pervasive infrastructure.

This current state is the result of an historical process, and one we can learn from, particularly if we want to understand the historical development of network infrastructure and its institutional, social, and technical negotiation. In the next section, we describe gateways between ARPANET and two smaller networks operating prior to TCP/IP: the ALOHANET and the Rutherford Appleton Laboratory.

3 Exploring ALOHANET

In 1968 - the same year that BBN began building the basic hardware of the ARPANET - engineers at the University of Hawaii began experimenting with an altogether different technology to create networks for resource sharing across campuses throughout the Hawaiian islands: UHF radio. By 1971 their project, named the Aloha Network, or, ALOHANET, allowed users at terminals throughout the university system to access software from the much larger computer system (called a "host") on the Honolulu campus. ALOHANET was fundamentally different from the ARPANET: it served to connect multiple users to a single host, rather than multiple users across multiple hosts. The network also differed in its medium of transmission: rather than transmitting data across leased telephone lines, as was the case with the ARPANET, ALOHANET terminals all shared a single UHF frequency. When packets of data were unintentionally transmitted at the same time by more than one node, they became corrupted and went

unreceived by the intended recipient. To remedy these conflicts, the sending node would simply wait for a period and re-transmit. Notably, this method was highly successful and survives today in geostationary satellite and cellular phone technologies (Schwartz & Abramson, 2009).

The University of Hawaii's ALOHANET experiment was, like the ARPANET, ARPA-funded. Norm Abramson, who led the project, became interested in connecting the ALOHANET, with its single node, to the ARPANET's several, and so expanding its users' potential resources (Binder, Abramson, Kuo, Okinaka, & Wax, 1975). This process of connecting the heterogeneous networks had both technical and social dimensions: socially, at the very least, it involved convincing Lawrence Roberts, the Program Manager responsible for the ARPANET, to extend the network to Hawaii. In Abramson's account, this task was accomplished when Abramson traveled to Larry Robert's office and, while Roberts stepped out of the room, drew Hawaii onto a chalkboard listing future ARPANET node installs. By the time Abramson received a call in preparation of an ARPANET IMP install in Hawaii several months later, Abramson forgot he had added himself to the list of ARPANET nodes (Pelky, 2007).

On the technical side, interconnecting ALOHANET with ARPANET meant turning the Menehune into an extended ARPANET host, while it continued to function as the host machine through which the ALOHANET terminals connected (Binder et al., 1975). The design decisions of this gateway remain unclear, and are the subject of ongoing research, but it appears that it allowed ALOHANET users access to the ARPANET, yet not the reverse. Also unclear is how the gateway was put to use -- specifically how ALOHANET users then may have (or have not) taken advantage of the ARPANET's resources. Nonetheless, once established in December 1972, the ALOHANET IMP formed the first gateway between the ARPANET and another computer network. Such a gateway remains significant for demonstrating that connection of heterogeneous networks was possible.

4 The Rutherford Appleton Laboratory

Parallel to the US efforts, the UK's National Physics Laboratory (NPL), within the Department of Technology, began an experimental network in 1968 that went operational as a local area network two years later. According to Kirstein (2009), the network's designers both realized the future importance of online data processing as well as the need to compete with the US in terms of computers and software. Once running, members of the ARPANET community expressed interest in connecting to the NPL network - but, like ALOHANET, the node required both political and technical support for its achievement, and was undertaken amidst some controversy. The UK government was attempting to join the European Economic Community at this time, and distancing its public institutions from the US made political sense (Kirstein, 1999). So, in 1973 a new London node joined the ARPANET based rather at the privately run Rutherford and Appleton Laboratory (RAL), a computer that connected to the University College of London academic network. As a gateway to ARPANET, the connection created the first international computer network.

Technically the project came about when RAL proposed converting their IBM 360/195 - then the largest computer at the UK - into a host that could connect to ARPANET remotely through satellite. ARPANET would need to ship over a TIP to complete the process. At this point, the project received needed financial support by the British Post Office and NPL and was able to move ahead, despite a snag when the UK Treasury briefly impounded the TIP for import duty and heavy VAT fines upon its arrival to the UK shores (Kirstein, 1999). The Treasury ultimately allowed the project to continue free of the prohibitive duty charge. As a result of this concession, any user of NPL's network could soon access the entire US ARPANET research community.

This connection also contributed to the ongoing dialogue around networking between the US the international community. Due to the transactions of the London node, for instance, the UK joined the SATNET - Atlantic Packet Satellite Network - project. SATNET required the US, which had no domestic satellites of its own, to partner with the UK, Germany, Norway, and Italy, all countries with earth stations. Through key, international multiple network experiments, such as a well-cited 1977 test that successfully inter-networked PRNET, SATNET, and ARPANET, the networking community went further in developing a fundamental protocol linking these heterogeneous networks together (Abbate, 1999; Kirstein, 2009).

5 Conclusion: Towards a History of Networked Gateways

These early gateways remind us that inter-networking, the attribute that gives the Internet its name, has its origins in experiments that were both bureaucratically and technically challenging. A question for scholars of the development of the Internet remains: how did the inter-connection of networks develop from socially and technically difficult hacks, to the comparatively seamless phenomena which is rendered invisible enough to be taken for granted?

Here we should establish a distinction between connection versus internetworking of heterogeneous networks, to which we return below. A connection between networks, such as the first host gateway between ALOHANET and ARPANET, does not link the networks on an equal footing. Modifications were made to the ALOHANET so that its users could access the ARPANET, but not the other way around. The gateway did not create a multi-network-wide addressing or routing system to send information over and between both networks; instead, it was a matter of one computer that would connect an ALOHANET user to the ARPANET on the latter network's terms. TCP/IP, then, addressed this asymmetry by providing a single addressing and routing system that could be utilized by heterogeneous networks.

Our contemporary Internet architecture, known as the Transmission Control Protocol/Internet Protocol (TCP/IP) suite or stack, is a layered (modular) series of components that work together to provide Internet connectivity. However, the history of TCP/IP alone does not suffice to account for the emergence of internetworking. After all, TCP/IP was one of a number of efforts to develop internetworking, with the the 1972 formation of the International Network Working Group (INWG) a major milestone in this history (McKenzie, 2011; Russell, 2014). What is more, the TCP/IP stack that governs the Internet is more than this single specification, as many other protocols are utilized. By focusing on the technologies that are specifically implicated in internetworking -- such as the Internet Protocol and the gateways it utilizes -- we can link this core feature of TCP/IP to the broader histories of early internetworking and network interconnection. Efforts to move from a singular history of the Internet to a more encompassing history of networking is already underway (Russell, 2012; Haigh, Russell, & Dutton, 2015). Focusing on gateways is a means to integrate connection and internetworking of networks into a single history of network integration. Our effort draws on this historiographical insight to better understand the work necessary to make not just computer networks, but the Internet (and internets) happen.

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