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Beyond the Americentric Narrative: Examining International Contributions to the Development of the Internet

Abstract

The internet is often portrayed as an invention of the United States of America, having grown solely from ARPANET, with little recognition given to the contributions made by other countries and regions. This paper challenges the Americentric narrative of the internet's evolution, highlighting the other early network developments made by international (non-U.S.) actors. Through critical analysis of primary and secondary sources, such as media representations and historical documentation, a detailed history of computer networks and gaps in the current historical accounts can be reconstructed. This paper explores the array of other networks developed in parallel to ARPANET, the unique innovations each of these networks made, and the complex intertwined nature of international collaboration. While the United States certainly played a significant role in the internet's creation, the dominant Americentric narrative not only erases the valuable contributions of other countries and regions but has potentially dire consequences for continued international collaboration and innovation because it furthers American exceptionalism, thus impacting foreign policy and relations. The history of the internet has been accurately chronicled many times, defined by containing correct information, but many of these are missing critical international contributions. The many historical accounts that represent the internet as having evolved exclusively from ARPANET are deeply flawed, as the

internet is a result of close global collaboration. Many of the current historical representations of the development of the internet, however, ignore the international participation in the development of the internet, leading to a sense of entitlement to the internet by U.S. based organizations as well as creating obstacles for further collaboration. By challenging the existing dominant narrative, this paper provides a more complete and inclusive historical account of the development of the internet.

Introduction

"The Internet is really the work of a thousand people and of all the stories about what different people have done, all the pieces fit together." Paul Baran, one of the seminal innovators on networking, in an interview with the New York Times explains how all the different stories fit together to create a complete picture (Hafner). Unfortunately, some of those pieces have been obscured and all but lost, making it much harder to get that picture, leaving most people with only a partial understanding of the origin of the internet.

The story begins in the 1960s, when the first paper on packet switching theory was published, the first WAN was created, the first hypertext system was designed, and the first computers communicate over ARPANET. By 1969, many of the foundations of the internet had already been laid, although there were only four computers on ARPANET, and it had not even been publicly announced. Three years later, the very first email was introduced along with the first demonstration of ARPANET, putting the spotlight on two researchers who emerged as leaders in this new field: Robert Kahn and Vinton Cerf. Soon after that, the existing networks were expanded, using satellites to connect to places like Hawaii previously separated by the ocean (Goodrich). By the mid-1980s, the Domain Name System was developed, allowing for much simpler navigation of the internet and emails, and the TCP/IP suite was developed. The TCP/IP suite was implemented on ARPANET and soon went on to become the standard for internet communications. By the end of the decade, there were over 100,000 hosts on the internet (Handley). Not long after, in the early 1990s, the World Wide Web was invented, and the first graphical web browser was released. The number of users on the World Wide Web was roughly doubling every year, and soon online shopping and e-commerce began to emerge as a significant part of the internet.

In many ways, this synopsis of the history of the internet is representative of many of the histories of the internet, nearly every development mentioned occurs in the United States until the mention of the World Wide Web, and every researcher mentioned was from the United States. Many of the scholarly articles will go into more detail, and those almost invariably mention Tim Berners-Lee, an English computer scientist who, while working in Switzerland, invented the World Wide Web (Berners-Lee). As a result of the Americentric Narrative, Robert Kahn and Vinton Cerf are often called the "fathers of the internet." While they were certainly very important, Tim Berners-Lee explains the way all their work built off one other as he accepted the Queen Elizabeth Prize for Engineering beside them, "Bob and Vint's work on building the Internet was re-enforced by Louis' work on datagrams and that enabled me to invent the web" ("Queen Elizabeth Prize"). The third name Berners-Lee mentioned, Pouzin, is another international researcher often left out of the mainstream narrative, a French computer scientist who helped to shape our networking protocols.

In fact, when going to a web address to this day, it is common to see something similar to: "https://www.example.com". In such an address, the "https" references a type of hypertext protocol invented by Robert Cailliau, a Belgian computer scientist, with Tim Berners-Lee. In the same address, the "www." refers to the World Wide Web, also invented by Berners-Lee. In fact, the ".com" is something called a "top level domain" which is part of a system, designed by the Canadian mathematician and computer scientist John Leslie King, called the Domain Name System, although he was working in the United States at the time ("Short History of Web"). It is understandable when a one-page synopsis leaves out some information, however, it is not just websites and YouTube videos promising a 'concise history of the internet' that seem to miss the contributions of these critical actors. The documentary "The Internet's Own Boy" written and directed by Brian Knappenberger is often criticized for not giving attention to the international contributions to the internet. The documentary is often considered one of the best films about the development of the internet and, while it does touch on some of the many US-based organizations, such as the Electronic Frontier Foundation, the only international researcher or organization mentioned is, like in so many of the other histories, Tim Berners-Lee.

This paper will begin with a historical overview of computer networks and the internet, followed by a review of the existing literature and analysis of gaps in the current historical accounts. Counterarguments will be explored before evaluating implications for the future of international collaboration and innovation in the digital age. This paper's goal is to address how the Americentric narrative not only erases the hard work and valuable contributions of international actors, but also how this false narrative negatively influences future collaboration and innovation and foreign relations. There are several areas that will be explored in order to achieve this goal, primarily:

1. What were the key international contributions to the development of the internet, and how do they challenge the dominant Americentric narrative?

2. How have media representations of the internet's development perpetuated the Americentric narrative, and what are the consequences of this narrative for international collaboration and innovation?
3. To what extent have counter-narratives and efforts to recognize international contributions to the development of the internet been successful, and what challenges remain?
4. How can a more inclusive understanding of the internet's development support continued international collaboration and innovation in the digital age?

To effectively analyze these topics, it is first necessary to explore an analytical narrative regarding the history of the internet, one synthesized by combining dozens of different sources in order to have a comprehensive account of the most significant developments of the internet regardless of where they occurred. This account will serve not just to identify and include the major contributions made to the development of network technologies from countries other than the U.S. but will also serve as a basis to analyze the way the different incomplete narratives can influence the actions of countries and organizations. Included is a table (see table 1 in Appendix A) of the most important developments separated between ARPANET-related and non-ARPANET contributions for the purpose of making it easier to follow along.

Historical Analysis

It is not enough to simply identify the contributions to the internet made by the U.S. and international actors, it is also necessary to analyze these contributions to ascertain their significances. Understanding how these different constituent elements were combined and evolved into the internet through various early computer networks allows a more thorough appreciation of the history of the internet. Computer networks trace their origins back to the 1930s, when the first concept was imagined by H.G. Wells in the “World Brain” where he wrote “The time is close at hand when any student, in any part of the world, will be able to sit with his projector in his own study at his or her own convenience to examine any book, any document, in an exact replica.”

Shortly after the Second World War, the concept arose once again, by the director of an organization responsible for coordinating scientific research during the war, Vannevar Bush, when he described his idea for the ‘memex’ – an information archival and retrieval machine very similar to that described by Wells. At this time, however, the only computers were prototypes which were used mainly for mathematical calculations during the war, such as the MANIAC 1 computer at the Los Alamos National Laboratory or the Colossus computer at Dollis Hills in London. The Colossus, developed by the British during the war to decipher encrypted messages, is considered to be the first programmable computer. These early computers lacked the ability to talk to one another in a way that would allow the sharing of information required to create something like the memex or the world brain.

The inability to share data would change, however, with the invention of SAGE and, later, SABRE. SAGE (Semi-Automatic Ground Environment) was developed by IBM and the U.S. Air Force created the first digital computers that were networked together to achieve real-time computing. The SAGE network became operational in 1958, and, only 2 years later, the first installation of the SABRE (Semi-Automatic Business Research Environment) network for American Airlines was deployed. The SABRE network was a centralized reservation system, allowing over ten thousand travel agents across the U.S. to book flights and hotels. Soon after its deployment, in 1962, over a dozen other airlines, as well as banks, businesses, and governments across the industrialized world established computer networks.

There were, however, other successful networks before the SAGE network, such as LEO. LEO, or the Lyons Electronic Office, was a network in the U.K. developed even before SAGE in 1954. It was quite successful; however, it lacked the funding of a military project, relegating it to an inventory management, payroll processing, and bakery distribution network that has been all but completely left out of the narrative of the internet's development, despite it being the first network for real-time computerized operations and the first business computer ("Meet LEO").

By the late 1950s, many Universities and research institutions started to explore the world of real-time computing, with the first being developed in MIT and soon thereafter, Carnegie Mellon University, Dartmouth College, and the RAND corporation, among others. J.C.R. Licklider, a member of the SAGE network project, left his position as an MIT professor to become a Vice President for Bolt Beranek and Newman (BBN) in 1957. There, he developed the BBN Time-Sharing System and pioneered what is now called personal computing (Cortada). Five years later, he took a leave from BNN when he was appointed as the Program Director for the newly created Information Processing Techniques office (IPTO) at ARPA. ARPA, or the Research Projects Agency, was a division of the United States Department of Defense and was established in response to Sputnik. As the Program Director of the IPTO, Licklider invested in creating new time-sharing systems for universities that could support over a hundred simultaneous users. Licklider also wrote the paper "Intergalactic Computer Network" where he proposed a worldwide inter-connection between computers that would enable scientists to cooperate by sharing their ideas and even computing resources, which would become seminal (Abbate). Lawrence G Roberts, a Ph.D. student and later a researcher at MIT on computer networks, realized that the ability to connect these ad hoc networks together was the next major step. With the help of Thomas Marrill, Roberts connected a computer in Massachusetts to a computer in California using a dial-up telephone line, creating the first instance of a Wide Area Network (WAN) (Gregersen).

The networks at the time of this experiment used a technology known as “circuit-switching,” where the network would allocate a physical circuit between the two endpoints and the user would maintain exclusive use of that circuit for the duration of the session. This resulted in very high idle time on the circuits and created a network that became more inefficient as it grew. The solution was to reject the then-established paradigm of pre-allocating a circuit for a given connection, and instead break the transmission into smaller sections, send each section across different network paths as they became available and, finally, reassemble the original message at the destination. This turned out to have many improvements over circuit switching, especially in reliability and utilization. There were three researchers all exploring this solution around the same time, and independently of one another: Paul Baran, Leonard Kleinrock, and Donald Davies (Campbell-Kelly and Garcia-Swartz).

Paul Baran, a Polish engineer, then working at the RAND Corporation, was the first to explore what he referred to as “distributed adaptive message block switching” which would break a transmission into smaller pieces which would be forwarded to the destination, with the resources to do so being allocated as needed (Baran). Baran was the first to publish his findings, in Report P-1995 in 1960, and in the next year would go on to present his findings to the U.S. Air Force (briefing b-265). Later, he improved upon his original theories in Report P-2626. Shortly thereafter, Leonard Kleinrock, a graduate student and researcher at MIT, presented his doctoral dissertation where he refers to “message switching.” A few years later, Donald Davies, at the National Physical Laboratory in the UK, found that computer communications experienced intermittent periods of high traffic while most of the time the circuit remained idle. To capitalize on this, Davies created what he called “packet switching” which would only utilize bandwidth while it was transmitting, and otherwise leave the circuit available to other users (Campbell-Kelly, *Data Communications*).

Baran’s publications and presentations went unheeded, as his design placed inexpensive and less reliable nodes throughout the network with the terminating points being more intelligent while the established design philosophies used a strong central connection. AT&T and Bell Labs engineers scoffed at Baran’s idea of non-dedicated circuits and a distributed transmission network. It wasn’t until Donald Davies’ colleague and assistant, Roger Scantlebury presented their paper on packet switching at the Symposium on Operating Systems Principles in October of 1967, that other researchers realized that packet switching was a solution to the issues presented by circuit switching (Shahin). At the same conference, Lawrence Roberts presented his plan for ARPANET, a way to interconnect the different time-share computers funded by ARPA using the existing telephone system. Robert Taylor, the Program Director for IPTO, recruited Lawrence Roberts shortly after he made the connection between the TX-2 computer in Massachusetts and the Q-32 computer in California. Lawrence Roberts became the program manager for ARPANET and, along with his team, developed an initial design for ARPANET. In this initial design, all host computers would connect directly to one another. Roberts tried to convince the directors of the time-share computers that ARPA had funded in the last several years, however, the directors rejected the proposal as they believed that their computers would be slowed down due to the substantial computer resources that would be required to manage network traffic. Wesley Clark, a member of Roberts’ team, suggested using a separate computer to handle the computation requirements for communication so Lawrence Roberts added this to his plan, and, later that year, presented it at the Symposium (Leiner).

At the Symposium, Roberts attended the presentation given by Roger Scantlebury and was inspired by the idea of packet switched networks. Roberts applied the ideas from Davies' team and sought out Paul Baran to consult about the idea of incorporating packet switching into ARPANET. After working closely with Baran and corresponding with Davies, Roberts designed a network that was eerily similar to Donald Davies' design of 3 years prior. When asked about it several years later, Roberts admitted that all packet switching networks built at that time were similar "in nearly all respects" to Davies' original design. Unfortunately, Davies was unable to secure funding and fought with the telecommunication companies for years before he was able to implement a network outside of a model for experimentation. As a result, ARPANET was the first network to implement packet switching, which has since become its greatest legacy (Bay).

ARPANET made its first connection between the University of California Los Angeles (UCLA) and the Stanford Research Institute (SRI) in 1969, and three years later was demonstrated publicly at the 1972 International Computer Communications Conference (ICCC). Between that first connection and first demonstration, three other major networks were created: NPLnet (developed in the United Kingdom as part of the National Physical Laboratory), Cyclades (developed in France as part of the IRIA), and ALOHAnet (a wireless and specialized network developed by the University of Hawaii). ALOHAnet became the first network to connect by satellite to ARPANET in December 1972. NORSAR (Norwegian Seismic Array) became the first non-U.S. node to connect to ARPANET less than a year later and, only a month after that, a connection to ARPANET via NORSAR was made from the University College of

London and the Royal Signals and Radar Establishment, a scientific research establishment in the UK (Shahin).

Another major innovation to happen in the early 1970s was the first systems to utilize the unused option of TV signals to carry information. The earliest systems only carried subtitles, however, soon the BBC (British Broadcasting Corporation) and IBA (Independent Broadcasting Association) started to create what became known as teletext, which could be used to carry channels and programming. The U.K. Post Office Telecommunications then created Prestel, an interactive system, which would allow users to access thousands of pages of information from a remote database with nothing but a television set and a phone line. France created something very similar to Prestel, called Minitel, which was the most successful online service prior to the World Wide Web and in many ways served as a model for the future development of online services even though it did not use any internet protocols or technologies (Mailland).

Although having been invented and existing on time sharing computer systems, email's addition to ARPANET was revolutionary as the messages were able to reach a remarkable number of users across the U.S. and even to parts of Europe. By 1973 email made up well over half of all network traffic and nearly all other networks added their own implementation of email. With email and communications on networks increased, the inability for these networks to connect became a significant constraint in the expansion of the online community, and so "internetworking" became the next major challenge (Leiner). The first major experiment with internetworking was the connection between the Cyclades network and NPLnet with the European Informatics Network (EIN). As Europe and the rest of the world looked to connect the globe, Xerox created the standard for Local Area Networks (LANs) using lessons learned from ALOHAnet and the Cyclades network to create a network that had both random access and more reliable packet switching (Goodrich; Hardy). Xerox also started connecting these different LANs together using its proprietary PUP (PARC Universal Packet) protocol.

These pioneering internetworking experiments would influence the development of the TCP/IP internetworking protocol that was starting to be created by Vinton Cerf and Robert Kahn. In the end of the 1970s, two more disruptive inventions were released: the first widespread 'personal computers' (PCs), and Multi-User Domains (MUDs). The first PCs released to become widespread – the PET 2001, Apple II and TRS-80 – and while they have the ability to be networked, PCs created resistance towards the centralization of computer networks. The first MUD was created by two students from the University of Essex in the UK, allowing several people to play against one another online. MUDs soon caught on, allowing for both gaming and socializing, becoming especially common amongst university students (Maximilian).

Representatives from the U.K. and French computer industry proposed creating a new standards committee under the International Organization for Standardization (ISO) called the Open Standards Interconnect (OSI). With full support from the U.S., several computer and telephone companies, as well as academic researchers, OSI moved forward to create a new global 'network of networks' through an open multi-layered system to promote modularity and interoperability. When asked about the chances of OSI's success, the first chairman of OSI, Charles Bachman, said, "The organizational problem alone is incredible. The technical problem is bigger than any one previously faced in information systems. And the political problems will challenge the most astute statesmen" (Russell, *OSI: The Internet That Wasn't*).

Unfortunately, Bachman would prove prophetic with this comment, and OSI would spend a decade in deliberations among committees where hundreds of engineers and the bureaucratic overhead became overwhelming. The Internet community's bias resulted in the rejection of any of the technological developments and insights that were created by OSI. In an article about OSI and the history of the internet written by Andrew Russell, he describes the famous incident where, “Several leaders, pressed to revise routing and addressing limitations that had not been anticipated when TCP and IP were designed, recommended that the community consider—if not adopt—some technical protocols developed within OSI. The hundreds of Internet engineers in attendance howled in protest and then sacked their leaders for their heresy” (Russell, *OSI: The Internet That Wasn’t*) Ultimately, the internet community did develop a similar system to the one being mentioned here, a connectionless protocol called the User Datagram Protocol, or UDP, using the name of made popular by the French Cyclades network. This was, however, not the first time that international collaboration to create a more connected digital world was attempted. In fact, since the beginning, there has been strong collaboration and attempts to work together.

Deployed only a year after ARPANET, the French Cyclades project, run by Louis Pouzin, was one of the most advanced packet switched networks at the time. Researchers and engineers on both projects collaborated closely, exchanging documentation and mutually visiting one another, however, a direct link between the two networks was never established. Gérard Le Lann, on one of his visits to Stanford described how well the researchers and engineers got along, saying, “…there started an exceptional experience …. We had insane evenings of brainstorming” (Russell and Schafer 891). Le Lann had gone to Stanford to help improve the Network Control Protocol (NCP) so that the several different U.S. networks could be interconnected. Unfortunately, the researchers were not the only people involved in the research projects, which were often backed by the state of the host nation and this fact would often interfere with any potential joint efforts.

Helen Milner argues “that [the internet’s] spread has been driven by neither technological nor economic factors alone. Rather, political factors exert a powerful influence,” and her claims are further substantiated by the people who helped to develop the internet. In later interviews, Le Lann and Pouzin admitted that, while the primitive NCP and expensive infrastructure required were barriers to connecting ARPANET and Cyclades together, the real reason the networks remained separated despite the strong rapport among scientists was due to fear of losing autonomy and that the “connection seemed to me to be politically dangerous” (Russell and Schafer 891). Similarly, despite the U.K. being connected to ARPANET with a node at the University College of London, the nationally funded NPLnet was not connected to ARPANET due to political pressures, despite several attempts to work together. France’s Cyclades and the UK’s NPLnet were, however, connected to one another through the European Informatics Network (EIN) and, while they maintained autonomy, were able to ensure compatibility and universal standards of communication (Russell and Schafer).

If the hurdle of compatible standards was exclusively a technical issue, then Cyclades, NPLnet, and ARPANET would have become connected much earlier, when the International Network Working Group (INWG) was formed at the ICCC in 1972 (the same conference that first demonstrated ARPANET). The INWG was created by Cerf, Pouzin, Scantlebury and their colleagues as a way to exchange ideas and develop a standard protocol for packet-switched networks. After three years of working towards this common goal, a summit in London resulted in a standard protocol being created, called INWG 96, which was approved and nearly every major computer network, including NPLnet, Cyclades, and EIN committed to the adoption and implementation of the new protocol (McKenzie). Despite Cerf’s role in its creation, his colleague

Robert Kahn was able to gain support from DARPA researchers by saying that they were too close to implementing an updated version of INWG 39.

Alexander McKenzie, one of the original members working on ARPANET, a member of first the Network Working Group in the U.S. and later one of the first members of the INWG (and later the chairman), wrote several papers recounting the development of the internet. One of his key insights was that, “the Internet might have exploded into the public consciousness five years earlier if European and U.S. research groups had been cooperating” (McKenzie 70) However, McKenzie also wondered how critical it was for the U.S. internet infrastructure to transition from government-owned to privately-owned, believing that the change marked a turning point in successful collaboration.

The National Science Foundation formed NSFNET, a new network built on the TCP/IP suite allowing it to connect networks together, soon linking supercomputers from Princeton, Pittsburgh, UCLA, University of Illinois at Urbana-Champaign, and Cornell. The new and wildly successful network was given ownership of much of what was once ARPANET, and it took over as the internet backbone. Soon, the first systems started making services available to the new “internet.” Starting with USENET, other services, like Gopher and Viola, start supporting connections across the internet. Soon, the Internet hosted millions of interesting and useful files, however, it was almost inaccessible because traversing the network, even with the aid of directories, was a monumental task (Nenberg). Tim Berners-Lee, working as a contractor at CERN European Particle Physics Laboratory in Geneva, Switzerland, wrote a proposal for a hypertext system in order to help with information loss and the growing complexity of the network being built. Berners-Lee suggests using a linked information system, showing a similar system he had developed before; however, his proposal was rejected (“Invention of WWW”).

After gaining experience in computer networking, Tim Berners-Lee returned to CERN and worked developing communications software. He soon started working on another proposal for a hypertext system to help share information. Berners-Lee met Robert Cailliau who had independently proposed a project to develop a hypertext system at CERN. Cailliau joined Berners-Lee as a partner, and together they were able to rewrite a new proposal, acquire funding, and recruit new team members. Soon, Berners-Lee developed the first web browser and hosted the first webserver. The first project they tackled was the CERN phonebook, recreating using hypertext to be easy and intuitive to navigate and hosting it on the website. Within the organization, the project was immediately accepted and proven as useful, however, Berners-Lee had titled his proposal the “WorldWideWeb,” and had every intent to make that happen (“Invention of WWW”).

Being connected to the internet (then just an ad hoc collection of now-internetworked networks, but not yet centralized and run by ISP and ICANN), Berners-Lee made a post on USENET detailing the steps involved in using the web browser as well as in creating and hosting new websites. He included an invitation to collaborate with the “WorldWideWeb” project, and a “line-mode” browser written by a student from the U.K., Nicola Pellow, which would allow almost any device to connect to the ‘web.’ Tim Berners-Lee soon added a telnet server to the CERN website, making a simple line browser available to anyone with a telnet client (Townes). CERN sent Berners-Lee on a trip where he visited MIT, attended an IETF meeting in Boston, and visited Xerox PARC. After returning, he was able to have CERN provide a certificate that the web technology was public domain. This, paired with his focus on making web technology as accessible as possible and his meetings with many of the influential organizations at the time led to the growth of the ‘web’ into what it has become today. With over 5 billion users, the internet has become one of the most ubiquitous inventions, and a steep increase in the number of users on the internet can be seen following Berners-Lee's trip in 1992 and 1993 raising awareness and creating groups to support the new concept of the 'web' (see figure 1 in Appendix A).

Review of Literature

"The ARPANET Sourcebook" edited by Peter Salus is a comprehensive collection of lesser-known documents that form the foundation of contemporary data networking, accompanied by forwards to provide context. One of these forwards was written by Dr. Leonard Kleinrock, where he claims to be, "often referred to as the Father of Modern Data Networking" (95). A few years previously, Leonard Kleinrock set up a webpage on the UCLA website that describes him as the "Inventor of the Internet Technology" and credits him with "having created the basic principles of packet switching" (Hafner) While there is no doubt that Kleinrock played a role in the development of the internet, his role was the mathematical analysis of networks. However, by relentlessly publishing, and his close friend and colleague Dr. Lawrence Roberts often agreeing, Kleinrock's claims to have invented packet switching has started to impact historical records. As discussed above, the concepts of packets for data communication were simultaneously and independently developed by both Paul Baran and Donald Davies.

While Kleinrock was the first to pioneer queueing theory in its role in analyzing network behavior, however his claims to have "anticipated the technology of packet switching" is not supported by any documentation at the time or since (Kleinrock). While his 1964 book, "Communication Nets - Stochastic Message Flow and Delay" does mention routing as well as the tradeoff between capacity and delay, nothing included had significant influence over the development of the internet. Kleinrock, being a close friend of Roberts, may have, during private conversations, played a greater role than the historical documentation shows, however, his Kleinrock's claims to have invented packetization, demand access, and several other critical aspects of modern network paradigms is inaccurate. Despite this, Kleinrock was able to influence the narrative enough that many sources now will attribute early packet switching to Kleinrock rather than Davies or Baran. In fact, some sources go as far as to say Kleinrock published the first paper on the internet (referring to his 1964 book) which was simply applying an established field of mathematics (Queueing theory) to an established telegraph network (Western Union Plan 55A network) with the goal of analyzing delays.

One of the critical aspects of packetization is in breaking up a message into smaller messages, as this greatly reduces delays and errors, all while allowing for bimodal traffic distributions. Baran and Davies both go into detail regarding these, however, Kleinrock not only never mentions any of these, but also makes no mention of breaking a message into smaller parts. In fact, the system described by Kleinrock is hop-to-hop message switching, which is significantly different than packet switching. John Naughton, author of "A Brief History of the Future: From Radio Days to Internet Years in a Lifetime" writes that, “Donald Davies is one of those men who brings to mind Harry Truman's observation that 'you can accomplish anything you want in life provided you don't mind who gets the credit.’” Despite being known as being humble, almost to a fault, Davies was adamant and vocal in saying that Kleinrock's writings had nothing to do with the developments of packet switching, and even saying, “I can find no evidence that he understood the principles of packet switching.” While more public than others, Davies’ and Kleinrock's dispute over whose contribution to the development of packetization theory is not unique. In fact, the past and current development environment is full of such disputes. Systems have since been put in place to try to prevent people from stealing intellectual property, to ensure due credit is given. Something that was not seen with the contributions made by the French Cyclades network.

While many of the narratives regarding the development of the internet leave the French Cyclades network out entirely, and the rest usually mention it in passing as another of the early packet switched networks, the program was quite influential, and the story of the internet is incomplete without it. The French Cyclades network was one of the first networks to use datagrams, and was more advanced than ARPANET in critical ways, though it was unable to grow due to political volatility and underfunding. Despite this, Vinton Cerf would recall in a 1990 interview regarding the creation of the Transport Control Protocol:

> "Several people had a lot of influence on how the design [of TCP] went. Bob [Kahn] and I spent a lot of time working through various concepts and we wrote that paper in 1974. But I had also a lot of exposure to Hubert Zimmermann and to Louis Pouzin, both of whom had been doing experiments at INRIA, it was called IRIA at the time, on packet switching. They had developed a system they called Cyclades, and the underlying network was called Cigale. It was a pure datagram network.... Anyway, Pouzin's ideas on windowing techniques were very appealing to me, and I incorporated them into the initial TCP design. A guy named Gérard Le Lann was at IRIA working with Pouzin and came to my lab at Stanford for a year and had a lot to do with the early discussions of what the TCP would look like."

The interviewer did not prompt Cerf or ask anything about France or if any other countries made contributions, however, Cerf, when retelling the creation of the internet, chose to include his international contemporaries and colleagues and give them credit for their contributions. This, among other reasons, may have been why so many of the researchers and engineers at the time were happy to work with Cerf and his team, and continued to write about it fondly for over three decades. In fact, when analyzing TCP, Janet Abbate referenced the close collaboration of Cerf, Le Lann, and Metcalfe saying, “the specifications for TCP . . . and thus the protocol reflected the design philosophies of Cyclades and Ethernet while deviating significantly from the approach that had been taken with the ARPANET." This collaboration is critical to keep in mind, as even though TCP is often considered the legacy of ARPANET, it was rather an amalgamation of concepts and perspectives that were so diverse specifically because of the multicultural and international aspects of the collaboration. In fact, when seeing how much the Cyclades network was ignored, Vinton Cerf would defend Pouzin as the “datagram guru” and would regularly cite Pouzin’s contributions to the design of “end-to-end” internet (Peter). While it is true that the internet was created through a global effort and collaboration by many different organizations, it is equally true that the U.S. has made significant advancements, especially in the early development of the internet.

Exploration of Counterarguments

Coming out of the Second World War, the United States made up half of the global GDP, and no other country could come close to matching the exportation of goods and intellectual property of the U.S. This is largely due to geography, with the U.S. being spared from having its industrial complex destroyed, faced fewer casualties, sold bonds to many other countries, and had greatly increased its industrial output, which the rest of the world was readily consuming while they were rebuilding. Not only that, but competition against another growing, and now nuclear power, the Soviet Union was encouraging innovation. As previously stated, ARPA was created in response to Sputnik, but early computers and networks that helped the U.S. get into development of networking technologies, such as the MANIAC I and SAGE were parts of the U.S. military complex. It is important to acknowledge that the U.S. made many important contributions, and even when the technologies or theories originated from international sources, it was the United States that would invest into the development and put together groups of some of the best academics in order to encourage innovation. Educational institutions like MIT or SRI, as well as corporate entities like Xerox PARC or the RAND Corporation, were seminal to the development of the internet. Just as internet took many contributions from all over the world, the United States played a significant role, to say nothing of the free market system in the U.S. meaning it was one of the first to commercialize the internet with companies such as CompuServe. While it is important to recognize the contributions of international actors, it is also important to acknowledge the role of U.S. actors in shaping the internet. A complete historical narrative and celebrating America's achievements are not mutually exclusive, in fact, not acknowledging the significance of U.S. contributions to the development of the internet would be as incomplete as not acknowledging the foreign contributions. Media, such as Jamal Shahin's *A European history of the Internet*, can exacerbate the problem as they try to achieve what they believe to be a fair balance by leaving out or underplaying the contributions of the United States. For collaboration to be most effective, it must move forward acknowledging all parties equally. It is not just countries or regions, however, that may get written out of the narrative due to geopolitical or other reasons, sometimes even domestic contemporaries are left out of the narrative.

It is an unfortunate truth that as long as there have been inventions there have been claims and counterclaims of precedence and people who do not get credit for the contributions they have made. This is not unique to the history of the internet, and even within the history of the internet, is not unique to foreign actors. In fact, one of the most egregious cases is again surrounding the TCP/IP protocols, only this time with an American company, Xerox. Robert Taylor, after being the Program Director for IPTO under ARPA for several years, was sent to Vietnam and, upon returning, decided not to return to the IPTO saying that, “I knew ARPANET would work. So I wanted to leave" (Taylor). Instead, Robert Taylor became the associate manager of the Computer Science Laboratory in Xerox PARC. During Taylors time at Xerox PARC, he worked on personal computers, ethernet, and PUP. PUP, or the PARC Universal Protocol, was a way to connect the Ethernets together, and later, to connect the Ethernet to ARPANET. PUP was very similar to TCP/IP, having come out a few years earlier, however, was kept secret as the rest of the Xerox Network System (XNS) protocol suite was developed. After having completed the PUP, Vinton Cerf and Robert Kahn invited some of the lead engineers from Xerox PARC to a meeting at Stanford to brainstorm something called the TCP/IP suite. Robert Metcalfe and John Shoch attended, however, the legal department at Xerox made it very clear to both of them that while they could attend, they could not tell anyone about PUP (Lunduke). The two PARC engineers went and every time one of the Stanford or other engineers proposed an idea, the PARC engineers would point out issues it would have or make suggestions. Later, one of the Stanford researchers sat back and pointed out to the room that the PARC engineers had clearly done this already. Robert Taylor would go on the record to say, “So, Vinton Cerf and Bob Kahn owe their fame to the Xerox attorneys. If it weren’t for the Xerox attorneys nobody would have ever heard of TCP/IP. TCP/IP designs were based a lot on PUP" (McJonese and Taylor).

While this may not be the case, as Taylor had some personal bias on the subject, the feedback that Metcalfe and Shoch, as well as other PARC researchers who shared their work with the Stanford team working on TCP/IP, greatly affected the direction of TCP/IP's development. The PUP suite was much more complete than TCP/IP, and the first internetwork was using PUP to connect the Ethernet to ARPANET (Lunduke). TCP/IP would ultimately incorporate most of the features of the PUP suite as well as improvements made from working with the designers of the French Cyclades network and insights made by the Stanford research team along with Vinton Cerf and Robert Kahn (Abbate). Unfortunately, Cerf and Kahn would be forever called the "fathers of the internet" all while the Xerox and Cyclades researchers and engineers would mostly be lost to history. While it is true that not all the unattributed contributions came from international sources, it does not make the fact that the lack of recognition for international contributors have strained international relations as well as negatively impacted the policies made by the U.S. and U.S. organizations due to a false sense of entitlement surrounding the development of the internet.

Future Implications

What started out as simply an incomplete history and a dispute over the provenance of the internet has grown into a much larger issue because it has impacted the way the U.S. views and, therefore, makes policies regarding the internet. As the Americentric narrative creates cultural momentum surrounding the idea of 'owning' or 'controlling' something that they created, the U.S. has strained potential collaboration and relations both for future research as well as with other countries. Unfortunately, the trust between other countries and the U.S. specifically regarding governance and stewardship of the internet has deteriorated to the point, that several are calling for an entirely new system of governance to be established. There are several ways for ongoing internet governance to take shape, and which one comes to be will impact not only how the internet is run and grows over time but will have significant political implications as well.

If the internet is able to remain as a collaborative and cooperative global project, there would be great opportunities for rapid development of technologies as different organizations could make contributions and build off of one another's developments. This would be similar to the early days of network development, such as how Lawrence Roberts used Donald Davies and Paul Baran's ideas of packetization in order to develop ARPANET, how Louis Pouzin was able to improve on the communication protocol developed for ARPANET, and how Vinton Cerf was able to incorporate Pouzin's ideas in order to create TCP. Unfortunately, this once again brings about the concerns of intellectual property and the loss of people's contributions, such as how Davies, Baran, and Pouzin are all often left out of the narrative, making others wary of the same thing happening to them.

In a proposal for collaborative research between Japan and the U.S. regarding computational neuroscience, Matsunami and Ohzawa made it clear that the lack of robust intellectual property rights and policies in the United States meant that for there to be meaningful collaboration, it was first necessary to "facilitate discussion of Intellectual Property (IP) issues in both countries" (Matsunami 12). It is unfortunate, but there remains hesitation on the part of organizations in countries like Japan – as well as France, Germany, and Israel – regarding collaboration and proposals like this which often stress how U.S. scientists seem surprised at the strength of the science and scientists of other countries; and how there needs to be more trust and equality in order to synergistically collaborate internationally.

As collaboration has been made more difficult by these issues, independent research has continued, and this has both its benefits and its drawbacks. The promotion of competing ideas has often been a motivation for innovation; however, such competition does not always favor the best idea. In the case of the early internet, American computer scientist and one of the lead engineers working on ARPANET, Robert Kahn, chose not to work with the International Networking Work Group and instead developed their own standards for network communication. Unfortunately, the network suite developed was less complete and took several years before it was on-par with those developed by INWG. Despite this, it was the network suite developed by Kahn that was ultimately adopted. Alexander Mckenzie, in a paper published by The Institute of Electrical and Electronic Engineers (IEEE), explained, "whether [Kahn] was right or wrong didn't matter; DARPA had a bigger research budget than any of the other research organizations, and for this reason, its protocol choice became dominant over time" (70). This ability to make decisions, right or wrong, however, is another of the potential benefits of a more independent development. Bureaucracy and issues with large organizations often lead to slower development, and an issue with international boards and committees is their tendency for long deliberations. Andrew Russell explains this issue with one of the first such multinational bodies governing the internet and its development, OSI, explaining how "the bureaucratic procedures used to structure the discussions didn't allow for the speedy production of standards… even trivial nuances of language… triggered complaints" (Russell *OSI: The Internet That Wasn't*). As in all things, there has to be a balance between openness and democratization of decision-making and the need for effective governance, and this is especially true in the complex and rapidly evolving technological landscape of the digital world. Finding a balance between collaborative and independent development of the internet and of networking is something that is still being worked on, as there have been several proposals for how to establish governance of the internet moving forward in the last few years.

Centralized hierarchical governance of the internet raises the issue of what body fills that role and what influence different political powers will have over that body. As of 2016, ICANN – now a global multistakeholder community – largely separated from the United States government. In a goal to remove the National Telecommunications and Information Agency (NTIA - a U.S. government agency) stewardship and continue in the privatization of the internet as well as allow the global community to hold an organization accountable, ICANN took on the roles of the IANA services. This was a result of whistle blower Edward Snowden, who released documents regarding the United States' illegal and unethical wiretapping and surveillance of internet traffic. Before this, the EU's Body of European Regulators for Electronic Communications and UN's International Telecommunication Union had made attempts to take over IANA, however, after the revelations confirmed long-standing suspicions, the world's largest tech companies issued the "Montevideo Statement," which called for globalization of ICANN and IANA. One of the requirements of the global internet community was that this role was not fulfilled by another government, or intergovernmental, organization.

Currently ICANN maintains a limited form of internet governance, along with the: Regional Internet Registries (RIRs), Internet Research Task Force (IRTF), Internet Engineering Task Force (IETF), Internet Society (ISOC), International Telecommunications Union (ITU), World Summit on the Information Society (WSIS), World Wide Web Consortium (W3C), the Internet Governance Forum (IGF), and several other competing organizations. Among the difficulties of establishing internet governance is the number of organizations that all currently play a role in. Many nations remain wary of the U.S. continuing what is often referred to as the "American Internet Hegemony" – this concern is substantiated by Senator Ted Cruz, along with four U.S. states, suing the NTIA to force the ICANN to reverse the transition of the stewardship over IANA. Besides that, when ICANN accepted the responsibilities of IANA, it had to gain approval solely of the United States government following very strict guidelines, which resulted in an organization which strongly reflects U.S. values and interests. Madeline Carr points out in her book *US Power and the Internet in International Relations: The Irony of the Information Age*, that ICANN and the multistakeholder community is largely made up of U.S.-based companies and organizations. In addition to that, the prioritization of internet freedom as well as interconnectedness of a commercialized internet is seen to align with long-standing U.S. policies designed to promote access to foreign markets for U.S. companies.

Politics has long affected the development of the internet, and countries are rightfully concerned about a continued centralized governance of the internet, not only from the U.S. but from any government or intergovernmental organization. Tim Berners-Lee, the original developer of the World Wide Web, describes what a future decentralized internet may look like, called the "Semantic Web," which has become one of the bases for Web3. This would remove any sort of centralized governance of the internet regulating hosting, domains, or data, instead promoting an open and distributed network. This protects not only against any government from being able to censor or collect data, but also would be more robust against either hackers or a server crash. This style of peer-to-peer network raises several concerns, such as the ability for criminals to abuse anonymity and lack of surveillance, as seen in other decentralized internet communities such as the dark web. Solutions for these issues are being developed, however, such as DIDs, or Decentralized Identifiers, which are a persistent and verifiable identifier for a user which does not require a centralized registry. Even with the tech industry's large open-source development community, Web3, or any decentralized internet, would likely still have some organization reviewing standards and ensuring interoperability. A totally decentralized internet is very difficult to implement and is likely far in the future, with concerns over arbitration and dispute resolution being at the forefront of many opposing arguments.

Another future potential for the internet, as a result of the troubled political climate surrounding it, is the potential of a nationally or regionally fragmented network. In the Montevideo Statement, the leaders of organizations such as the W3C, ISOC, IETF, ICANN, and more, all, "reinforced the importance of globally coherent Internet operations, and warned against Internet fragmentation at a national level." Such a fragmented internet would have significant economic and political consequences. Fragmentation could result in a lack of interoperability between networking protocols and cross-border data flows, just as seen in the early days of internet development, when the U.S., France, and the U.K. were unable to connect their networks to one another. Similarly, this would not be a technical challenge, but rather a political and organizational one. This lack of interconnectedness would mean a reduction in global online transactions and make it much more difficult to maintain global brands. It would also affect investments and international trade as companies and even governments would face challenges in exchanging data. Fragmentation would also affect the political aspects of the internet, both foreign and domestic. A nationally or regionally fragmented internet would allow for countries or regions to create internets that more closely align with their own interests and values, as well as give much more power to those governing the particular fragment of the internet, favoring a more centralized flow of data. This would give the governing body much greater control over the content that is allowed or blocked within the borders of its internet, allowing authoritarian regimes to exert greater control over their populations, limit access to information that is critical of the government or promotes dissent, and restrict the ability of citizens to communicate with one another or the outside world.

Internet fragmentation along national or regional lines is unfortunately a risk that cannot be dismissed at this time, and it is important to analyze what brought it to be an issue in order to understand what can be done to prevent it. As the U.S. worked on developing its internet, it would take certain aspects of other networks, and incorporate the advancements that the developers saw that fit with the goal for their network, however, they would often leave out other aspects. For example, the European Informatics Network included multiple languages in the 1970s, however, universal acceptance of Internationalized Domain Names (IDN) is something that IANA and ICANN have yet to achieve. In fact, the U.K. – a country whose official language was fully included with basic ASCII since the very first networks – has been one of the strongest proponents for universal acceptance of IDNs. ICANN's lack of universal acceptance of IDNs prevents countries like China, Russia, India, and many others – in fact any that don't use the English alphabet – from being able to access the internet using their native language in the URL. The United States' ownership of IANA, and DNS accordingly, for such a long period of time, despite having come to an end, has left many countries and people concerned for the future of the internet. IANA, which is responsible for the allocation of IP address, caused an issue when it allocated only nine million global IP addresses to China, while it had already allocated nearly twice that number just to Stanford University in the U.S. (Drissel 117). This, along with many of the other decisions and actions taken by ICANN, even after its separation from the U.S. government, has led to many people who are involved in internet governance to believe that an entirely new organization must be created. David Drissel, a professor of social sciences specializing in internet governance and international relations, explained that, "ICANN's origins and charter are ultimately too intertwined with American interests to be truly effective… the international legitimacy and credibility of the organization [is] dubious at best" (Drissel 118). This mistrust of not only the U.S. but the international multistakeholder organization that it created, as well as the U.S. creating sanctions against Chinese companies, such as Hauwei and ZTE, has greatly strained the relations between them. In fact, not only do the actions that the U.S. have taken made cooperation and collaboration more difficult, the U.S. government put Hauwei on the Entity List prohibiting any U.S. company from collaborating or trading with them. The U.S. has also created the "Clean Network Initiative" which has the goal of building an alliance of countries and companies to 'compete' with China. As part of this initiative, however, the U.S. Department of Commerce all but completely blocked China, Chinese firms, and Chinese scientists from participation in standardization bodies (Kholer 32).

This politically dangerous move, unfortunately, did not have the desired effect. Rather than reducing the control that the Chinese government had over the global technology infrastructure, it led to the Chinese creating the 'Digital Silk Road.' As part of China's Belt and Road Initiative (BRI), it has engaged with 138 countries in some way to promote, "cross-border optical cables, the internationalization of the Beidou satellite navigation system, and the adoption of Chinese standards" (Kholer 31). This independent Chinese infrastructure could mean that a fragmented internet is coming soon, with countries having to pick a side for what internet they want to be on. China may utilize 'debt diplomacy' as it has with other parts of the BRI to take the choice away from countries it builds its infrastructure within. While there have been several counter-initiatives as a result of the perceived threat, unfortunately, the Western countries have been unable to successfully cooperate, and it has resulted in several inefficient and overlapping infrastructures that only further illustrate the dangers that concerns about collaborative efforts can cause.

Conclusion

Robert Taylor admits to not being optimistic that people will get credit for their contributions, saying that, “History is made by the people who write about it, not the people who truly make it.” The issue with the statement is that there are people writing about the underrepresented histories of the internet. In the last few years, especially since ICANN became a multistakeholder community, there have been more articles published trying to bring light to and inform people about this serious topic. The significance of this does not end with whether or not Pouzin or Zimmermann get credit for what they contributed to the internet community. The significance of this research lies in its potential to reveal how incomplete documentation and missing parts of the story can create biases and influence decisions at an international level. Creating a more welcoming community for future study of technology and for the internet as a whole. Prioritizing IDNs and making the internet more equal for everyone in order to preserve the interconnected global community that the internet was able to create. “History is made by the people who write about it” – that’s the significance of this research. By highlighting the contributions of underrepresented groups and international actors, this paper not only provides a more comprehensive understanding of the history of the internet but analyzes the global power dynamics created by cultural and political discourse on technology. Ultimately, further research and further papers have the potential to shift the conversation around the history of the internet to be more diverse and inclusive, and doing so can create a more collaborative and cooperative global internet community.

Annotated Bibliography

Barry M. Leiner, Vinton G. Cerf, David D. Clark, Robert E. Kahn, Leonard Kleinrock, Daniel C. Lynch, Jon Postel, Larry G. Roberts, and Stephen Wolff. 2009. A brief history of the internet. SIGCOMM Comput. Commun. Rev. 39, 5 (October 2009), 22–31. https://doi.org/10.1145/1629607.1629613

This paper is a factual re-telling and rendering of the events and activities associated with the development of the early Internet and is a valable contribution to the historical record. The contributing authors did their best to incorporate only factual material into this document. It is well sourced and presented fairly with no detection of bias. Despite the passage of time and the many blurred details that have not been represented in the body of the document it remains one an accurate presentation of an early, and key, developmental period. This paper has been frequently cited by subsequent authors of note. This paper is especially useful as it is a primary source by some of the most influential authors and researchers in the field, and it served as a framework for the history of this paper as well as providing some further directions to research in.

Bay, Morten. “Hot Potatoes and Postmen: How Packet Switching Became ARPANET’s Greatest Legacy.” *Internet Histories*, vol. 3, no. 1, Mar. 2019, pp. 15–30. *EBSCOhost*, https://doi-org.libdb.njit.edu:8443/10.1080/24701475.2018.1544726.

ARPANET demonstrated that packet switching was an effective routing principle for computer networks, accelerating the evolution towards the current network paradigm, in which This paper describes how packetization came to be found in almost all forms of digital communication. This effective network routing principle, as demonstrated by ARPANET, accelerated the evolution of our current paradigm. Popular literature tends to recognize three originators: Paul Baran, Donald Davies and Leonard Kleinrock. This paper focuses on the risky and highly consequential decision to base the ARPANET design on this previously untested technology. Credit for actual discoveries and provenance are left to other researchers. The review of newly revealed documents indicates that Paul Baran had a much more substantial influence on the decision to use packet switching for ARPANET than folklore or the superficial histories indicate and, conversely, Donald Davies role may have been less important. It is hard to discount the possibility of unseen bias in any paper so focused on individual contributions rather than technology, but this paper appears balanced, reasoned, and well-sourced. The references and named contributors are significant. This paper makes substantial claims and defends them well though the defense of Kleinrock may be somewhat revisionist. While his paper makes a strong case against Donald Davies it is in the minority in that respect. It also clearly depicts the significance that packet switching, distributed routing, and TCP had to the internet, substantiating other claims, such as that of Pouzin, that contributions made to those parts of the early network development remain relevant to the internet and its development.

Campbell-Kelly, Martin, & Garcia-Swartz, D. D. (2013). The History of the Internet: The Missing Narratives. Journal of Information Technology, 28(1), 18–33. https://doi.org/10.1057/jit.2013.4

This paper challenges the widespread notion that the internet grew, almost exclusively, from an ARPANET “seed”. The paper contextualizes ARPANET as merely one of many networks developed during this early period and that these disparate networks were destined to combine into an internet with, or without, ARPANET's existence. It further adds quantification to the above by systematically reviewing these various networks and demonstrating that ARPANET was merely a member of a crowd, and perhaps not even as large of a one as previously thought and claimed. It continues to contextualize various emergent technologies such as TCP/IP and the World Wide Web and other presumably dominant designs within the framework of evolving industries and historical accidents which, combined, led to wide acceptance. This paper may be biased in that it appears determined to prove a pre-existing point rather than investigating the question dispassionately. However, its arguments are convincing, and they sit upon an impressive set of supporting references. This paper was very useful as it introduced many of the other early networks and contributions made that were often left unattributed or were attributed to the U.S.

Campbell-Kelly, Martin. "Data Communications at the National Physical Laboratory (1965-1975)." *IEEE Annals of the History of Computing*, vol. 9, no. 4, 1987, pp. 221–247., https://doi.org/10.1109/mahc.1987.10023.

This paper focuses on a decade, 1965-1975, of data communications activity at the National Physical Laboratory (NPL) regarding the development of packet switching. Donald Davies first proposed packet switching in the context of data communications in 1965 which, in turn, led to the construction of the NPL Data Communications Network by 1970. This network served both as a model for a possible U.K. national network and as a practical local area network (LAN) for the NPL site. The report describes the impact of the NPL work on other early networks, such as ARPANET and the British Experimental Packet-Switched Service (EPSS), and on data communications in general. Citations of this paper focus more on the archaeology and human factors of early network design rather than the technology but are nonetheless, noteworthy. It appears comprehensively researched and logically laid out. This was very useful as it went into detail regarding the early international network developments. The United Kingdom was the first country to explore a computer network such as this, and yet that fact is often ignored in exchange for the better funded and ultimately more successful ARPANET, despite it being inspired by Davies' paper.

Drissel, David. "Internet Governance in a Multipolar World: Challenging American Hegemony." Cambridge Review of International Affairs, vol. 19, no. 1, 18 Jan. 2007, pp. 105–120., https://doi.org/10.1080/09557570500501812.

This paper spans the topic of Internet governance from the earliest trans-Atlantic connected communities of the 1970s to today's wide array of self-regulating agencies. This paper assesses the current system of governance dominated by US-sponsored bodies such as ICANN and contrasts it with the emerging paradigm of an international and multilateral oversight of cyberspace resources. Disputes and allegations of American regulatory unilateral bias are examined. Potential for bias in this paper is detected early with the non-technical phrases such as 'the haves and have-nots' and the 'heat and soul' of the internet and conflict reaching a 'fever pitch'. Such sentiments detract from a very real, and credible argument for the need to reassess internet governance. Special attention to the review of the

proposed changes to organizational structures and processes is warranted. This text is especially useful in analyzing the effects of the so-called "American Hegemony" as well as the potential future implications of different types of internet governance.

Emspak, Jesse, and Kim Ann Zimmermann. "Internet History Timeline: ARPANET to the World Wide Web." Internet History, Live Science, 8 Apr. 2022, https://www.livescience.com/20727-internet-history.html.

This article is very interesting given the context of this paper as it represents the 'incomplete internet history' that is often portrayed and, in this paper, being challenged. This article, a notable departure from the other references herein, gives unchallenged credit to Kleinrock and fails to even mention the other claimants to packet switching or the existence of other networks besides ARPANET. This article is biased and only superficially researched. This article is used as a baseline and as a representative example of the dominant Americentric narrative.

Hafner, Katie. "A Paternity Dispute Divides Net Pioneers." *The New York Times*, The New York Times, 8 Nov. 2001, https://www.nytimes.com/2001/11/08/technology/a-paternity-dispute-divides-net-pioneers.html.

This article delivers a balanced summary of the competing, sometimes acrimonious, claims of Donald Davies and Leonard Kleinrock regarding credit for the initial ideas behind today's all-important packet switching technology. Determined to be fair, it offers equal amounts of weighted commentary and quotes for each position and there is no attempt to produce technological evidence or even reach a consensus of subjective opinions. It is meant to highlight an issue, not resolve one – however, it includes quotations by some of the people who worked directly with both Davies and Kleinrock and who were involved in the early development of networking technologies.

Haggart, Blayne. "The Last Gasp of the Internet Hegemon." Internet Governance, Centre for International Governance Innovation, 3 Sept. 2020, https://www.cigionline.org/articles/last-gasp-internet-hegemon/.

This article, although not scientific nor objective, is useful as it describes political affects that the shift in the balance of power in internet governance and the potential impact of the United States' reduced control over the internet. The author argues that the US government's transition of control over the Internet Assigned Numbers Authority (IANA) to the Internet Corporation for Assigned Names and Numbers (ICANN) represents a loss of American hegemony over the internet, as other countries become more involved in internet governance. This article is biased, has few references, and is passionately written rather than scientifically rigorous – however, it provides an insight into the types of articles that are written about the United States and its policies regarding the internet from outside of its borders as well as an insight into how other countries view the U.S. Furthermore, after finding and cross-reviewing several peer-reviewed pieces of literature, all the information is accurate, even if written with catastrophizing rhetoric.

Russell, Andrew L., and Valérie Schafer. "In the Shadow of ARPANET and Internet: Louis Pouzin and the Cyclades Network in the 1970s." *Technology and Culture*, vol. 55, no. 4, 2014, pp. 880–907. *JSTOR*, http://www.jstor.org/stable/24468474. Accessed 2 May 2023.

This text explores the history of the Cyclades Network, a lesser-known computer network that existed alongside ARPANET and the Internet in the 1970s. The article focuses on Louis Pouzin, the creator of the Cyclades Network, and his contribution to computer networking through his invention and advocacy of "Datagrams." The paper highlights how the Cyclades Network differed from ARPANET and the Internet and its impact on the development of computer networking. Overall, this article provides valuable insights into an important but often overlooked chapter in the history of computer networking. This text is particularly interesting as it is the international collaborative result between two of the greatest technological historians currently, one in the United States and one in France. This article is very thoroughly and rigorously researched, analyzing several other pieces of literature as well as interviews with the people involved in the internet's development from both the United States as well as France. This article is especially useful as it is specifically analyzing how the U.S.'s ARPANET has occluded the other early networks, in this case Cyclades, from the public eye, including interviews with some of the most important developers who worked on it, such as Vinton Cerf.

Shahin, Jamal. "A European history of the Internet." Science and Public Policy 33.9 (2006): 681-693.

This article represents the obverse side of the coin, the European, or non-American, perspective of internet history. It highlights the initially reluctant approach the European Community took towards the internet as well as the re-doubled interest in later years under the EU. It goes on to discuss the EU's current plans for the future of the internet and its determination to have more of a leadership role in its governance. There is a bias in its tendency to ignore non-European contributions and events, however this is made clear in the title; the goal of the paper is to provide an insight into European history specifically and makes no claim to be a complete history. The writing and scholarship are high quality. This article provides a detailed look into the European, specifically French and English, work on network technology development, as well as the affects that politics, economics, and geography impacted the different developments, something which is often left out of other historical accounts.

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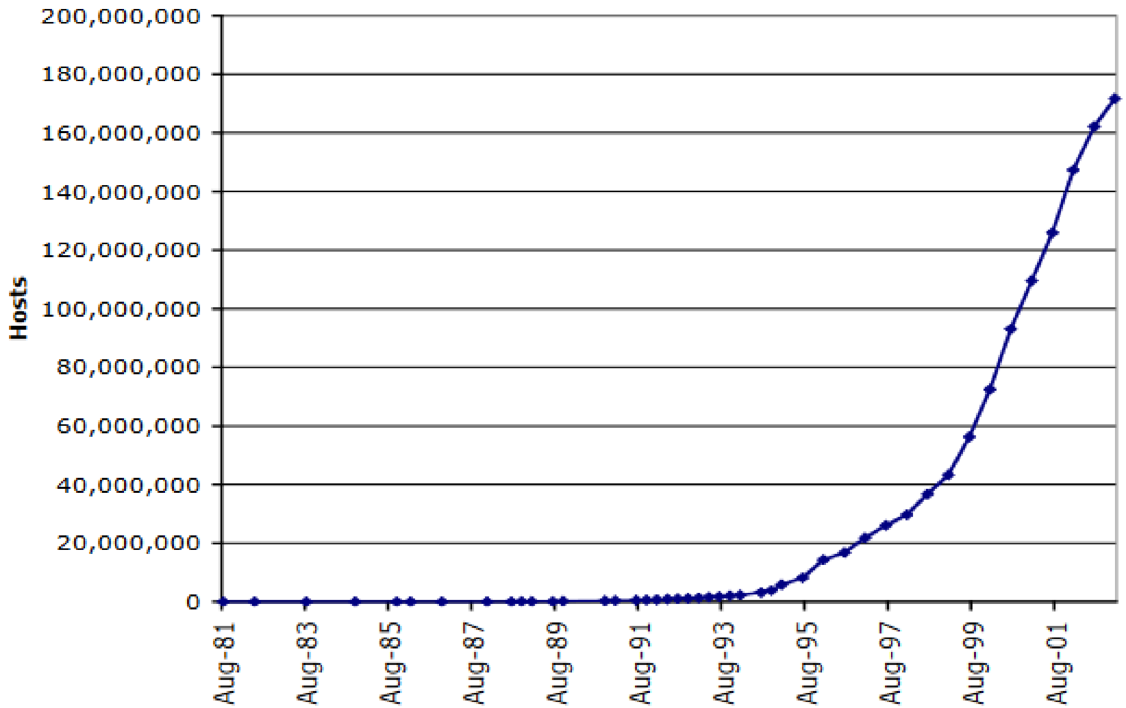
Appendix A

Table 1
An Internet Timeline

Year	*General network developments*	*ARPA-related network developments*
(A) 1938–1969		
1938	Wells, *World Brain*	
1945	Bush, 'As We May Think'	
1958		ARPA established
1960		Licklider, *Man Computer Symbiosis*
1961	MIT Compatible Time-Sharing	
1962	SAGE system	Licklider Program Director at ARPA
	ERMA banking network	IPTO formed at ARPA
		Baran's packet-switching paper
1965	SABRE reservations system	ARPA network study
	MIT Project MAC	Davies' packet-switched network
	Commercial time-sharing	
	Remote processing systems	
	Online information systems	
1967		ARPA adopts packet-switching
1969		First ARPANET node at UCLA
(B) 1971–1995		
1971	Tymnet packet-switched network	
1972		
1973	First EDI network (railroads)	
1974	IBM announces SNA	TCP specified
1975	Telenet packet-switched network	
	X.25 defined by the CCITT	
1976	UPC in supermarkets	
1977	OSI project	
1978	First Bulletin Board System	TCP/IP specified
	MicroNET (CompuServe)	
1979	First videotex systems	
1983	AOL online service	Milnet separated from ARPANET
	MCI email service	
1984	Prodigy online service	
1986		NSFNET established by the NSF
		X.400 protocol specified
1990	WWW functional at CERN	ARPA internet subsumed into NSFNET
1991	Gopher live	
	WWW released by CERN	
	WAIS invented	
1993	MOSAIC browser	
1994	First Internet service provider	
1995	The Internet a private entity	The Internet a private entity

Source: Campbell-Kelly, Martin, and Daniel D Garcia-Swartz. "The History of the Internet: The Missing Narratives." Journal of Information Technology 28.1 (2013): 18-33.

Figure 1
Computers on the Net



Source: *Handley, Mark. "Slides from Presentations and Public Talks." Mark Handley: Assorted Presentations, UCL Department of Computer Science, http://www0.cs.ucl.ac.uk/staff/m.handley/slides/.*

Appendix B

TCP/IP: A set of communication protocols used to connect devices on the internet. Developed in the 1970s by Vint Cerf and Bob Kahn, it is the foundation of modern internet communication.

Ethernet: A computer networking technology used for local area networks (LANs) that was developed in the 1970s by Robert Metcalfe and his colleagues at Xerox PARC.

OSI (Open Systems Interconnection) Model: A conceptual model that describes how different protocols and network devices interact to enable communication between computers on a network.

World Wide Web (WWW): A system of interlinked hypertext documents that can be accessed via the internet. Developed by Tim Berners-Lee in 1989.

HTML (Hypertext Markup Language): the standard markup language used to create web pages and other information that can be displayed in a web browser.

Mosaic: The first web browser with a graphical user interface, developed by Marc Andreessen and his team at the National Center for Supercomputing Applications (NCSA) in 1993.

X.25: A packet-switched network protocol that was widely used in the 1970s and 1980s for international data communication.

FTP (File Transfer Protocol): A protocol used for transferring files over the internet.

SMTP (Simple Mail Transfer Protocol): A protocol used for sending email messages between servers on the internet.

Telnet: A protocol used for remotely accessing computers or other devices over a network.

DNS (Domain Name System): A protocol used to translate domain names (such as www.example.com) into IP addresses that computers can use to connect to websites.

ARP (Address Resolution Protocol): A protocol used to map a computer's MAC address to its IP address.

SNMP (Simple Network Management Protocol): A protocol used to manage and monitor network devices.

IPX/SPX (Internetwork Packet Exchange/Sequenced Packet Exchange): A set of protocols used by Novell NetWare to communicate over a network.

IETF (Internet Engineering Task Force): A global open standards organization responsible for developing and promoting voluntary internet standards.